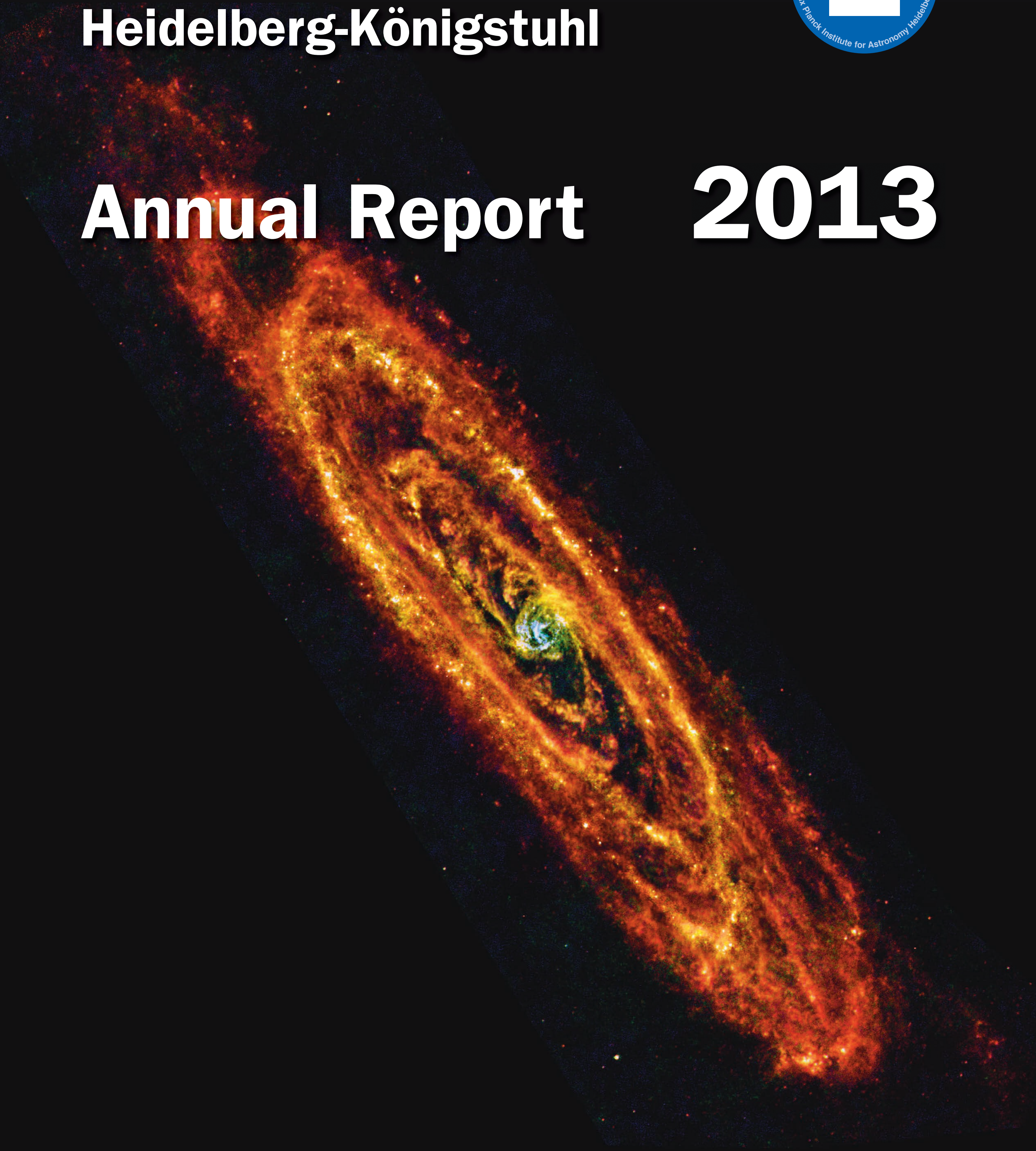
Max Planck Institute for Astronomy

Heidelberg-Königstuhl

Annual Report 2013



Cover Picture:
The infrared image of the well-known close-by neighbor galaxy M 31 in the constellation Andromeda was taken with the European Herschel Space Telescope. It is part of a program led by Oliver Krause of the Planet- and Star Formation Department at the Max Planck Institute for Astronomy (MPIA). See Chapter I.1, page 8.

Credits: ESA / Herschel / PACS & SPIRE Consortium, Oliver Krause, HSC, Hendrik Linz.

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Staff: By the end of 2013, a staff of 310 was employed at MPIA (including externally funded positions). This includes 209 scientists, of which 67 were junior and visiting scientists, and 59 were PhD students.

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Contents

Preface

This Annual Report describes the scientific activities at the Max Planck Institute for Astronomy (MPIA) in Heidelberg. It is intended for our colleagues worldwide as well as for the interested public.

In addition to presentations of some selected scientific results of the year, we also report in more depth on a few selected research areas at MPIA and on some of our ambitious instrumentation projects. Furthermore, some other activities and highlights of the life at our institute are presented.

We hope that this annual report, edited by Klaus Jäger, Markus Pössel and Axel M. Quetz, will give the reader a flavour of the research, work and life at our institute and we would like to thank all authors who have contributed to this issue.

Thomas Henning, Hans-Walter Rix

Heidelberg, November 2014

I. General

I.1 MPIA's Scientific Mission

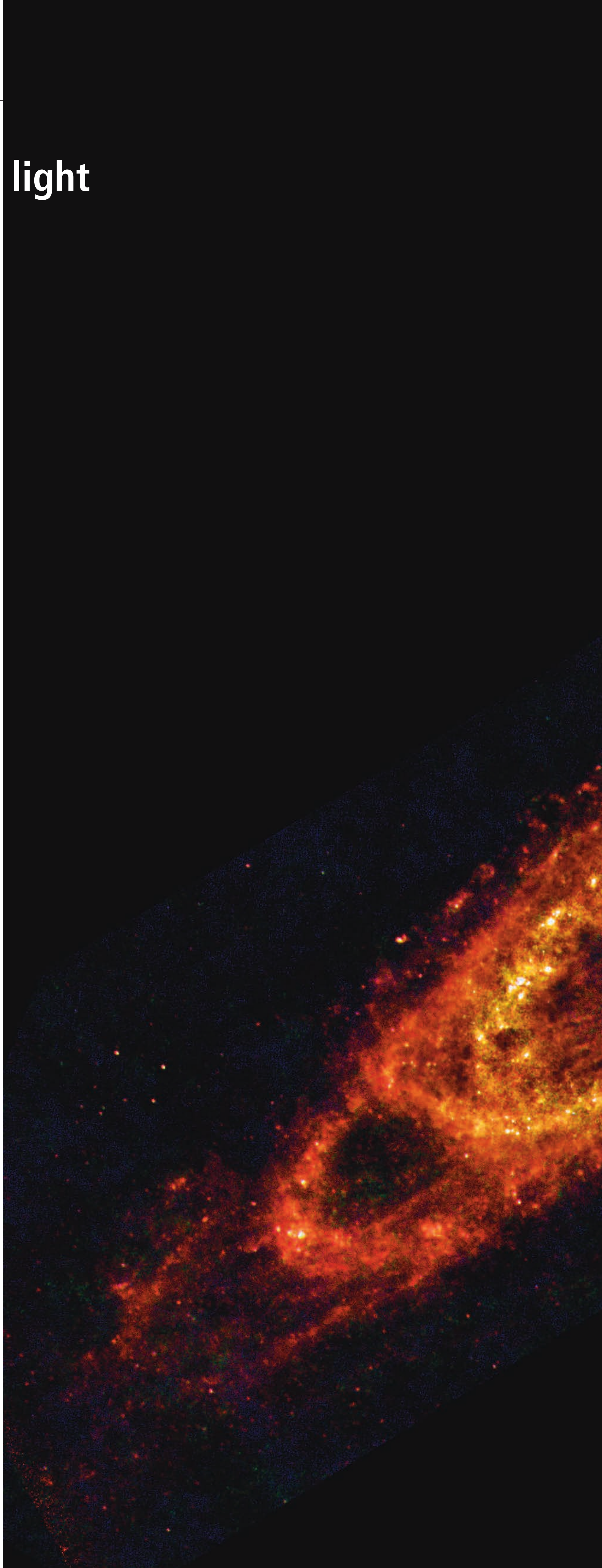
Astrophysical research at the Max Planck Institute for Astronomy (MPIA) is organized within two scientific departments: Planet and Star Formation (PSF) and Galaxies and Cosmology (GC). MPIA scientists design, execute and analyse observing programs and surveys and connect the physical nature of the observed phenomena with theoretical studies and numerical simulations. An important role plays the development and operation of telescopes and their instrumentation. Here, MPIA is taking a leading role in both ground-based and space-based instrumentation with focus on optical and infrared spectral regions, adaptive optics and interferometry.

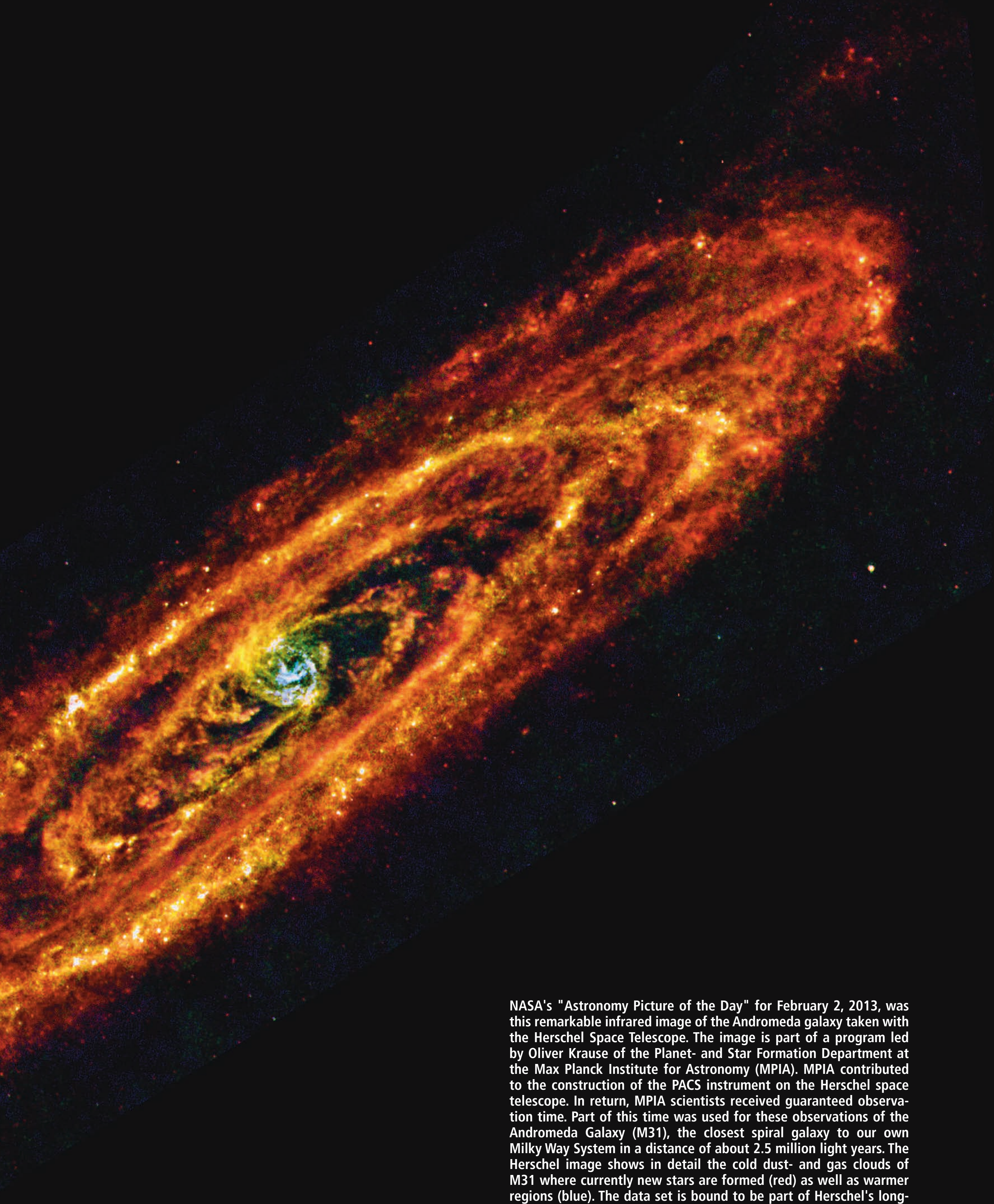
The main research fields of the two departments are complementary in both scientific and practical terms. Obviously, star formation is a critical aspect of the formation and evolution of galaxies, and the instrumentation capabilities required by both departments share strong commonalities: e.g. requirements for high spatial resolution, powerful survey capabilities, and the importance of access to the infrared and millimeter spectral regions.

Some selected facts from today and the past…

- MPIA was founded in 1969. Since then, MPIA has a prominent and successful tradition of de-veloping and building instruments for ground-based and space-based astronomical observations to support the main focus of MPIA: independent research regarding the formation and evolution of planets, stars, galaxies and the universe as a whole.
- During the 1970s and 1980s the construction of the Calar Alto Observatory had been an important focus of the MPIA. Since 2004 the observatory is jointly operated as Centro Astronomico Hispano Aleman (Caha) by the Max Planck Society, represented by the MPIA, and the Consejo Superior de Investigaciones Científicas (CSIC), represented by the Instituto de Astrofísica de Andalucía (IAA), as an organization of Spanish law.
- MPIA also uses its 2.2 m telescope in operation since 1984 at the European Southern Observatory (Eso) at La Silla in Chile.
- Since 1997, MPIA has been the coordinating insti¬tute for the German participation in the Large Binocular Telescope (LBT) on Mt. Graham near Tucson, Arizona. LBT is the largest single telescope in the world and has two 8.4 m – mirrors on a single mount.
- The construction and implementation of Isophot aboard Iso, the first Infrared Space Observatory of the European Space Agency Esa, was led by MPIA. The knowledge gained with Iso was the basis for MPIA's prominent role in current space projects such as Herschel and JWST.
- In 2003, MPIAs interferometric instrument MIDI started its successful operation at the ESO-Very Large Telescope. MIDI is the precursor of MATISSE which is currently under development.
- In 2007, MPIA became the University of Hawaii's largest Partner in the international Pan-Starrs1 (PS1) project.
- In 2009, the HERSCHEL Space Telescope was launched successfully with an Ariane 5 rocket..
- In 2013, MPIA hosted five Independent Research Groups (two Emmy Noether groups supported by the German Science Foundation DFG, and two groups supported by the Max Planck Society, MPS, and one group supported by the MPS and the Humboldt Foundation). By the end of the year, a staff of 310 colleagues was employed at MPIA (including externally funded positions). This includes 209 scientists, of which 67 were junior and visiting scientists, and 59 were PhD students.

Andromeda in a new light





NASA's "Astronomy Picture of the Day" for February 2, 2013, was this remarkable infrared image of the Andromeda galaxy taken with the Herschel Space Telescope. The image is part of a program led by Oliver Krause of the Planet- and Star Formation Department at the Max Planck Institute for Astronomy (MPIA). MPIA contributed to the construction of the PACS instrument on the Herschel space telescope. In return, MPIA scientists received guaranteed observation time. Part of this time was used for these observations of the Andromeda Galaxy (M31), the closest spiral galaxy to our own Milky Way System in a distance of about 2.5 million light years. The Herschel image shows in detail the cold dust- and gas clouds of M31 where currently new stars are formed (red) as well as warmer regions (blue). The data set is bound to be part of Herschel's long-term legacy – 20 years from now, astronomers may still be using it in their analyses.

Credit: ESA / Herschel / PACS & SPIRE Consortium, O. Krause, HSC, H. Linz

I.2 Planet- and Star Formation – The PSF Department

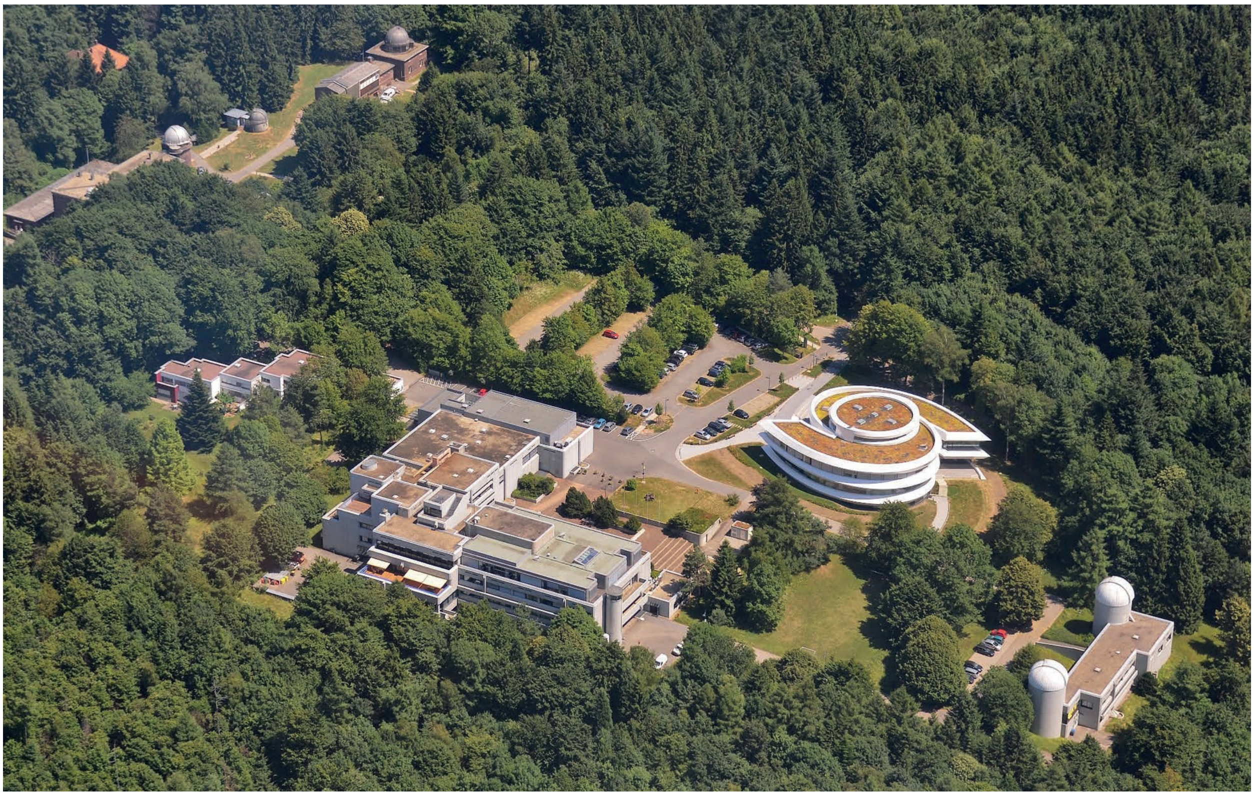
The link between stars and galaxies

The formation of stars is a fundamental process in the Universe, shaping the structure of entire galaxies and determining their chemical state. The formation of individual stars can be best studied in nearby molecular clouds (see Fig.I.2.2). The study of star formation in other galaxies allows us to understand this process under physical conditions which can be very different from those in the Milky Way. Our studies of star formation in the Magellanic Clouds allow an investigation of the effect of metallicity on the star formation process, which is certainly an important factor in understanding star formation in the early Universe. Stars are born in the dense and cold cores of molecular clouds, which become gravitationally unstable and, in general, fragment to form even binaries and multiple stellar systems. The role of magnetic fields or turbulence in controlling the onset of star formation remains one of the open key questions which is immediately related to the shape of the initial (sub-)stellar mass function in different environments. Dynamical interactions in multiple systems may be a crucial factor for the formation of Brown Dwarfs. Massive star formation takes place in clusters, leading to complex star-forming regions. The rapid evolution of massive protostars and the associated energetic phenomena provide an enormous challenge in identifying the formation path of massive stars.

Looking behind the curtain …

The earliest phases of star formation are obscured by enormous amounts of dust and gas and can only be detected by sensitive far-infrared and (sub-) millimeter observations. At later evolutionary stages, the objects "glow" at near- and mid-infrared wavelengths, and finally become visible at optical wavelengths. Our observing programs cover a wide range of wavelengths with a special emphasis on infrared and (sub-) millimeter observations. The formation of planets and planetary systems is a natural by-product of low-mass star formation. Because of angular momentum conservation, accretion of matter onto the central protostar happens predominantly through a circumstellar disk. Disks around T Tauri stars are the natural birthplaces of planetary systems, resembling the solar nebula 4.5Gyr ago. During the active accretion phase, bipolar molecular outflows and ionized jets are produced, which in turn play an important role in the evolution of star-disk systems. We are now using protoplanetary disks as laboratories for understanding the formation of our own solar system and the diversity of

Fig. I.2.1: Aerial view of the MPIA campus with the main building (left of center), the "Haus der Astronomie" HdA with its spiral shape and the two telescope domes of the "Elsässer Laboratory".



Credit: Sebastian Egner

other planetary systems detected so far. The research of the Planet and Star Formation department is focused on the understanding of the earliest phases of stars, in both the low and high stellar mass regime. Observations with space observatories such as Spitzer, HST and Herschel, as well as ground-based infrared and (sub-) millimeter telescopes, allow the detection and characterization of massive protostars and their subsequent evolution. The vigorous use of submillimeter facilities has also prepared the department for observations with the new Atacama Large Millimeter Array (ALMA).

The investigation of Brown Dwarfs, which were first detected in 1995, is another important research topic. How do Brown Dwarfs form? Are young substellar objects also surrounded by disks? What is the binarity fraction and the exact mass of these objects? What is the composition of their atmoSPHEREs? These are among the burning questions which are attacked by MPIA scientists.

The formation of planetary systems and the search for other planets

With the detection of the first extrasolar planets, the study of planet formation in protoplanetary disks entered a new phase. The department is well-positioned

Fig. I.2.2: JHK color-composite image of the galactic star formation region W3Main taken with the LUCI-I-instrument at the Large Binocular Telescope (LBT). With such observations at near-infrared wavelengths astronomers are able to reveal details about the processes of star formation occurring deep within molecular clouds.

Credit: MPIA / A. Bik

to play an important role in these studies, with a combination of infrared and sub-millimetre observations, numerical (magneto-)hydrodynamical simulations, and radiative transfer studies. Imaging with the Hubble Space Telescope and the wealth of data from the Spitzer Telescope and between 2009 and 2013 from Herschel is providing new insights into the earliest stages of planet formation. Improved spatial resolution from our adaptive optics program, infrared interferometry with large telescopes and long baselines, and the use of millimeter interferometers provide insights into the disk structure and the evolution on spatial scales relevant to planet formation. Gas evolution in disks is studied by high-resolution infrared spectroscopy and the accretion behaviour by multi-object spectroscopy.

We have started new observing programs to search for extrasolar planets through direct imaging, the transit technique, and astrometry. With the Spectral Differential Imaging facility (SDI) at the VLT, we provided a new mode for high-contrast imaging with the adaptive optics instrument NACO. This system presently outperforms any other similar device in the world and was paving the way for the development of Eso's SPHERE instrument, where MPIA is Co-PI institute. The department actively participates in the planet search program SEEDS with the Subaru telescope on Mauna Kea (Hawaii). The theoretical program of the PSF department focuses on complex numerical simulations of protoplanetary disk evolution, including the interplay between radiation, dynamics, chemistry, and grain evolution. The study of the formation of massive stars constitutes another topic for theoretical studies. Multidimensional radiative transfer codes, both for molecular lines and the dust continuum, have been developed in the department. These theoretical studies are also well integrated with the various observational key projects.

The understanding of many of the microphysical processes and the composition of dust and gas requires dedicated laboratory studies. Such a laboratory astrophysics unit is part of the Planet and Star Formation department, and is located at the Institute for Solid-State Physics of the University of Jena. This group investigates the spectroscopic properties of nanoparticles, as well as molecules, especially PAH's, in the gas phase.

Primordial Cosmic Fuel for a Galaxy

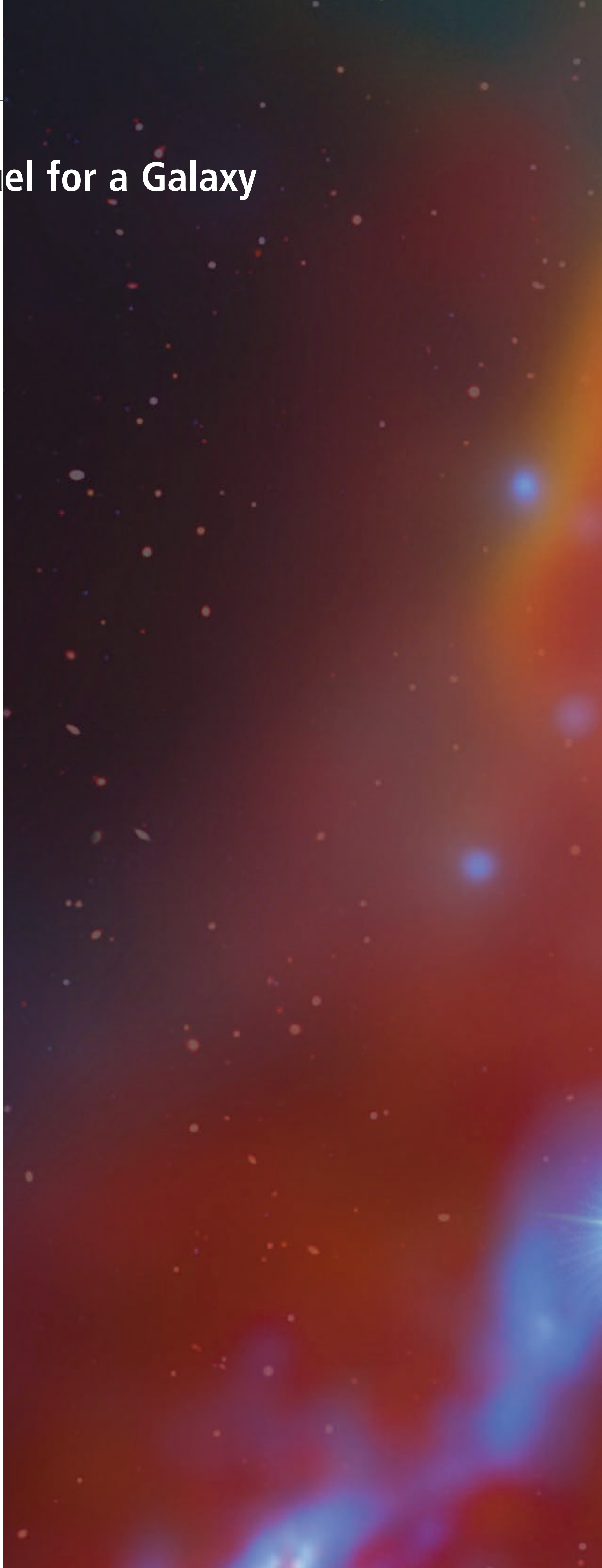


Image of a galaxy (center) with incoming cold gas flow produced by rendering the gas distribution in a supercomputer simulation of a forming galaxy. A stream of primordial inflowing gas is illuminated from behind by a distant background quasar (lower left; quasar added by an artist, along with the starry background). Using data collected from the largest optical telescopes in the world, researchers led by Neil Crighton (MPIA and Swinburne University of Technology) have now made the first unambiguous detection of this accretion of pristine gas onto a star-forming galaxy that was previously theorized to exist based on cosmological simulations of galaxy formation. This simulation shown here was run by the Making Galaxies in a Cosmological Context (MaGICC) project in the theory group of the Galaxies and Cosmology Department at MPIA. For details see also chapter II.8. at page 50.

Credit: MPIA / G. Stinson / A. V. Macciò

I.3 Galaxies and Cosmology – The GC-Department

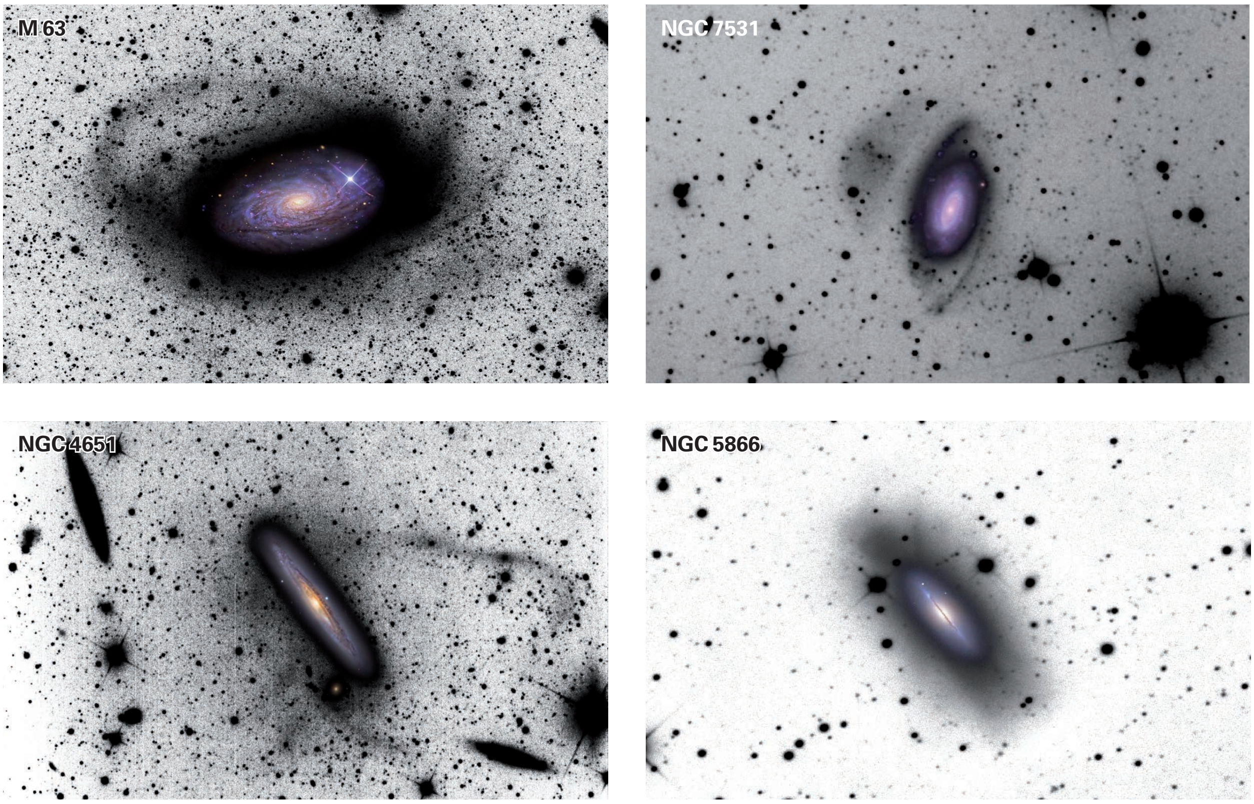
The "Realm of Galaxies"

Shortly after the Big Bang, the Universe was rather "simple" and nearly homogeneous. Now it is beautifully complex, with rich "hierarchical" structure over a wide range of physical scales: from the filamentary distribution of galaxies on large scales (the "cosmic web") to galaxies themselves, down to clusters of stars, individual stars, and their planets. The formation of this wealth of structure appears to be driven by gravitational instabilities, but to make things 'work' these instabilities must arise in good part from a dominant, but yet to be identified, dark matter component.

The galaxies we observe in the present-day universe represent a central layer in this hierarchical order, each consisting of millions to billions of stars, gas, and dust, all embedded in halos of dark matter. As Edwin Hubble already realized 80 years ago, these "island universes" do not show the full variety of morphology (or visual appearance) and structures that seem physically possible. On the one hand, the variety of galaxies seems vast: galaxies as an object class span ten orders of magnitude in their stellar masses, and the rate of new star formation varies similarly; the physical sizes of different galaxies still vary by a factor of 100. While some galaxies apparently do not have a black hole at their centers, in other galaxies this central black hole has the mass of more than one billion suns.

On the other hand, observations have shown, particularly in the last 15 years, that only a small fraction of the possible combinations of the characteristic galactic quantities (stellar masses and ages, size, central black hole, etc.) are actually realized in the universe. Virtually all physical properties strongly correlate with all other properties: massive galaxies are large; massive galaxies contain virtually no young stars; the central black hole contains a constant mass fraction of the spherical star distribution ten million times its size. While spiral galaxies are the most common galaxy type, no such galaxy is among the most massive ones.

Fig. I.3.1: Examples for traces of spirals swallowing dwarf galaxies. For all images, the central part is an ordinary positive image. In the outer regions, the negative of the image is shown. In this way, the faint structures that were target of a special survey are more readily discerned. Wisps, plumes, stellar streams, partially disrupted satellites or stellar cloud indicate that we are witnessing merger processes. Such recurrent merger events during billions of years play an important role for the evolution of galaxies. This side top row: M 63, NGC 7531, bottom row: NGC 4651, NGC 5866. Facing page top row: NGC 1084, NGC 3521, bottom row: NGC 4651, NGC 1055.



Credit: D. Martínez-Delgado (MPIA and IAC), R. Jay Gabany (Blackbird Obs.), K. Crawford (Rancho del Sol Obs.) et al.

This means that the "realm of galaxies", as Hubble called it, shows a high degree of order. How this order developed from the random mass fluctuations existing after the Big Bang is a fundamental question of galaxy formation and a central issue of cosmology.

There are three broad lines of explanation for the limited variety in the zoo of galaxies: Either, observed galaxies represent the only stable configurations. Alternatively, the cosmological initial conditions only permit the formation of the galaxies we see. Or, the overall process of galaxy formation results in a limited set of outcomes because it is very much self-regulating.

What questions would we like to answer?

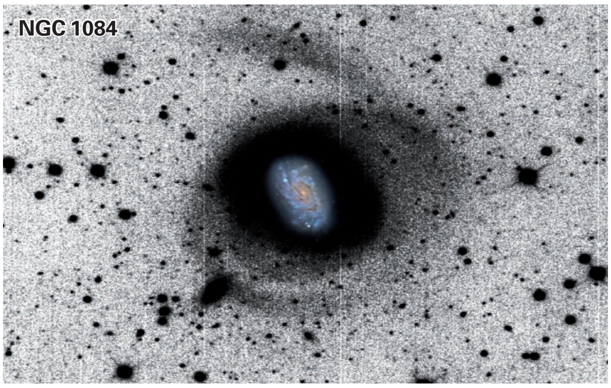
Many of the projects that the MPIA researchers are pursuing ultimately address when and where these three mechanisms play a role. Some of the specific questions being discussed by researchers in this department are:

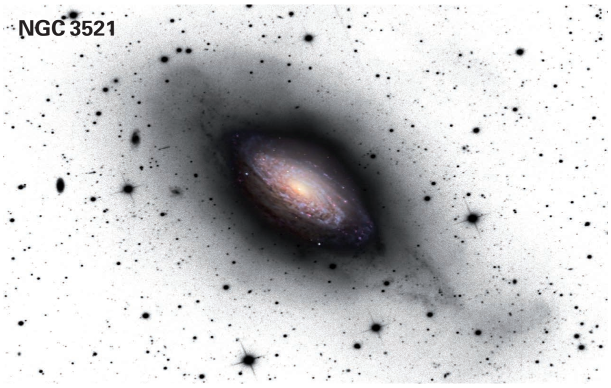
- During which cosmological epoch did most of the stars form?
- Is cosmic star formation now coming to its end? Why has the star formation rate declined over the last six billion years?
- Which galaxies reside in which dark matter halos?
- How did the central black holes in galaxies form and grow?
- Why is it possible to predict the properties of the small-sized central black hole from the overall size of a galaxy?
- Which processes determine the structure and morphology of galaxies and when do these processes occur?
- What is the state of the interstellar medium, the raw material from which new stars form?
- What is the state of the intergalactic medium, in the space between galaxies, where most of the atoms in the univere reside?
- Can the various observations be understood ab initio within a comprehensive model?
- How did the Milky Way, our Rosetta Stone of galaxy evolution, form?

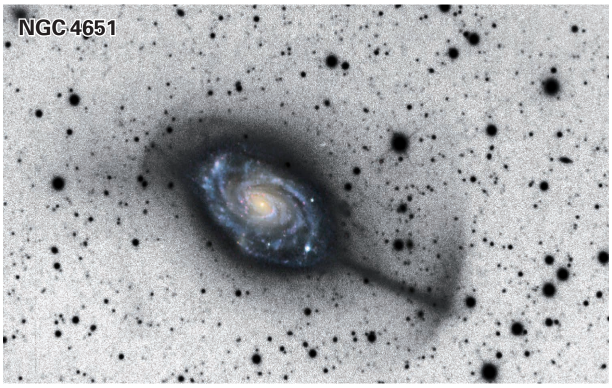
What do we do to find the answers?

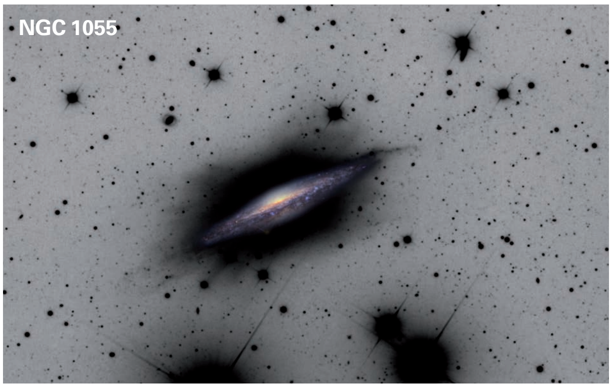
The approaches used at MPIA to tackle these questions comprise three aspects: the detailed study of galaxies in the present-day Universe; the direct study of galaxies at earlier cosmic epochs through the observation of distant (high-redshift) objects; and the comparison of observations with physical models. The observational capabilities for the field require survey telescopes, large telescopes for sheer photon collecting power on faint sources, and particular techniques such as Adaptive Optics and Interferometry to achieve high spatial resolution. Comprehensive studies of galaxy evolution require observations from the X-rays to the radio wavelengths.

The MPIA has been an important partner in several of the surveys that have brought, or promise to bring, break-









throughs in these areas: the PanStarrs-1 survey which has successfully started in 2010; the Sloan Digital Sky Survey (SDSS) and Segue for the Milky Way and Local Group; complemented since 2008 by the LBC cameras at the Large Binocular Telescope (LBT); the 2.2m telescope on La Silla has enabled the Combo-17 galaxy evolution survey; the VLT and the LBT are used to follow-up this survey work; the IRAC and MPIS instruments on the Spitzer Space Telescope; and the PACS Instrument of the Herschel mission to study star formation and the interstellar medium, complemented by the VLA, the Plateau de Bure Interferometer, APEX and ALMA at radio and submillimeter wavelengths. The Galaxies and Cosmology department truly carries out multi-wavelength astrophysics.

I.4 Current Instrumentation for Ground-based Astronomy

The currrent activities of MPIA in the area of ground-based instrumentation concentrate on spectroscopy, high-fidelity imaging, and interferometric instruments for the Eso VLT/VLTI and the LBT, and survey instruments for Calar Alto. MPIA is also involved in studies for future instruments for the European ELT (E-ELT), a planned next generation telescope with a 39m main mirror.

Instrumentation for the Large Binocular Telescope (LBT)

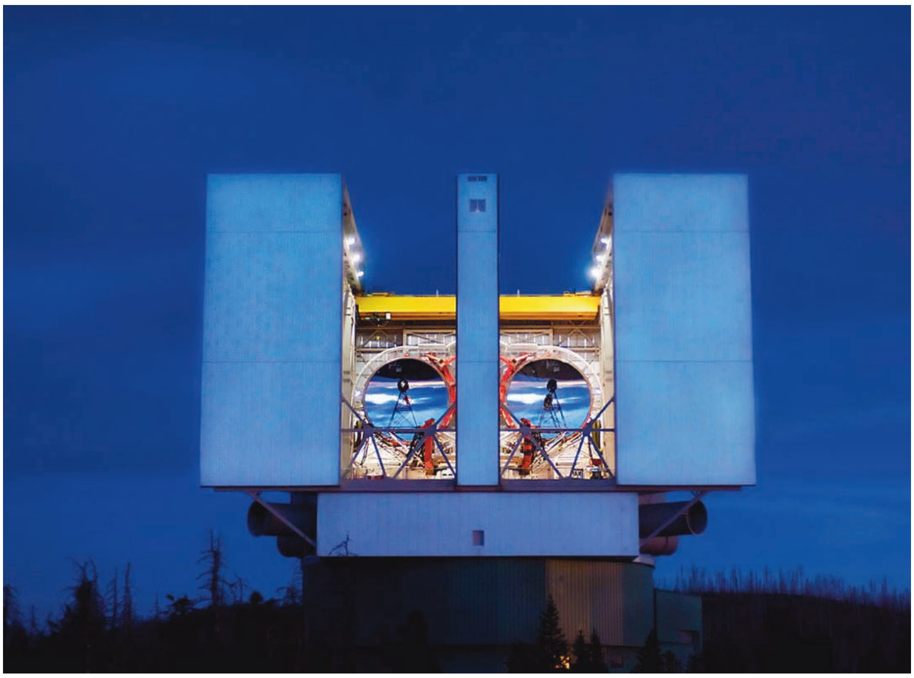
LUCI 1 and LUCI 2 are two near-infrared cryogenic imaging cameras and multi-object spectrographs for the LBT. These instruments were built together with the Landessternwarte Heidelberg, the MPE Garching, the University of Bochum, and the Fachhochschule for Technology and Design in Mannheim. They provide a $4' \times 4'$ field-of-view in seeing limited mode. At the beginning of 2010 the first excellent spectra and images have been published. With the adaptive secondary mirrors, diffraction-limited performance over a field of about $0\overset{\prime}{.}5 \times 0\overset{\prime}{.}5$ is possible. Adaptive optics will also permit users to achieve spectral resolving powers of several tens of thousands. Scientific applications for the multi-mode LUCI instruments are many, including studies of star formation in nearby galaxies.

Since not always reference stars sufficiently suitable for the adaptive optics correction can be found in the field of view of a telescope, a Laser guide star system called ARGOS is currently developed and tested. ARGOS creates artificial reference stars at the night sky (see Chapter III.2 for details).

The by far largest instrumentation project at MPIA is the near-infrared beam combiner Linc-Nirvana (LN), which presently is being assembled and tested at the institute. MPIA leads a consortium with the Italian Observatories (Inaf), the MPIfR Bonn, and the University of Cologne. By coherent combination of the two LBT primary mirrors via Fizeau interferometry and with multi-conjugated adaptive optics in a final increment, LN could provide diffraction-limited imaging over a $10\overset{\prime\prime}{.}5 \times 10\overset{\prime\prime}{.}5$ field of view in the 1–2.4 µm regime, with the spatial resolution of a 23 m telescope. Scientific applications range from supernova cosmology, galaxy formation, and extragalactic stellar populations and star formation, to extrasolar planets, stellar multiplicity, the structure of circumstellar disks, and the imaging of solar-system planets and their atmoSPHEREs.

In order to prepare for the final implementation of the complex instrument the test system PATHFINDER was developed and successfully mounted at the LBT in 2013. For details on PATHFINDER see chapter III.2.

Fig. I.4.1: The Large Binocular Telescope (LBT) at Mount Graham in Arizona (USA). With its two 8.4m mirrors on a single mount, the LBT is currently the largest single telescope in the world with a total light gathering power of a 12m telescope.



Credit: LBTO

Instrumentation for ESO's VLT/VLTI

In September 2008, the differential delay lines for the dual-feed VLTI system PRIMA were installed on Cerro Paranal, Chile. PRIMA was built by MPIA together with Geneva Observatory and the Landessternwarte Heidelberg. In the related science project ESPRI, the differential delay lines will be used in the combined K-band light with two 1.8m VLT Auxiliary Telescopes, in order to measure the separation of targets with micro-arcsecond precision. The goal is the dynamical determination of the masses of extrasolar planets by precise astrometric measurements of the orbital reflex-motions of planetary host stars.

MPIA is participating in the second-generation VLTI projects MATISSE and GRAVITY. The MATISSE consortium consists of nine institutes led by the Observatoire de la Côte d'Azur. MATISSE will combine the light from all four VLT 8.2 m telescopes in the mid-infrared for high spatial resolution image reconstruction on angular scales of 10–20 milliarcseconds. The scientific applications range from studies of Active Galactic Nuclei (AGN) to the formation of planetary systems and of massive stars, and the study of circumstellar environments.

GRAVITY will also combine the light of the four VLT 8.2 m telescopes, but in the near-infrared. The GRAVITY consortium is led by MPE Garching; the partners include MPIA, l'Observatoire de Paris, and the University of Cologne. Assisted by a high-performance adaptive optics system, GRAVITY will provide precision narrow-angle astrometry and phase referenced imaging of faint objects over a field of view of 2″. Applications are the study of motions close to the massive black hole in the galactic center, the direct detection of intermediate mass black holes in the Galaxy, dynamical mass determinations of extrasolar planets, the origin of protostellar jets, and the imaging of stars and gas in obscured regions of AGNs, star forming regions, or protoplanetary disks.

As Co-PI institute in a consortium with the Laboratoire d'Astrophysique de l'Observatoire in Grenoble, the Laboratoire d'Astrophysique in Marseille, ETH Zürich and the University of Amsterdam, the MPIA coleads the development of SPHERE, a VLT instrument specialized for the imaging of Jupiter-like extrasolar planets. To overcome the huge brightness contrast between the planet and its host star, SPHERE will use eXtreme Adaptive Optics (XAO), coronography, and three differential imaging-capable focal plane subinstruments that will, respectively, employ polarimetry in the visual, dual imagery in the near-infrared, and integral field J-band spectroscopy.

Survey instrumentation for Calar Alto (CAHA) and other Observatories

The Panoramic Near-infrared Camera (PANIC) is a wide-field general purpose instrument for the CAHA 2.2 m telescope and a joint development of the MPIA and the Instituto de Astrofísica de Andalucía. With four Hawaii2-RG detectors, it will provide a field of view of 30′ × 30′ allowing surveys of extragalactic, galactic, and solar system objects. PANIC will have First Light in fall 2014.

CARMENES, however, is a high-resolution near-infrared and optical Échelle Spectrograph currently be-

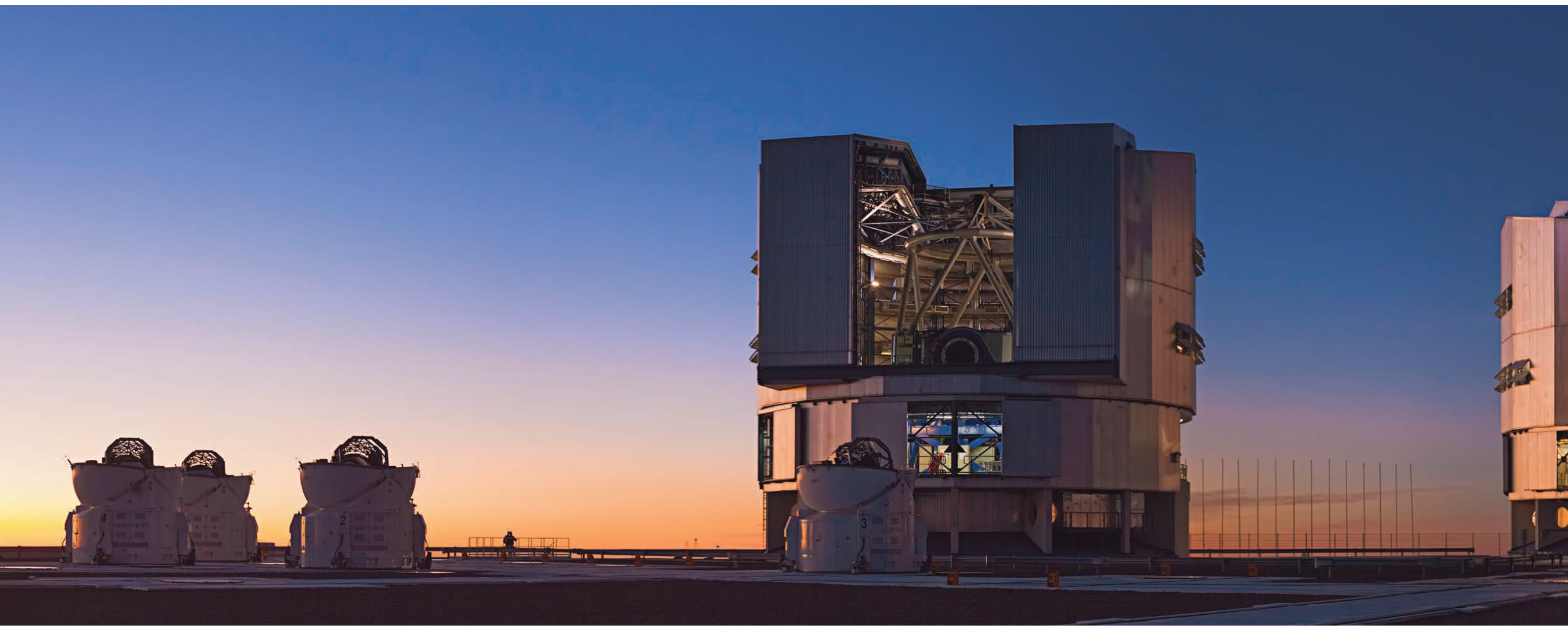


Fig. I.4.2: Panoramic view of the ESO Paranal Observatory in Chile. The large buildings are hosting the four Unit-Telescopes of the VLT – each with an 8.2m primary mirror. To the left the smaller buildings of the movable 1.8-metre Auxiliary Telescopes.

ing built for the CAHA 3.5 m telescope by a consortium of German and Spanish institutions. It aims to survey ~ 300 late type main-sequence stars to find Exoplanets in their habitable zones.

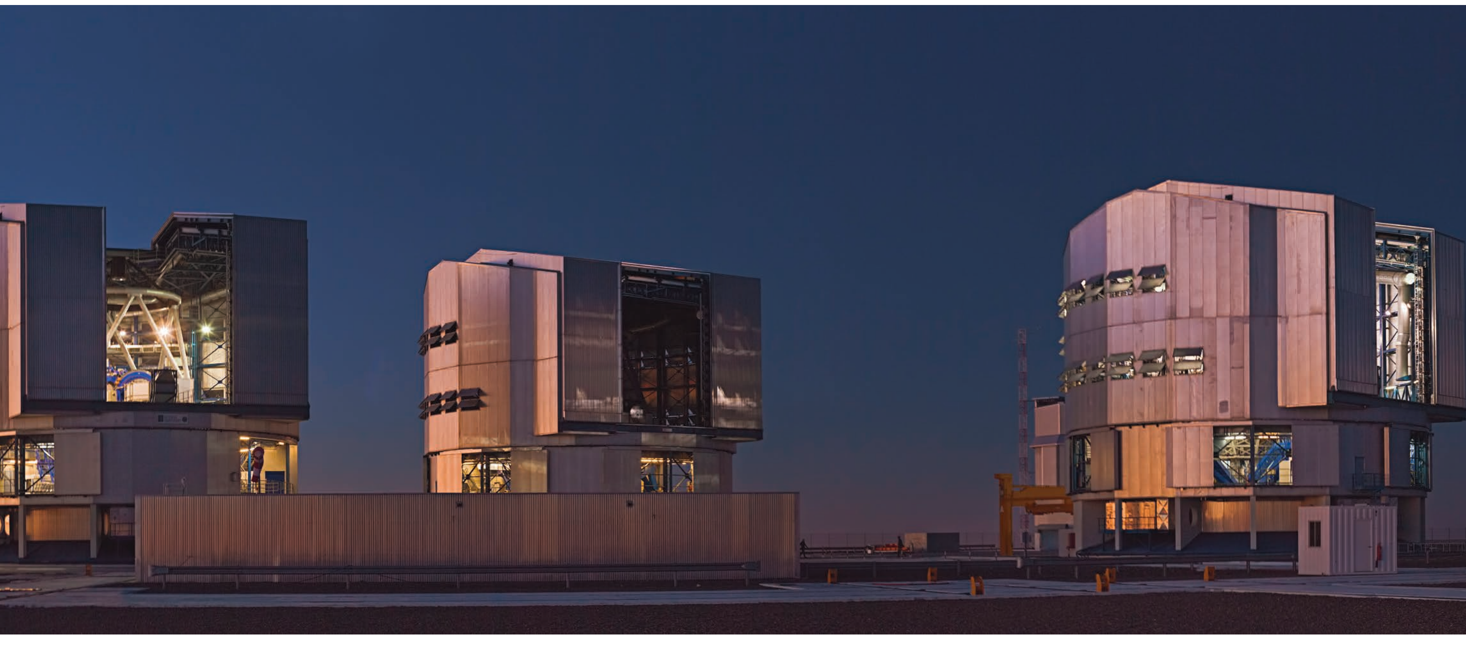
The search for transiting extrasolar planets by surveying a large number of nearby stars is the goal of the Hat-South project, a collaboration between Harvard, the Australian National University, and MPIA. HAT-South is a network of 24 small-sized automated telescopes located at Las Campanas in Chile, Siding Springs in Australia, and at the H.E.S.S. site in Namibia. MPIA is responsible for the site preparation and operations of the Namibian node.

Furthermore, MPIA scientists still use the ESO/MPG 2.2 m Telescope at La Silla, e.g. for special survey work.

MPIA and the future European Extremely Large Telescope – E-ELT

In 2010, an Eso commission led by MPIA already finished the search for the site of the planned 39 m E-ELT. It will be the mountain Cerro Armazones in Chile's Atacama Desert. MPIA has already participated in two studies for instruments: METIS and MICADO. METIS is a thermal/mid-infrared imager and spectrograph covering a wavelength range from 3–14 microns. Adaptive optics will permit diffraction-limited observations. Science cases are conditions in the early solar system, formation and evolution of protoplanetary disks, studies of the galactic center and of the luminous centers of nearby galaxies, high-redshift AGNs and high-redshift gamma ray bursts.

MICADO is a near-infrared imaging camera with multi-conjugated adaptive optics that will provide a spatial resolution exceeding that of the James Webb Space Telescope (JWST) by a factor of 6 to 7. It will have a sensitivity down to 29mag in bandpasses from I to K. Applications range from young stellar objects in our galaxy to star formation in high-redshift galaxies. High astrometric precision will further advance studies of stellar orbits around the black hole in the galactic center, of the proper motions of globular clusters, the structure, the stellar populations, and the interstellar dust distribution in galaxies with redshifts $z < 1$.



Credit: ESO / B. Tafreshi (twanight.org)

I.5 Current Instrumentation for Space-based Astronomy

HERSCHEL and JWST

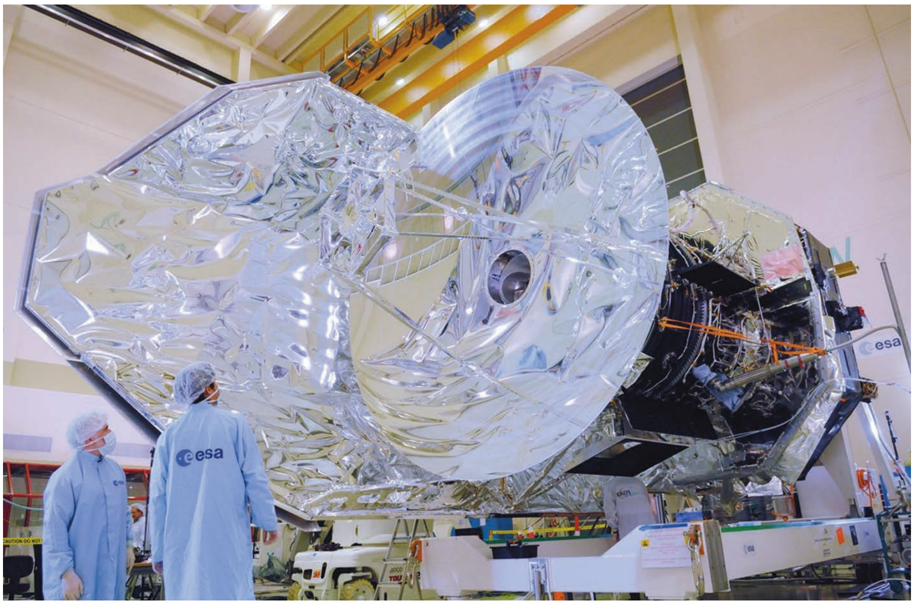
Europe's far infrared and submillimetre space observatory Herschel has finished its very successful four year long mission in April 2013. MPIA has been one of the four major partners in the development of the PACS instrument (PI institute: MPE in Garching). which enables imaging and spectroscopy in the wavelength range from 60 to 210 mm with unprecedented sensitivity and spatial resolution. MPIA was responsible for delivering the PACS focal plane chopper, for characterizing the spectrometer cameras and their –270 °C readout electronics. The institute coordinated a large number of tasks for the calibration of the instrument and has been responsible for establishing the PACS performance verification phase plan and the central PACS calibration document. In particular, the MPIA team has exclusively carried out the detailed mission planning of all PACS performance verification phase operational days, utilizing dedicated software tools, and has delivered the observational data bases to the Herschel Science Center at ESAC in Villafranca (Spain) and the Mission Operations Center at ESOC in Darmstadt (Germany). The MPIA team had build up also a corresponding calibration plan for Herschel's routine phase and also ensured the optimum inflight setup of the Ge:Ga spectrometer detector arrays following a procedure developed MPIAs space laboratory.

MPIA is the leading institute in Germany for the development of instrumentation for the James Webb Space Telescope which will be launched in this decade as the successor to the Hubble Space Telescope. JWST will be equipped with a folding 6.5 meter primary mirror and four science instruments. As a member of a European consortium, MPIA is responsible for the development of the cryogenic wheel mechanisms required for precise and reliable positioning of the optical components in JWST's mid-infrared instrument MIRI and is also leading the electrical system engineering of this instrument. MIRI consists of a high-resolution imager and a medium resolution spectrometer and will work in the wavelength range from 5 to 28 micron.

In 2009 the flight model of the filter wheel mechanism was delivered for integration into MIRIs imager section. MIRI is now the first completed JWST science instrument after passing all acceptance tests and is currently being integrated into the Integrated Science Instrument Module at Goddard Space Flight Centre.

MPIA also provides critical components for the second JWST instrument mainly developed in Europe, the near-infrared multi-object spectrograph NirSpec This contribution, as well as our participation in the NirSpec science team, will provide the astronomers at MPIA with further excellent opportunities for powerful infrared observations. For the development of the precision optics of MIRI and NirSpec, MPIA has closely co-operated with Carl Zeiss Optronics, Oberkochen, and Astrium GmbH, Ottobrunn and Friedrichshafen. With the end of 2010, all tasks regarding the cryogenic mechanisms were successfully finished and they were integrated into MIRI and NirSpec.

Fig. I.5.1: The HERSCHEL Space Observatory in 2009 before launch.



Credit: ESA

EUCLID and SPICA – Future Missions within the Esa Cosmic Vision Program

EUCLID has the goal of mapping the geometry of the "dark Universe" by studying the distance-redshift relationship and the evolution of cosmic structures. To this end, the shapes and redshifts of galaxies and galaxy clusters will be measured out to redshifts $z \sim 2$, that is, to a look-back time of 10 billion years, thereby covering the entire period over which Dark Energy played a significant role in accelerating the expansion of the Universe. The observ-ing strategy of EUCLID will be based on baryonic acoustic oscillations measurements and weak gravitational lens-ing, two complementary methods to probe dark energy. The EUCLID survey will produce 20 000 square degrees visible and near-infrared images of the extragalactic sky at a spatial resolution of 0.030 arcsec. It will also yield medium resolution ($R = 400$) spectra of about a third of all galaxies brighter than 22 mag in the same survey area. During October 2011, EUCLID was selected as one of two missions to be carried out. A possible launch date could be 2017 or 2018.

SPICA, the Space Infrared Telescope for Cosmology and Astrophysics, is another astronomy mission of Esa's Cosmic Vision in which MPIA is participating in the study phase. The mission is planned to be the next space astronomy mission after Herschel observing in the far infrared (launch probably in 2019). It will feature a cold 3.2m telescope providing up two orders of magnitude sensitivity advantage, mostly for spectroscopic observations, over existing far-infrared facilities. SPICA is led by the Japanese Space Agency Jaxa. Europe has proposed to participate with the far infrared instrument SAFARI, the telescope mirror, and support of the ground segment.

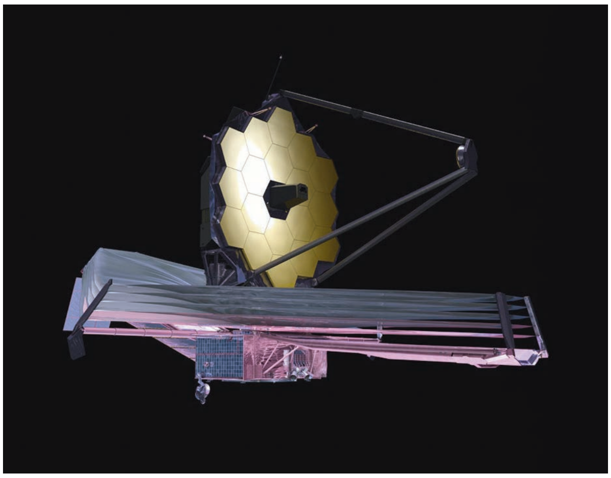
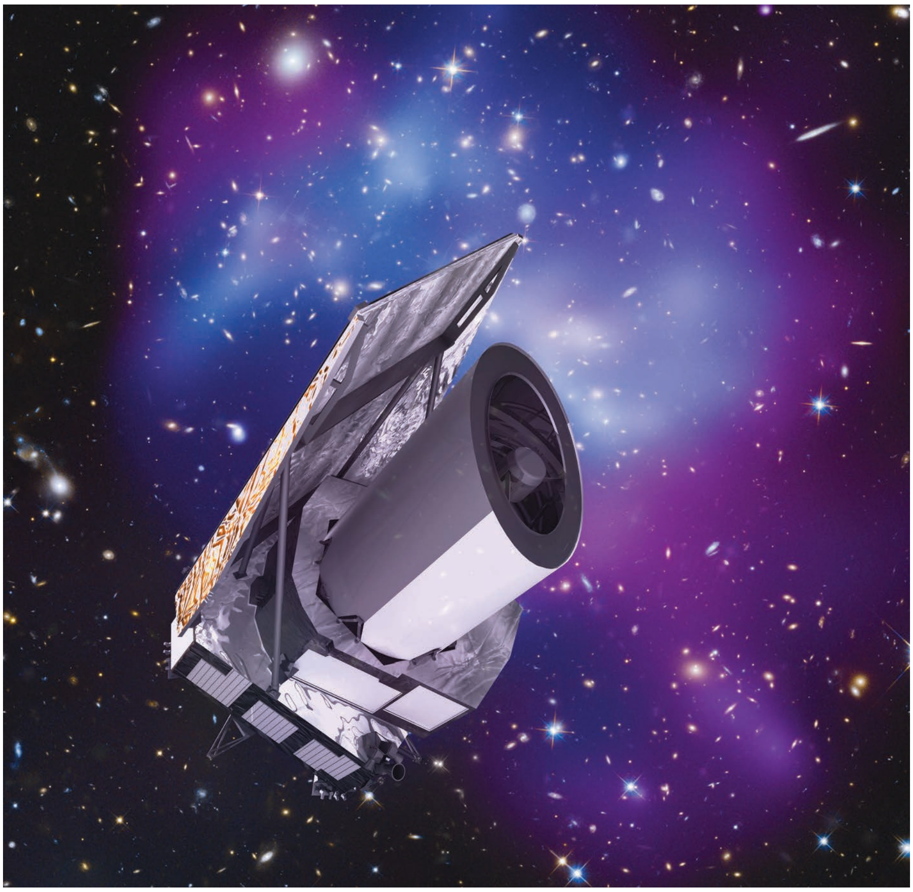

Credit: NASA

Fig. I.5.2: The James Webb Space Observatory with its 6.5m main mirror (yellow structure).

Fig. I.5.3: Computer rendering of EUCLID.


Credit: ESA

I.6 Further National and International Collaborations

Today, science – and instrumentation projects are often too large and expensive to be carried out by a single group or institute. MPIA is therefore participating in or even leading a number of national and international collaborations. One typical example is the Herschel Space Observatory project (see section I.5), where MPIA is the largest Co-I institute in the PACS instrument consortium, which consists of partners from 6 European countries. Additionally, the institute leads two Herschel guaranteed Time Key Programs on "The earliest phases of star formation" and "The Dusty Young Universe: Photometry and Spectroscopy of Quasars at z < 2" and participates in nine other Herschel Open and Guaranteed Time Key Programs. All these observing programs are also large international collaborations.

MPIA is strategically well-placed: Heidelberg has become one of Germany's foremost centers of astronomical research. Cooperation with the High-energy Astrophysics Department of the MPI for Nuclear Physics (MPIK), the new Heidelberg Institute for Theoretical Studies (HITS), and with the three university institutes of the Center for Astronomy Heidelberg (ZAH) is manifold. Also, the "International Max Planck Research School" for Astronomy and Cosmic Physics (IMPRS, see Section I.7) is run jointly by the Max Planck Institutes and the University. Nationally, MPIA has extensive cooperations with the MPI for Extraterrestrial Physics in Garching and the MPI for Radio Astronomy in Bonn, as well as with numerous other German institutes.

SDSS, PanStarrs1 and GAIA

SDSS, the Sloan Digital Sky Survey, has revolutionized wide-field surveying at optical wavelengths. It is the most extensive imaging and spectroscopy sky survey to date, imaging about a quarter of the entire sky in five filters. The final catalogue provides positions, magnitudes, and colors of an estimated one hundred million celestial objects as well as redshifts of about one million galaxies and quasars. Observations are made with a 2.5 m telescope specially built for this purpose at Apache Point Observatory, New Mexico. The MPIA was the first of what is now twelve European partner institutes in SDSS and the only one to participate since the inception of surveying. In exchange for material and financial contributions to the SDSS, a team of scientists at the MPIA receives full access to the data. In 2005, the "original" SDSS was completed, and an extension, SDSS-II/Segue, focusing on Milky Way structure, was completed in mid 2008. Currently runs SDSS III and SDSS IV will start in 2014.

MPIA is also a partner in Pan-Starrs1 (PS1), the most ambitious sky survey project since the SDSS, as part of the Pan-Starrs1 Science Consortium (PS1SC). It is an international collaboration, involving the University of Hawaii, the MPE, Johns Hopkins University, the Harvard-Smithsonian Center for Astrophysics/Las Cumbres Observatory Global Telescope, the Universities of Durham, Edinburgh and Belfast, and Taiwan's National Central University.

Since 2009, PS1 uses a dedicated 1.8m telescope and a record-breaking 1.4 Gigapixel Camera with a 7-square-degree field of view to carry out multiple time-domain imaging surveys in its g, r, i, z, y filter set: the "3pi" survey of all of the sky visible from its location on Haleakala (Hawaii), a medium-deep supernova survey, as well as a dedicated survey of the Andromeda galaxy and a search for transiting planets. Including this planet search, MPIA scientists are leading four out of twelve key science projects within PS1SC, covering in addition the search for the most distant quasars and the coolest stars, as well as a comprehensive study of the Local Group's structure.

The Institute is also leading a major data analysis aspect of Esa's GAIA project, a space observatory successfully launched in December 2013. GAIA is the successor to the Hipparcos astrometry satellite, exceeding the latter's sensitivity by several orders of magnitude. The satellite measures positions, magnitudes, and radial velocities of one billion stars, in addition to numerous galaxies, quasars and asteroids. GAIA will provide photometric data in 15 spectral bands as well as spectra. Unlike Hipparcos, GAIA does not need to be provided with an input catalogue, but will measure systematically all accessible objects. Automatic object classification will thus be of major importance for data analysis. Concepts for coping with this demanding task are being developed at the MPIA (supported by a grant from DLR).

EU-Networks and other examples of national and worldwide collaborations

The MPIA is participating in a number of other national and worldwide collaborations and initiatives, in part as project leader. These include:

FRINGE – Frontiers of Interferometry in Germany. This German Center for Interferometry is located at MPIA and emphasizes the Institute's prominent role in Germany in this innovative astronomical technique. The goal is to coordinate efforts and interests of the German astronomical community in this field with respect to the European Interferometric Initiative – including the development next generation interferometric instruments such as MATISSE and GRAVITY. The long-term perspective is to establish a European interferometric center for the optical and infrared wavelength region. Besides MPIA, institutes in Potsdam, Jena, Freiburg, Garching, Bonn, Hamburg, Cologne, Kiel and Munich belong to FRInGE.

OPTICON is a network of all operators of major telescopes in Europe, financed by the European Union. Its main goal is to optimize use and development of scientific technical infrastructure, in order to increase scientific results and reduce costs.

ESPRI – Exoplanet Search with Prima – aims at carrying out the first systematic astrometric planet search with a measurement accuracy of 10 – 20 micro-arcseconds. For this purpose, differential delay lines for the Prima facility at the VLTI. were built and the astrometric data reduction software was developed (in collaboration with Eso, ZAH/Landessternwarte Heidelberg, Geneva Observatory).

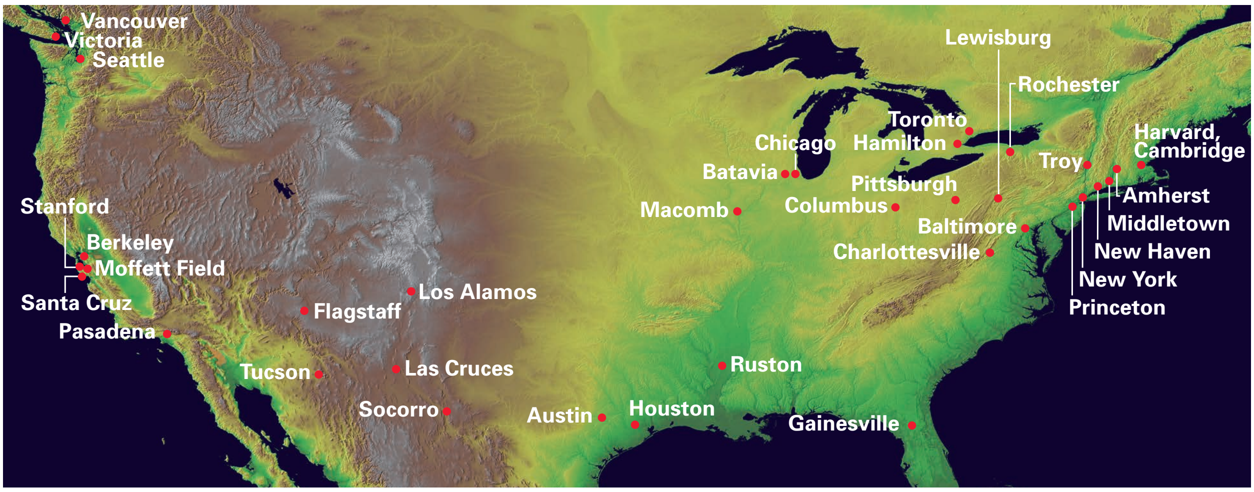
CID: The "Chemistry In Disks" project is a joint collaboration with Bordeaux, Jena and Iram (Grenoble). To study the physical structure and chemical composition of protoplanetary disks at various evolutionary stages by observing bright protoplanetary disks orbiting low-mass (T-Tauri) and intermediate-mass (Herbig Ae) stars with the Plateau de Bure interferometer and the Iram30m antenna.

SEEDS – an imaging survey to search for giant planets and protoplanetary/debris disks around 500 nearby stars using the Subaru telescope at Mauna Kea – in a collaboration between NAOJ, Princeton and MPIA.

Sisco – Spectroscopic and Imaging Surveys for Cosmology – is an EU network dedicated to the study of galaxy evolution with the help of sky surveys. The Institute has made pivotal contributions to this network through Cadis, Combo-17, and the Gems surveys.

Elixir, an EU network dedicated to exploit the unprecedented capabilities of the NirSpec instrument on the JWST space mission.

Fig. I.6.1: Position of MPIA's international partner institutes outside of Europe. In addition, the MPIA has more than 50 international partner institutes in European countries (not shown).



Credit: NASA "Blue Marble" / MPIA

Credit: NASA "Blue Marble" / MPIA

I.7 Education and Outreach

Training the next generation of scientists and communicating astronomy to the public has a long-standing tradition on the Königstuhl. The "Haus der Astronomie" (HdA), our center for education and public outreach erected on the Campus of the MPIA during 2011 amplifies and strengthen the efforts of all Heidelberg astronomers directed to this goal.

Students come from all over the world to the MPIA to carry out research for their master or doctoral thesis. A majority of these students are formally enrolled at the University of Heidelberg. In turn, a number of scientists at the MPIA have adjunct faculty status at the University.

The institute offers advanced practical courses or "mini research projects" for undergraduate students. These practical courses offer the students an early, practically oriented insight into astrophysical research and are an excellent preparatory step for a later thesis.

The International Max Planck Research School (IMPRS) for Astronomy and Cosmic Physics, which was established by the Max Planck Society and the University of Heidelberg, started in 2005, and offers PhD students from all over the world a three-years education under excellent conditions in experimental and theoretical research in the field of astronomy and cosmic physics. It is supported by the five astronomical research institutes in Heidelberg.

The institute's mission also includes educating and informing the general public about astronomical research. Members of the institute give talks at schools, education centers and planetaria. They also appear at press conferences or on radio and television programs, in particular on the occasion of astronomical events that attract major public attention. Numerous groups of visitors come to the MPIA on the Königstuhl and even thousands of visitors to our open house events. Our "Public Lectures on Sunday Morning" started in 2006, always lead to a sold-out auditorium at MPIA and now at the HdA. Also the one week long practical course offered to interested schoolchildren is always immediately booked out. And yearly, MPIA participates in the Girls' Day, an annual nationwide campaign intended to encourage schoolgirls to learn about professions that are still mainly male-dominated.

For decades, the monthly magazine "Sterne und Weltraum" (Stars and Space, SuW of the Spektrum-Verlag) is published at the MPIA. This journal is intended for the general public and offers a lively forum both for professional and amateur astronomers. A significant fraction of the readers are teachers and pupils. Together with SuW, didactic material is produced monthly within our successful project "Science to schools!", which helps teachers to treat interesting topics of current astronomical research during regular classes in physics and natural sciences. The project was sponsored by the Klaus Tschira Foundation from 2005 to 2009, and is now continued in the HdA. The didactic material is made freely available through the web and is widely used in german-speaking countries.

Credit: MPIA / A. M. Quetz

Fig. I.7.1: The "Haus der Astronomie" on the Campus of the MPIA is our center for education and public outreach. It was erected in 2011. From above, the building resembles the spiral galaxy Messier 51.

In the HdA, the educational and public outreach activities of astronomers in Heidelberg are concentrated and developed further. Information for the media and the general public, the development of didactic material, simulations and visualizations, and the training of university students and teachers play a major role. Furthermore, the HdA supports contacts and communication between scientists. The Klaus Tschira Foundation has financed the building and its technical equipment, and the Max Planck Society is operating the facility. In addition, the City of Heidelberg, the State of Baden-Württemberg, and the University of Heidelberg are contributing to the personnel costs, and the astronomers at MPIA and at the University's Center for Astronomy will also bring in activities related to public and educational outreach. During 2009, the center's core team was assembled and construction work was started. At the end of 2010, the basic structure of the building, including the planetarium dome was finished. And only one year later, in December 2011, we celebrated the inauguration of the "Haus der Astronomie" (see Chapter IV.3).

II. Scientific Highlights

II.1 TW Hydrae: There's more to astronomers' favorite planetary nursery than previously thought

Pay-off for a scientific gamble: Unusual measurement with the Herschel Space Observatory shows that astronomers' favourite planetary nursery contains much more matter than previously thought.

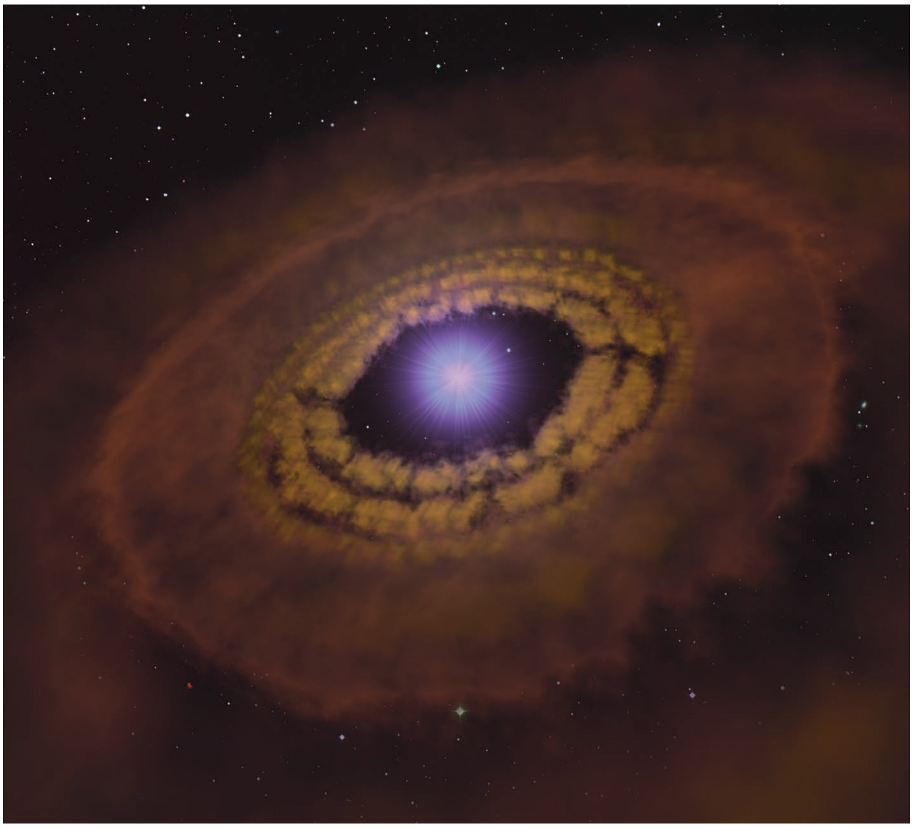
Where Egyptologists have their Rosetta Stone and geneticists their Drosophila fruit flies, astronomers studying planet formation have TW Hydrae: A readily accessible sample object with the potential to provide foundations for an entire area of study. TW Hydrae is a young star with about the same mass as the Sun. It is surrounded by a protoplanetary disk: a disk of dense gas and dust in which small grains of ice and dust clump to form larger objects and, eventually, into planets. This is how our Solar System came into being more than 4 billion years ago.

What is special about the TW Hydrae disk is its proximity to Earth: at a distance of 176 light-years from Earth, this disk is two-and-a-half times closer to us than the next nearest specimens, giving astronomers an unparalleled view of this highly interesting object – if only figuratively, because the disk is too small to show up on an image; its presence and properties can only be deduced by comparing light received from the system at different wavelengths (that is, the object's spectrum) with the prediction of models.

In consequence, TW Hydrae has one of the most frequently observed protoplanetary disks of all, and its observations are a key to testing current models of planet formation. That's why it was especially vexing that one of the fundamental parameters of the disk had remained fairly uncertain: The total mass of the molecular hydrogen gas contained within the disk. This mass value is crucial in determining how many and what kinds of planets can be expected to form.

Previous mass determinations had been heavily dependent on model assumptions. Whenever astronomers want to estimate the abundance of some compound,

Fig. II.1.1: Artist's impression of the gas and dust disk around the young star TW Hydrae. New measurements using the Herschel space telescope have shown that the mass of the disk is greater than previously thought.



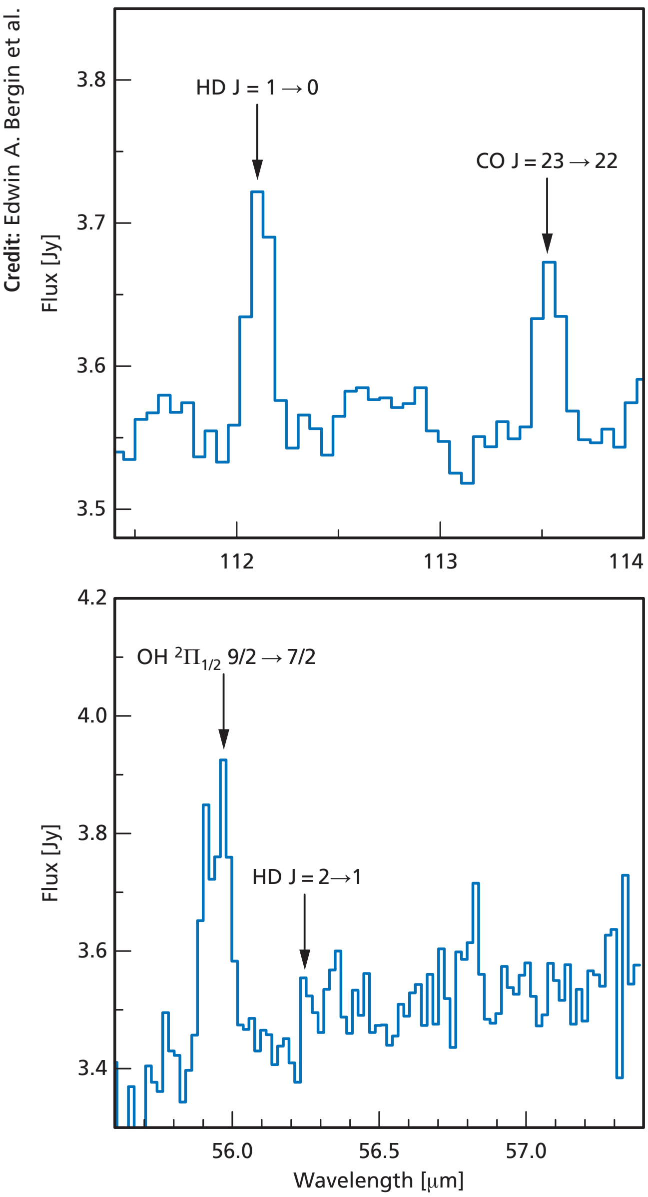


Fig. II.1.2: Herschel detection spectrum for hydrogen deuteride (HD) in the TW Hydrae protoplanetary disk. *Top:* The fundamental line of HD has a wavelength of about 112 μm. On 20 November 2011, it was detected from the direction of the disk of TW Hydrae with very little room for error (9 σ level). The total integrated energy flux received from this line is at $(6.3 \pm 0.7) \times 10^{-18}$ W/m². The warm disk atmosphere is also detected, via the CO line visible further to the right. *Bottom:* Simultaneously, another line associated with HD was detected. The detection limit at reasonable certainty (3 σ level) lies at 8×10^{-18} W/m². To the left of the HD line is the doublet OH $^2\Pi_{1/2}$, with a wavelength near 55.94 μm. In both parts of the image, there is a continuum contribution due to the thermal radiation emitted by the dust, with a spectral flux density of about 3.55 Jansky.

they search for characteristic light announcing the compound's presence. But this doesn't work for molecular hydrogen, as hydrogen molecules do not emit detectable radiation. Previous methods had relied on indirect tracers to deduce the amount of hydrogen present, that is, molecules that are usually found in the company of hydrogen, measuring the abundance of carbon monoxide and of dust in TW Hya, and using additional measurements and models to infer the abundance of molecular hydrogen.

But mass estimates based on the thermal emission from dust grains in the disk require assumptions about the opacity of the dust, whose value can change dramatically as dust clumps into larger and larger grains, leading to large uncertainty. Adding to the uncertainty are assumptions about the gas-to-dust ratio, a correction factor derived from measurements of the interstellar medium.

Mass estimates based on the presence of CO, on the other hand, are troubled by the fact that the disk is opaque to this type of radiation. Observations can only show the surface of the disk; their relation to the bulk of the disk then must be inferred using a suitable model. That is why previous mass measurements spanned a huge range of values between 0.5 and 63 Jupiter masses.

This was the situation when a group of astronomers that included MPIA director Thomas Henning set out to determine the mass of TW Hya much more precisely. The astronomers, led by Edward A. Bergin of the University of Michigan, made use of the fact that not all hydrogen molecules are created equal: Some very few of them contain a deuterium atom – where the atomic nucleus of hydrogen consists of a single proton, deuterium has an additional neutron. This slight change means that these "hydrogen deuteride" molecules consisting of one deuterium and one ordinary hydrogen atom emit radiation associated with rotational degrees of freedom which is a million times stronger than for ordinary molecular hydrogen. Its intensity depends on the temperature of the gas; this temperature was measured via ALMA observations of carbon monoxide (CO J = 3 → 2).

The ratio of deuterium to hydrogen appears to be constant in our cosmic neighbourhood, as a survey of objects with distances of less than about 300 light-years from the Sun shows (Linsky 1998). Detect the hydrogen deuteride and multiply by this ratio, and you will get a good estimate for the total amount of molecular hydrogen present.

Should some of the deuterium atoms be hidden in more complex molecules (notably polycyclic aromatic hydrocarbon) or in molecular ice, or should parts of the disk be opaque for this kind of radiation, the estimate will be too low. The temperature estimate, derived from CO lines, is also likely to be somewhat too low – it probes material near the surface of the disk, which, if anything, should have a higher temperature than the deeper regions from which the hydrogen deuteride lines originate. But all the possible corrections push the mass above the given conservative limits; this is why, as a lower limit, the current mass estimate is very reliable.

The observations themselves were a challenge, as well. The fundamental line of hydrogen deuteride ($J = \mathcal{N} \rightarrow 0$) has a wavelength of 112 μm, placing it firmly in the far-infrared region of the spectrum. This kind of radiation is absorbed by water vapour in the atmosphere, and can only be observed from space or from the stratosphere, leaving the Herschel Space Telescope and the flying observatory SOFIA as the only options.

The Herschel Space Telescope provides the unique combination of sensitivity at the required wavelengths and spectrum-taking ability ("spectral resolution") required for detecting the unusual molecules. The combination of 36 Herschel observations with a total exposure time of nearly 7 hours on November 20, 2011, detected the $J = 1 \rightarrow 0$ line unambiguously (at the 9 level).

The observations were performed as part of the Herschel Open Time Programme "A New Method to Determine the Gas Mass in Protoplanetary Disks" led by Bergin, and they made use of Herschel's instrument PACS ("Photodetector Array Camera & Spectrometer"), a combination of camera and spectrograph for wavelengths between 57 and 210 µm. PACS was constructed with key contributions from MPIA.

The observation sets a lower limit for the disk mass at 52 Jupiter masses, with an uncertainty ten times smaller than previous result. They were published as E. A. Bergin et al., "An Old Disk That Can Still Form a Planetary System" in the January 31 edition of the journal Nature.

While TW Hydrae is estimated to be relatively old for a stellar system with disk (between 3 and 10 million years), this shows that there is still ample of matter in the disk to form a planetary system larger than our own (which arose from a much lighter disk). On this solid basis, additional observations, notably with the millimeter/submillimeter array ALMA in Chile, promise much more detailed future disk models for TW Hydrae – and, consequently, much more rigorous tests of theories of planet formation.

Fig. II.1.3: Artist's impression of the ESA's Herschel Space Telescope. MPIA was responsible for key contributions to the telescope's PACS instrument (Photoconducting Array Camera and Spectrometer PACS, with far-infrared imaging and spectroscopic capabilities from 60 to 210 µm), including design and construction of components (chopper and Ge:Ga detectors), pre-flight support and instrument calibration and verification.

Credit: ESA

Even so, the new method of mass determination is not likely to become a standard tool. Lines of this kind are difficult to detect. This is only the second time hydrogen deuteride has been detected outside our Solar System, the first being an observation with the ISO satellite within the Orion nebula (Wright et al. 1999). The present result is bound to remain a special case – albeit with far-reaching consequences for our understanding of planet formation.

The observations also throw an interesting light on how science is done – and how it shouldn't be done. Thomas Henning retains a vivid memory about how the project started, with a conversation between him, Ted Bergin, and Ewine van Dishoeck. He recalls that the astronomers realized immediately that Herschel was their only chance to make this kind of measurement, but also that there was a definite risk: At least one model predicted that Herschel observations of this kind should not see anything at all. That's the clear lesson TW Hydrae holds for the committees that allocate funding for scientific projects or, in the case of astronomy, observing time on major telescopes – and which sometimes take a rather conservative stance, practically requiring the applicant to guarantee their project will work. In the end, the Herschel results were much better than the astronomers had dare hope. Henning concludes that calculated risks are essential for scientific breakthroughs – or, put differently, that a project which cannot possibly fail is unlikely to do interesting science. TW Hydrae is a good example of how a calculated scientific gamble can pay off.

Thomas Henning

in collaboration with
Edwin A. Bergin, L. Ilsedore Cleeves
(both University of Michigan),
Uma Gorty
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Klaus Pontoppidan (Space Telescope Science Institute),
Chunhua Qi (CfA), Colette Salyk (NOAO),
and Ewine F. van Dishoeck (Max Planck Institute
for Extraterrestrial Physics and Leiden Observatory)

Edwin A. Bergin et al.: "An old disk still capable of forming a planetary system". In: *Nature* **493**, pp. 644–646, 2013. DOI: 10.1038/nature11805

II.2 Novel approach in hunt for cosmic particle accelerator

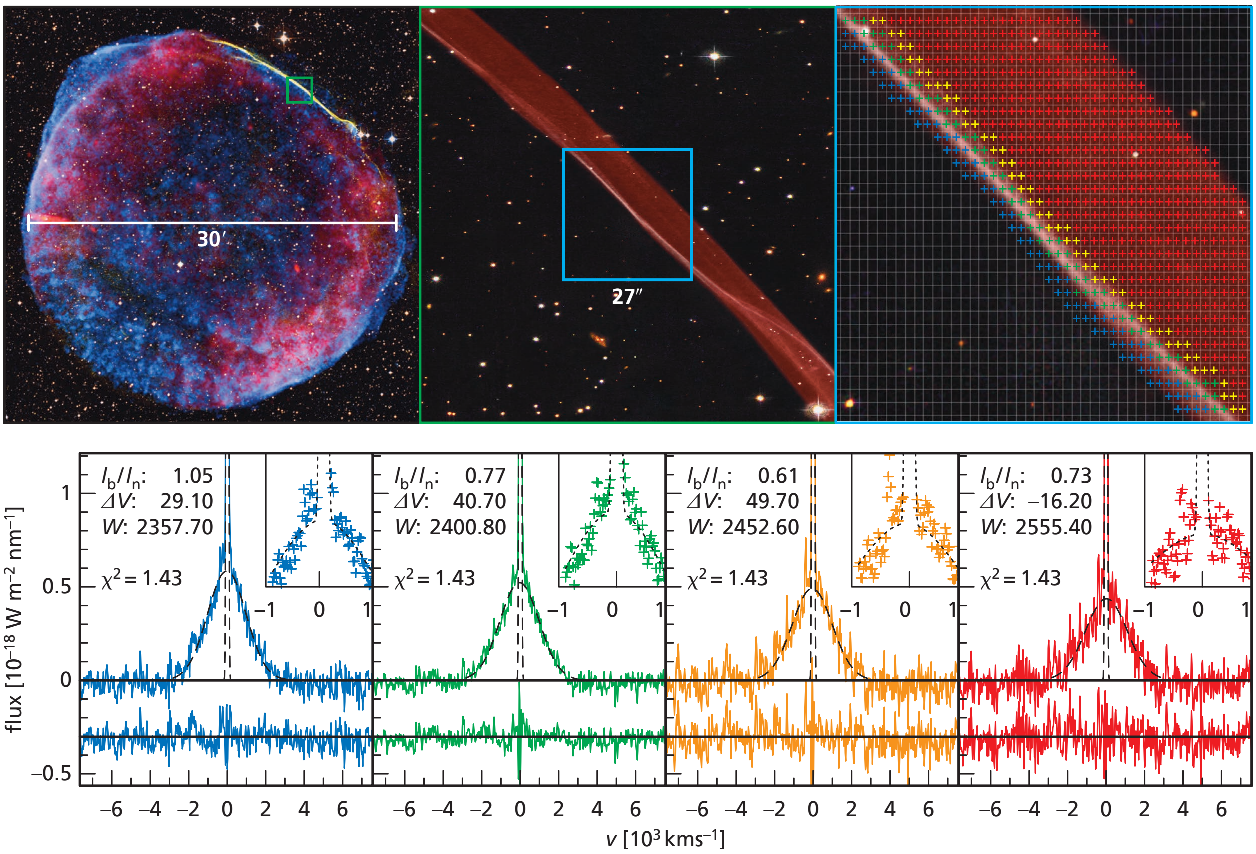
Detailed observations of the supernova remnant SN 1006 show physical processes that could produce the precursors of cosmic rays, highly energetic particles reaching the Earth from space.

When Victor Hess first discovered cosmic ray particles hitting Earth almost exactly a hundred years ago, he had little notion about their origin. Since then, ever more sensitive observations of these particles have turned up a number of sources. Among them are supernova remnants – cosmic blast waves launched by stellar explosions; expanding gas shells flung into space when certain stars end their lives in a supernova.

Where such a blast wave meets the surrounding interstellar medium, there is an abrupt change in density and temperature: a shock front similar to the sonic boom produced by an aircraft going supersonic. This expanding, high-velocity shock front is a natural candidate for a cosmic particle accelerator.

In late 2012/early 2013, the first observational evidence of accelerated protons in these shock regions was found. The discovery was made by a team of astronomers

Fig. II.2.1: Detailed spectroscopic measurements of a shock front in the supernova remnant SN 1006. *Top row:* Zoom-in on the shock region under study. To the left, a composite image combining data from different wavelengths: Radio (red), X-ray (blue) and optical (yellow, orange and light blue). The supernova remnant has the same angular size as the full moon. The green region indicates the region of the shock front shown in more detail in the center image, taken with the Hubble Space Telescope and showing the characteristic light emitted by hydrogen atoms (Hα). The box shows the area of the shock front examined in the present study, and shown in more detail on the right. The region was studied with VIMOS-IFU, a specialized spectrograph at the European Southern Observatory's Very Large Telescope (VLT) in Chile. The crosses with different colors indicate the pixels that were combined to determine the spectra of four characteristic regions directly at the shock front and to both sides of it. The four resulting spectra are shown in the *bottom row*, together with curve fits (one narrow and one broader Gaussian) and, offset by -0.3 for clarity, the difference between the observed spectra and the best fits. These differences as well as the values of the parameters used to judge the fit quality (reduced χ^2) show that non-Gaussianity is present; most of the mismatching appears to come from the region around the line core (insets) from –1000 to 1000 km/s. For the yellow and red graphs, the flux is rescaled by factors 2 and 0.5, respectively, relatively to the blue graph.



Credit: Top left NASA/CXC/Rutgers/G.Cassam-Chenaï, J.Hughes et al. (X-ray), NRAO/AUI/NSF/GBT/VLA/Dyer, Maddalena & Cornwell (radio), Middlebury College/F. Winkler, NOAO/AURA/NSF/CTIO Schmidt & DSS (optical); top center: NASA, ESA, and the Hubble Heritage Team (STScI/AURA); top right and spectra: Nikolic et al./MPIA

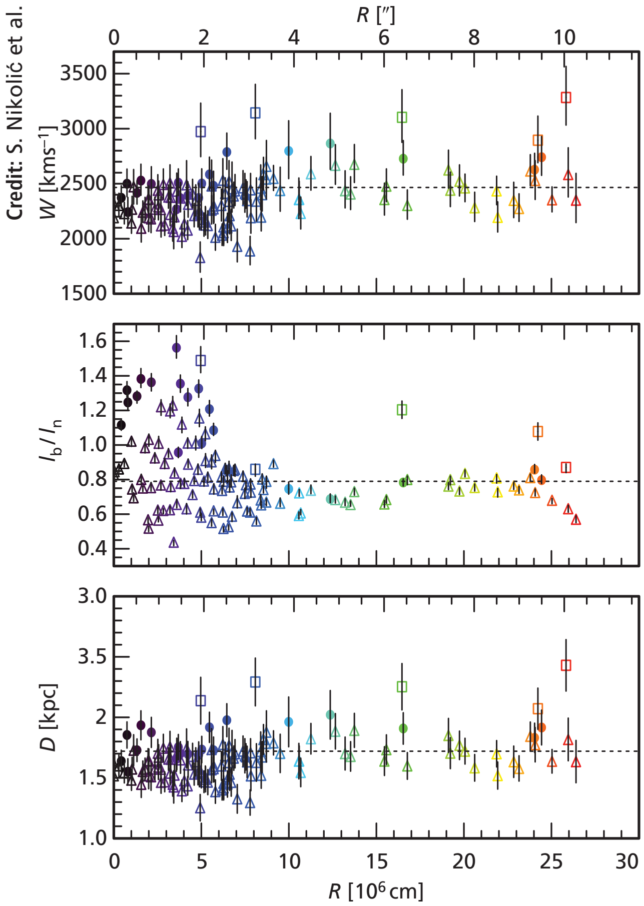


Fig. II.2.2: Spectral line properties for the different regions in and around the shock, plotted by increasing distance R from the inner rim (black and purple) to the outer rim (orange and red). R is given both in arc seconds (top scale) and in cm (bottom scale). *From top to bottom:* the line width W of the broad fitted line (FWHM) can be used to infer the shock velocity. The ratio of intensities between the broad and the narrow line, I_b/I_n, contains information on how energy is shared between the pre- and postshock regions; in two of the strips, low values for this ratio around 0.6 to 0.7 indicate that particles are travelling from the postshock region upstream to the preshock region, depositing their energy. Comparison of the observed proper motion measurement with the shock velocities as derived from comparison with a model allows for an estimate of the supernova remnant's distance from Earth. That the distance estimates are not the same implies that at certain positions fast-moving particles have removed energy from the shock and thus changed its properties. The dashed horizontal lines indicate the measured values of W = 2465.76 km/s, $I_b/I_n = 0.79$ and distance $D = 1.72$ kpc (= 5600 light-years) obtained by combining the spectra for all the shock front pixels.

led by MPIA graduate student Sladjana Nikolić. Targeting the supernova remnant SN 1006, the scientists were able to probe in unprecedented detail the region where the gas ejected during the supernova meets the surrounding interstellar matter.

While the accelerated protons discovered by Nikolić and her colleagues are not the sought-for high-energy cosmic rays themselves, they could be the necessary "seed particles", which go on to interact with the shock to reach the extremely high energies required and fly off into space as cosmic ray particles.

The key result of the new observations is a first detailed look at the microphysical processes in and around the shock region. The researchers found evidence for a precursor region directly in front of the shock, which is thought to be a prerequisite of cosmic ray production. Also, the precursor region is being heated in just the way one would expect if there were protons carrying away energy from the region directly behind the shock.

The new evidence emerged during careful observational analysis by Nikolić as part of her work towards a doctoral degree at the University of Heidelberg. They are based on a modern technique known as integral field spectroscopy, which allows astronomers to simultaneously probe the composition of light received from numerous locations within their telescope's field of view. This was the first time the technique had been applied successfully to a supernova remnant.

Nikolić and her colleagues used the spectrograph VIMOS at the European Southern Observatory's Very Large Telescope in Chile to map a small part of the shock front of the supernova SN 1006, simultaneously analyzing light ("taking spectra") from more than 100 locations within that region. Analysis of the data – one and a half years' worth of hard work – provided detailed information about the way that hydrogen atoms in the region are being excited in and around the shock front, and of the temperatures in front of and behind the shock. This fairly unorthodox usage of integral field spectroscopy – which is more commonly used to study very distant galaxies – rewarded the observers with a level of precision that far exceeds all previous studies.

The study, which was published in the journal Science, is also important because of the directions it suggests for future research. Emissions such as the ones by Nikolić and her colleagues are very, very faint compared to the usual target objects for this type of instrument. This opens the door to a whole range of possible follow-up observations – some of which might yield definite evidence for how cosmic rays are produced.

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Sladjana Nikolić et al.: "An Integral View of Fast Shocks Around Supernova 1006". In: *Science* **340**, pp. 45–48, 2013. DOI: 10.1126/science.1228297

II.3 In Orion, Herschel finds the youngest stars yet

A combination of the Herschel Space Observatory with the submillimeter telescope APEX leads to the discovery and characterization of the youngest known protostars yet: stellar embryos still deeply embedded in unexpectedly dense dust cocoons.

Stars are born in hiding, behind layers of dust, deep within the clouds of molecular gas whose collapse brings them into existence. The younger a star-to-be (or "protostar"), the more difficult it is to observe. Over the past years, using ever more advanced infrared technology, there has been a veritable race for finding protostars in ever earlier stages of development. This year, a group of astronomers led by MPIA's Amelia Stutz managed to discover and characterize the youngest known protostars yet.

The discovery happened when one of the members of the team, Tom Megeath of the University of Toledo, Ohio, compared images of a recently discovered protostar in Orion, taken with the Spitzer and Herschel space telescopes. The Herschel images were part of the Herschel Orion Protostar Survey (HOPS), for which Megeath is principal investigator; in one of them, he noticed an additional object that did not show up in the image taken by Spitzer at somewhat shorter wavelengths.

For physicists, this is a smoking gun. After all, the so-called thermal radiation objects emit due to their temperature is governed by simple physical laws. Cold objects radiate predominantly at very long wavelengths. When talking about visible light, these lie towards the red end of the spectrum: colder objects are redder.

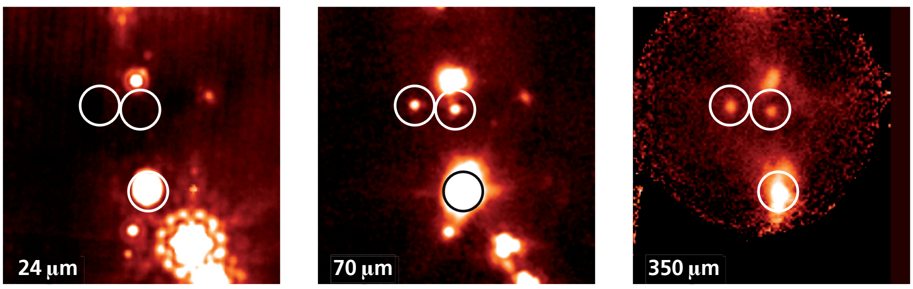
Quite generally, cold objects are likely to be invisible at shorter wavelengths and only detectable at longer ones. We know this from everyday life comparing a hot object, namely an incandescent bulb, with a comparatively cold object, a human body (cf. Fig. II.3.3): An incandescent bulb, its filament heated to about 3400 degrees Celsius, produces sizeable amounts of visible light, showing up clearly on a photograph taken in an otherwise dark room. Without an additional light-source, a human being, however, will not show up on such a photograph, since humans do not radiate visible light. But at a body temperature of around 37 degrees Celsius, a human will emit infrared radiation, and show up on an image taken with a long-wavelength infrared camera.

Similarly, the astronomers realized that, when it came to the newly discovered object in the Herschel image, they could be looking at an exceptionally cool protostar. This was an exciting prospect, since at such low temperatures, this would be a protostar in a much earlier developmental stage than anyone had ever seen before!

After this first compelling discovery, Stutz then carefully combed through the data looking for more examples of other similar specimens in Orion. She ended up with a total of 55 of these apparently very cold objects.

But the universe has one additional trick up its sleeve: Very distant cosmic objects appear "redshifted", which can make a very distant ordinary galaxy look like a very cold nearby protostar. The astronomers needed to separate protostars from extragalactic impostors. This could only be done with a different kind of data, such as the images provided by the APEX antenna, a radio dish with a diameter of 12 metres, which can receive light at even longer wavelengths than Herschel. APEX is a collaboration between the Max Planck Institute for Radio Astronomy (MPIfR), the Onsala Space Observatory (OSO) and the European Southern Observatory (ESO), located at Chajnantor in the Chilean Andes at an altitude of more than 5100 meters.

Fig. II.3.1: Three of the PACS Bright Red Sources (PBRS) found with the Herschel Space Observatory, which appear to be among the youngest known protostars. The leftmost panel shows an image taken with the Spitzer Space Telescope (at 24 μm) in which the upper two objects are completely invisible, while the lower one is not clearly identifiable as a protostar. The two panels on the right show images taken with the Herschel Space Observatory (at 70 μm) and with the APEX submillimeter telescope (at 350 μm), which allowed for the identification of all three objects as some of the earliest known protostars yet.



Credit: MPIA/A. M. Stutz

Credit: MPIA/A. M. Stutz

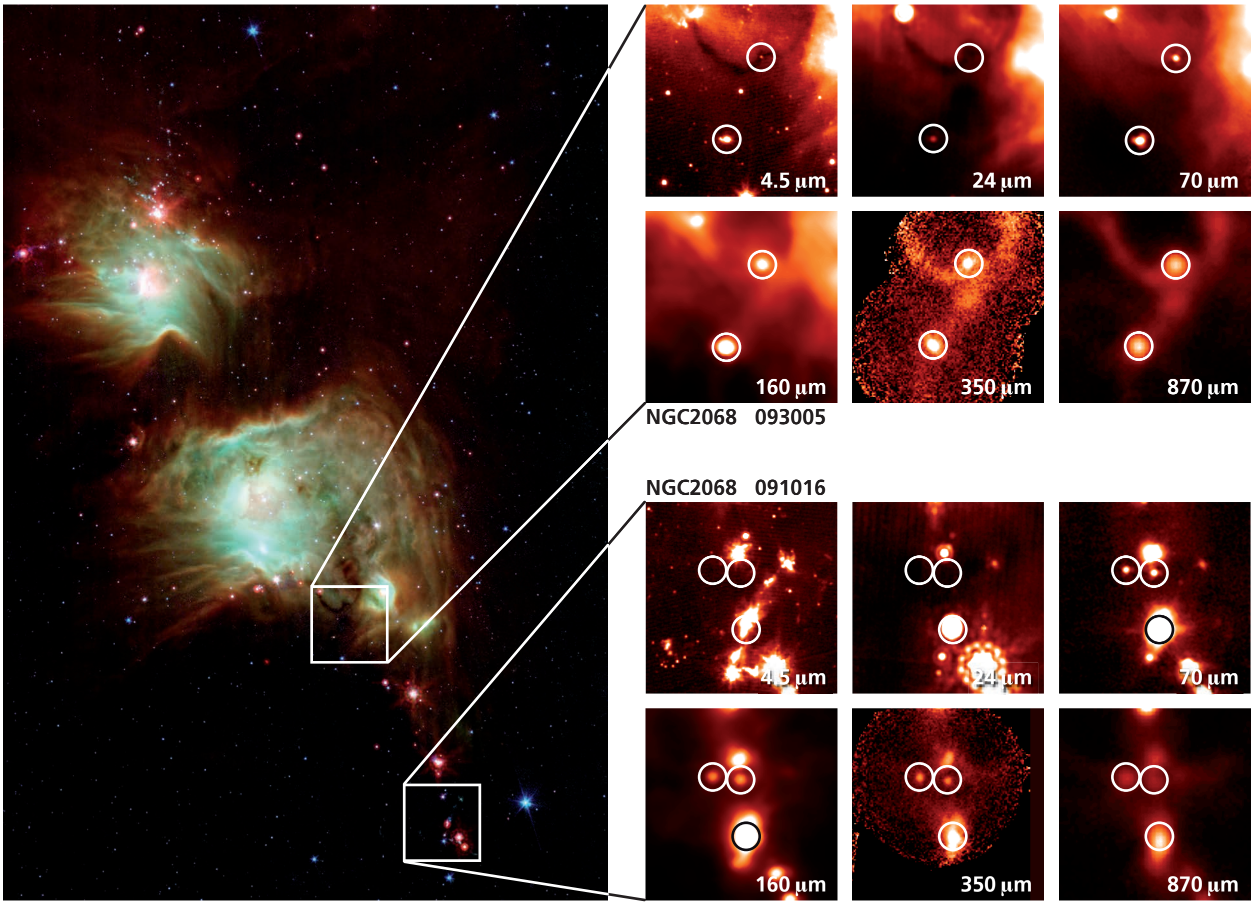
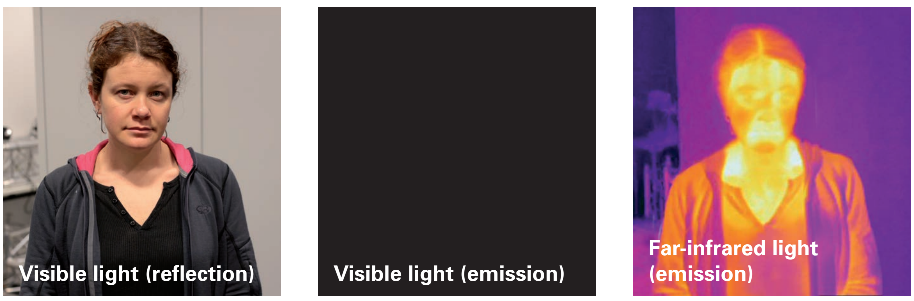


Fig. II.3.2: The large-scale image shows the reflection nebula M 78, or NGC 2068, in the constellation Orion, imaged with the Spitzer Space Telescope. Blue represents infrared light with wavelengths of 3.6 µm and 4.5 µm and green shows light at 5.8 µm and 8 µm, both captured by Spitzer's infrared array camera IRAC. Red represents 24 µm light detected by Spitzer's multiband imaging photometer MIPS. The smaller-scale images show a total of five of the PACS Bright Red Sources (PBRS) discovered by Stutz et al. Their status as very young and dense protostars could not be determined without Herschel and APEX, and some of the sources are not even visible in the Spitzer images. At longer wavelengths (70 µm and 160 µm with Herschel-PACS, 350 µm and 870 µm with the APEX telescope) they shine brightly, as would be expected for very cold objects. Their low temperatures are the key to identifying these objects as protostars in the earliest stages currently known.

Fig. II.3.3: Cooler objects emit light at longer wavelengths, and may be invisible at shorter one. This series of images shows team leader Amelia M. Stutz in the reflected light produced by an incandescent bulb (*left image*). Dr. Stutz' temperature is not sufficiently high to emit significant amounts of visible light; in the absence of an external light source, she remains invisible (*middle image*). However, like all humans, Dr. Stutz emits far-infrared light, at far longer wavelengths than those of visible light, that can be imaged with a thermal camera (*right image*). Hence, just like the objects she discovered, Dr. Stutz remains invisible at shorter wavelengths and shows up on images taken at longer wavelengths.



Credit: A. M. Stutz

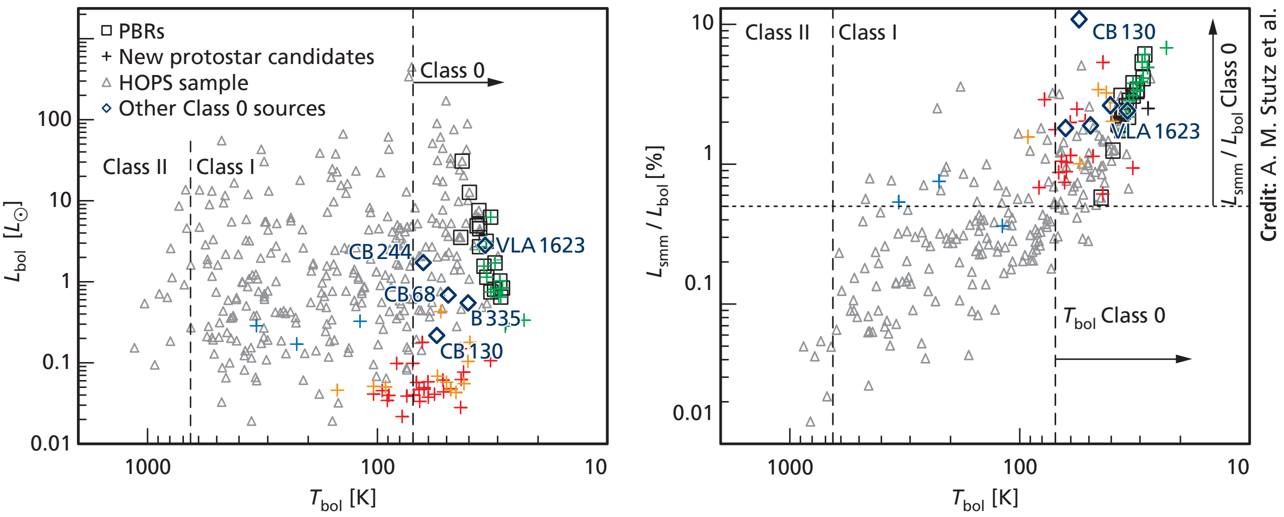


Fig. II.3.4: Comparison of the new candidate protostars (+ symbols) with the protostars from the Herschel Orion Protostar Survey (HOPS; light gray triangles). The squares correspond to the PBRS sample (sources with extreme 70 to 24 μm colors), which includes members from the new candidate protostar sample as well as from the HOPS protostar sample. In the diagram on the left, submillimeter luminosity is plotted against (bolometric) temperature; the diagram on the right does the same for the ratio of submillimeter and total (bolometric) luminosity. Vertical dashed lines indicate the conventional divisions between classes of protostars according to their temperature, Class 0 objects being the youngest (with an age of 0.15 million years or less). Clearly, the PBRS sample has the lowest values for bolometric temperature, indicating that the spectral energy distributions (SEDs) are consistent with these objects' being extremely young protostars. In the panel on the right, the horizontal dotted line indicates the threshold postulated by André et al. (2000) for Class 0 protostars. Both evolutionary diagnostics and temperature range show that the PBRS sample occupies the extrema of parameter space associated with extremely young and envelope-dominated protostars.

With the combined data, and carefully comparing their observations with physical models of protostars and similar objects, Stutz and her colleagues narrowed their list to 15 reliably identified new protostars. They dubbed the reddest sources "PACS Bright Red Sources", PBRS for short, after the Herschel instrument PACS whose images had led to their discovery in the first place.

At a temperature of no more than 20 Kelvin, corresponding to 20 degrees Celsius above absolute zero, the PBRS are so cold that they do not emit sufficient radiation to be detected by the Spitzer infrared space telescope. They do, however, show clearly on measurements with the Herschel space Observatory and with APEX at even longer wavelengths.

Going by the analysis of Stutz and her colleagues, these are the youngest protostars yet observed: dusty gas envelopes with masses between 1/5 and 2 times that of the Sun, heated to about 20 degrees Celsius above absolute zero (20 K) by a protostar hidden deep inside.

This makes them highly desirable objects of study for astronomers interested in star formation. The earliest stages are where protostars are expected to build up most of their mass. But they are also hardest to observe, and up until then, theorists building models of star formation had no direct way of comparing their models' predictions for these earliest stages with observations. Thanks to Stutz and their colleagues, that has changed.

Meanwhile, the observers are already busy with the next stages of their campaign: Follow-up observations with Herschel on eight of the PBRS to look for traces of the gas outflows predicted for these early prototypes, and observations using the Green Bank Telescope of light characteristic for denser regions populated by gas molecules. The astronomers also hope for observation time on ALMA, the array of submillimeter antennae currently under construction in the Atacama desert: ALMA should be able to reveal finer details of the envelopes, and allow for more precise measurements of their densities.

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Amelia M. Stutz et al.: "A Herschel and APEX Census of the Reddest Sources in Orion: Searching for the Youngest Protostars". In: *Astrophysical Journal* **767**, article id. 36, 2013. DOI: 10.1088/0004-637X/767/1/36

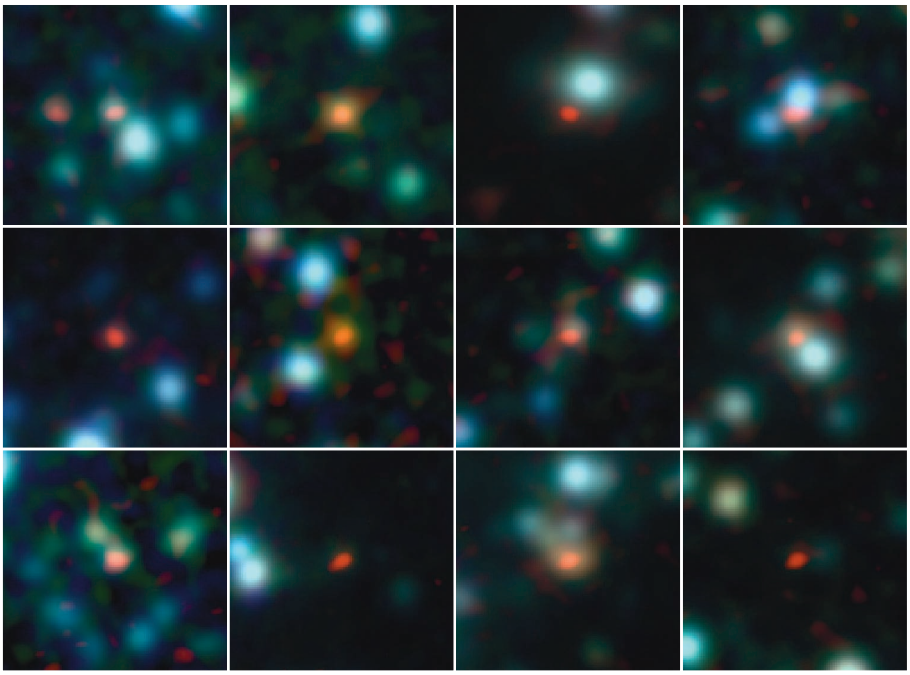
II.4 Pinpointing the most fertile galaxies in the universe

Pinpointing the positions of more than 100 of the most fertile star-forming galaxies with the compound telescope ALMA clears up a mystery about these objects' observed productivity – and shows that previous studies had frequently mis-identified such galaxies.

Submillimeter galaxies, discovered in the late 1990s, produce so many new stars as to be responsible for a significant fraction of the total energy output of all galaxies over the course of all of cosmic history. A side effect of having many (and many massive) stars is the production of lots of dust: As these stars' atmospheres expand (in particular in the "Asymptotic Giant Branch" stage), molecules can cluster together. For the right kinds of molecules, this results in the formation of dust grains. Stellar winds blow those dust grains into the wider neighbourhood. Supernova remnants, which are formed in the explosions ending the life of massive stars, are also candidate loci for dust production.Whether it was produced during the submillimeter galaxies' intense phases of star formation, or present beforehand: fact is that in the most extreme cases, these fertile galaxies are so deeply shrouded in dust they are effectively hidden from sight for astronomers observing in visible light. That is why, in order to make a full census of these objects, and to reliably gauge their star formation activity, astronomers need to resort to submillimeter observations, supplemented by infrared or radio observations.

Previous submillimeter surveys of these distant objects suffered from a lack of detail. The amount of detail a telescope can see – its resolution – depends on the telescope's size: The larger the telescope, the finer the details that can be resolved. But the maximal resolution also depends on the wavelength of the electromagnetic radiation involved. At submillimeter wavelengths, a telescope needs to be more than a hundred times larger than an ordinary, visible-light telescope to achieve the same level of detail! Until recently, astronomers observing in that wavelength regime had very limited options: For large-scale surveys, they could only use single-dish telescopes (such as the APEX telescope in Chile), which promised moderate resolution at best. For higher resolution, they could turn to arrays such as the Plateau de Bure Interferometer in France. But the comparatively low sensitivity of those arrays meant that considerable time would need to be spent observing each particular source. In a world

Fig. II.4.1: A team of astronomers led by MPIA researchers has used ALMA (the Atacama Large Millimeter/submillimeter Array) to pinpoint the locations of over 100 of the most fertile star-forming galaxies in the early Universe. This image shows close-ups of a selection of these galaxies. The ALMA observations, at submillimetre wavelengths, are shown in orange/red and are overlaid on an infrared view of the region as seen by the IRAC camera on the Spitzer Space Telescope. Previous observations had not been sharp enough to unambiguously identify these galaxies in images at other wavelengths.



Credit: ALMA (ESO/NAOJ/NRAO), APEX (MPIfR/ESO/OSO), J. Hodge (MPIA) et al., A. Weiss et al., NASA Spitzer Science Center where competition for telescope time is fierce, this effectively meant that only very few submillimeter galaxies could be studied at high resolution.

But now, a team led by Ian Smail (Durham University, UK) has completed a large, yet highly detailed survey of more than 100 such objects using the international compound telescope ALMA (Atacama Large Millimeter/Submillimeter Array), located in Chile, at a resolution more than a factor 10 better than previous surveys. The observations, targeting a region known as the Extended Chandra Deep Field South in the Southern constellation Fornax, made use of 15 of ALMA's antennas, which were combined to act as a single, large telescope.

ALMA represents a considerable boost in resolution and sensitivity at the same time – even in its preliminary configurations, with less than a quarter of its eventual 66 antennae. In the configuration used for the survey of Smail and colleagues, ALMA has the same resolution as a single radio dish with a diameter of 125 meters. This is a factor 10 better than for the best previous survey, which used the APEX telescope: a single 12 meter dish. The new survey has a resolution of 1.6 arcseconds, as compared to nearly 20 arcseconds for APEX. And thanks to its high sensitivity, ALMA needed a mere two minutes to complete observations for each of the galaxies in the survey, making large-scale surveys feasible.

The survey targeted galaxies that had previously been detected with a survey using the APEX telescope, a single-dish telescope at the same location as ALMA. That survey, the LABOCA ECDFS Submillimeter Survey (LESS), had in turn chosen that specific location, the Chandra Deep Field South, because it is one of the best studied regions of the Southern Sky.

The new survey's high-resolution images for a large number of galaxies helped to solve one apparent mystery concerning submillimeter galaxies – a result for which the lead was Alexander Karim, now at the Argelander Institute for Astronomy, Bonn and Durham University, UK, and formerly a PhD student at the Max Planck Institute for Astronomy.

Previously, the brightest submillimeter galaxies had been thought to be forming stars at a rate of more than a thousand times that of our home galaxy, the Milky Way. This represents a problem, as stars emit intense radiation: In order to collapse and form new stars, clouds of matter need to collapse. Sufficiently intense radiation can disrupt star formation by heating up matter and/or dispersing existing dense clouds. From model calculations, the early values of the order of 1000 solar masses' worth of material being transformed into stars every year was precariously close to that limit, raising the question whether or not such high rates were physically possible.

But in each of those problematic cases, where earlier surveys had shown a single, hyperactive galaxy, the ALMA images revealed multiple, separate, smaller galaxies, each forming stars at a more reasonable rate: The light that is observed in each of these cases is coming not from

Credit: MPIA / J. Hodge

Fig. II.4.2: Jacqueline Hodge of the Max Planck Institute for Astronomy, the PI of this study, in front of some of the ALMA antennas during the telescope array's commissioning process in spring 2011, in which Hodge participated.

one galaxy, but from two or more galaxies with somewhat lower individual star formation rates; in this way the problem has found an elegant solution.

The survey data, which has been published in the *Astrophysical Journal* with MPIA's Jacqueline Hodge as the lead author, also promises to put future studies of submillimeter galaxies onto a solid footing. In order to understand an object's physical properties, astronomers typically need observations in more than one region of the electromagnetic spectrum. Identifying one and the same source both in a submillimeter image and in an infrared image – saying that this blob in infrared image A corresponds to that other blob in submillimeter image B, for example – requires precise knowledge about the location of the source. The new survey shows that previous attempts to identify the infrared and radio counterparts of submillimeter galaxies were considerably error-prone, leading to incorrect identifications in about a third of all cases. With the new, much more precise submillimeter position measurements, astronomers will be able to avoid such mistakes in the future.

The work by Smail, Hodge, Karim and their colleagues has set the stage for the next logical step: Examinations at even higher resolution, deploying the full power of the completed ALMA array with all of its 66 antennas, could

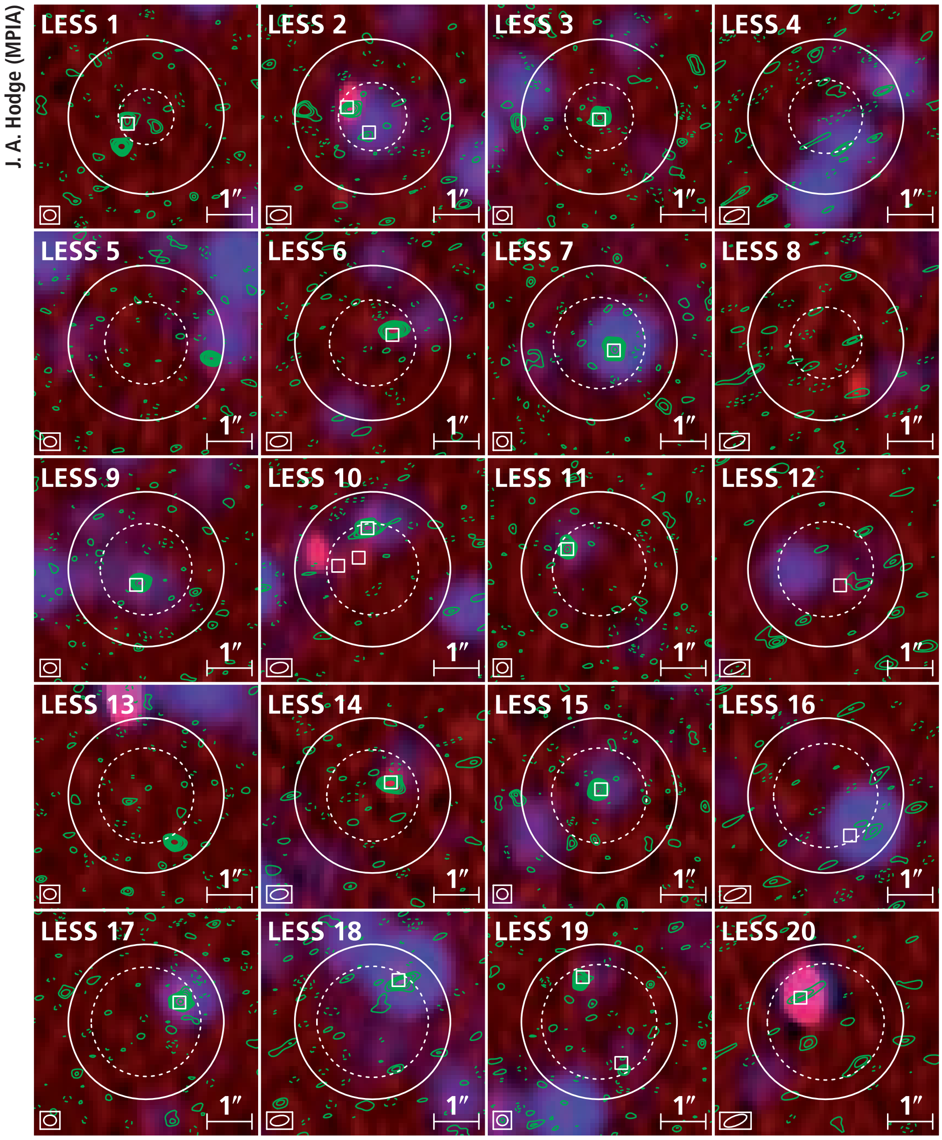


Fig. II.4.3: Contours of ALMA observations at a wavelength of 870 μm (green) on the background of false-color multi-wavelength images produced from data taken with the Very Large Array (VLA) at 1.4 GHz (red) and the MIPS instrument of the Spitzer Space Telescope at 24 μm (blue). The dashed circle shows the search radius used in an earlier study (Biggs et al. 2011) to identify radio and mid-infrared counterparts to the submillimeter sources detected in the LESS survey; the small white/yellow squares indicate the positions of the predicted robust/tentative counterparts. The fact that ALMA can resolve many objects viewed as single by earlier studies into multiple sources is clearly visible. Shape and size of the combined ALMA beam are shown in the bottom left corner of each map; the large circle indicates the size (FWHM) of the beam of each single ALMA antenna. ALMA contours are in steps of 1σ starting at ±2σ.

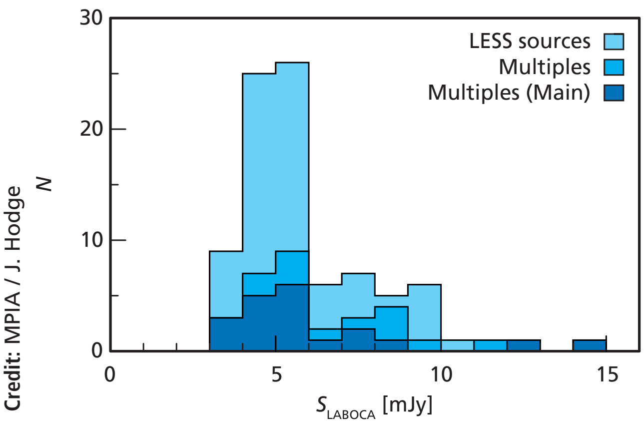


Fig. II.4.4: Histogram of LABOCA/ALMA flux density values in mJy. The light blue histogram includes those sources in the LESS survey for which good quality (rms < 0.6 mJy per beam, axis ratio < 2) ALMA observations could be obtained. Shown filled in medium blue and in dark blue are histograms for two subsets of these objects: In dark blue, all fields that could be resolved into multiple submillimeter galaxies within the primary beam, in medium blue all fields that can be resolved into multiples if submillimeter galaxies outside the primary beam are included. The three brightest LESS sources, with flux densities > 9 mJy, are all resolved as multiples.

help elucidate the nature of submillimeter galaxies. The most plausible scenario is that submillimeter galaxies are created when large galaxies collide, their mutual gravitational pull triggering an intense phase of star formation. High-resolution images could show aspects of those galaxies' shapes, and possibly traces of the collision process itself.

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Jacqueline A. Hodge et al.: "An ALMA Survey of Submillimeter Galaxies in the Extended Chandra Deep Field South: Source Catalog and Multiplicity". In: Astrophysical Journal 768, article id. 91, 2013. DOI: 10.1088/0004-637X/768/1/91
Alexander Karim et al.: "An ALMA survey of submillimetre galaxies in the Extended Chandra Deep Field South: high-resolution 870 μm source counts". In: Monthly Notices of the Royal Astronomical Society 432, pp. 2–9, 2013. DOI: 10.1093/mnras/stt196

II.5 The most exciting candidates for habitable exoplanets yet

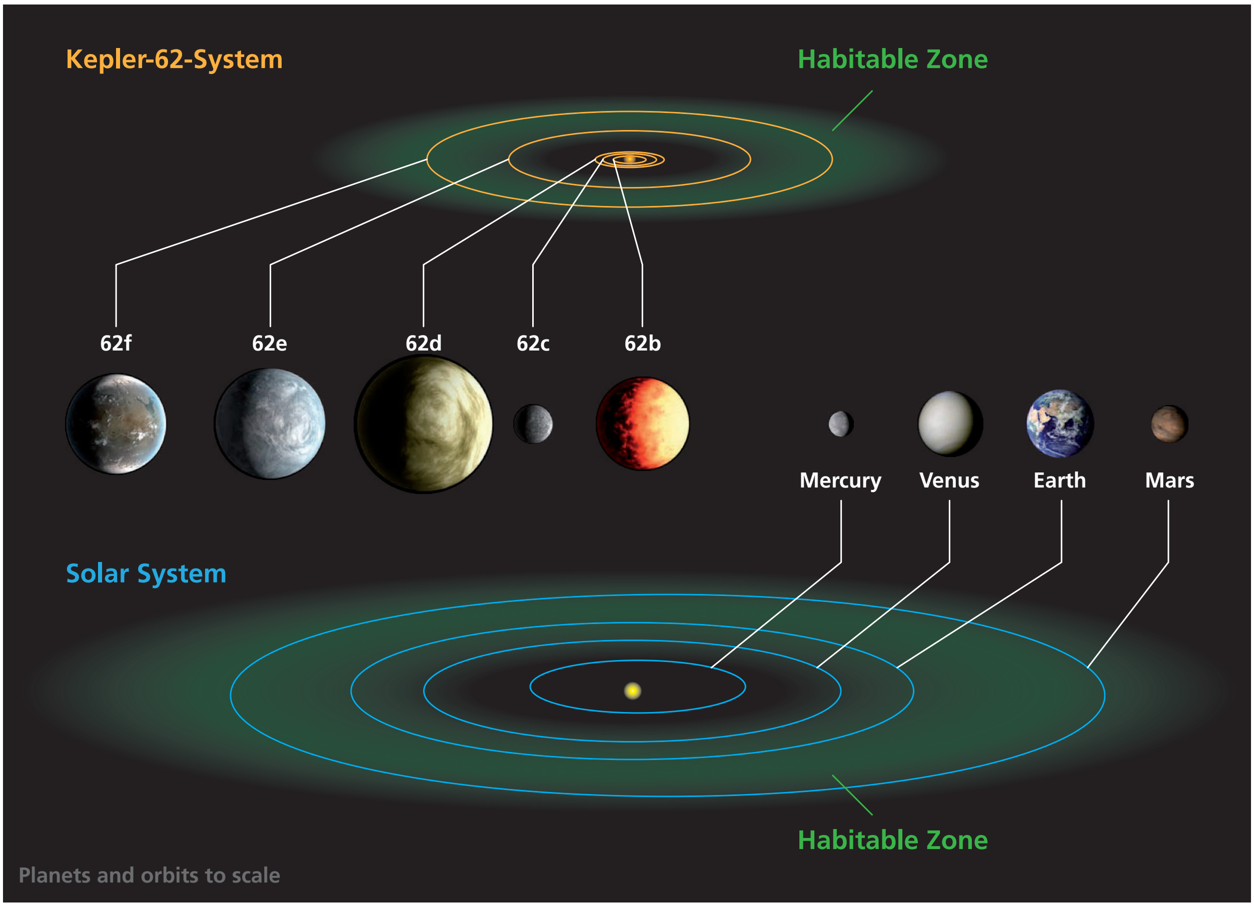
In April 2013, an international team of scientists analyzing data from NASA's Kepler mission, which includes Lisa Kaltenegger from the Max Planck Institute for Astronomy, announced the discovery of the first small, potentially rocky Kepler planets, orbiting in the Habitable Zone of their star. The planets, called Kepler-62e and Kepler-62f, orbit a star that is slightly smaller and cooler than our own Sun.

NASA's Kepler Space Telescope went looking for exoplanets (that is, planets orbiting stars other than the Sun) between 2009 and 2013. Using the transit method, an indirect detection method based on planets passing in front of their host stars and shielding some of the star's light, the mission's prime objective was to find earth-sized planets – and hopefully some that could potentially harbour life.

The latter aspect is why, in the list of Kepler discoveries, the planets designated as Kepler-62e and -62f are particularly noteworthy. Their discovery was announced in April 2013 during a press conference at NASA's Ames Research Center in Moffett Field, California, whose panelists included not only NASA's director of astrophysics, Paul Hertz, Kepler science principal investigator William Borucki, but also MPIA's Lisa Kaltenegger (who also holds a position at the Harvard-Smithsonian Center for Astrophysics in Boston). Kaltenegger, who is not a part of the Kepler team, had been consulted as an external expert in order to estimate the potential life-friendliness of the Kepler-62 system.

The star Kepler-62 is located in the constellation Lyra, at a distance of 1200 light-years from Earth. It is somewhat smaller and cooler than our own Sun (spectral type K2V, estimated mass 0.7 solar masses, estimated radius

Fig. II.5.1: Comparison of the planetary system around the star Kepler-62 with our own Solar System. The relative size of the planetary orbits (*top and bottom*) is to scale. The planets (*center*) are also to scale, relative to each other. The habitable zone – the zone around the star that allows for liquid water on the surface of a planet orbiting at that distance – is shown in green. Kepler-62e and Kepler-62f are the best candidates yet for habitable planets: solid planets orbiting their host star in the habitable zone.



Credit: NASA

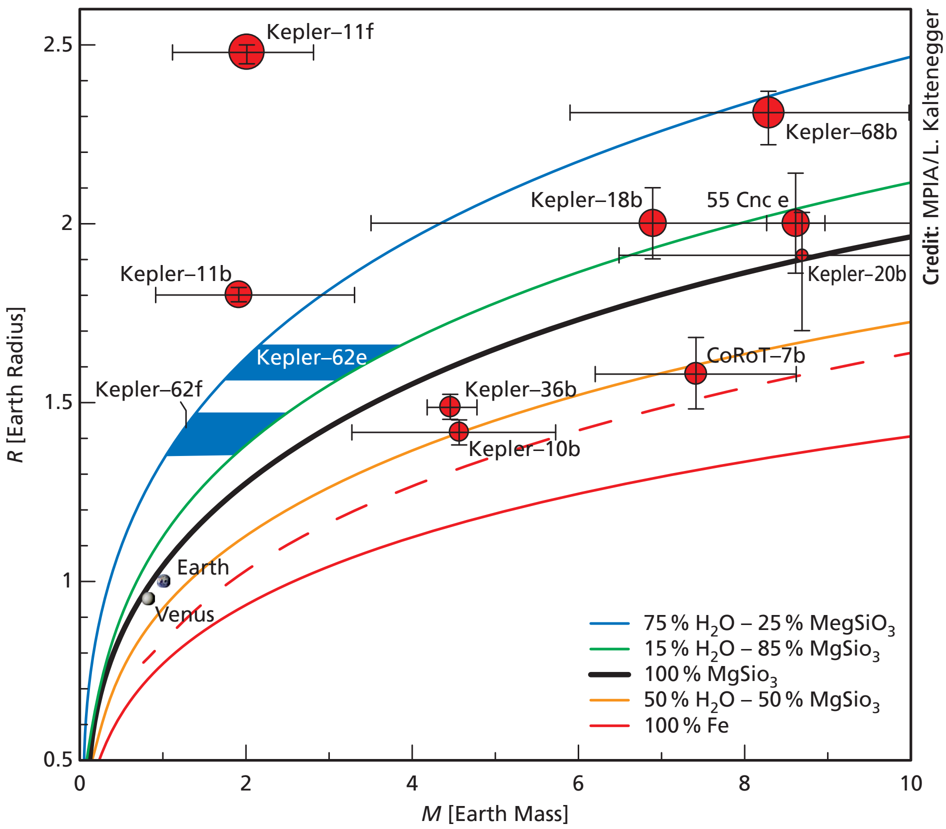


Fig. II.5.2: Masses and sizes for selected planets. The curves show the mass-radius-relation (average density) for different types of planets: The blue line indicates the loci of planets made mostly (75%) of water, the black line that of planets like our Earth that consist almost exclusively of rock (represented here by the mineral Enstatite, $MgSiO_3$, a member of the pyroxite silicate mineral series that makes up most of the Earth's mantle), and so on. The measured radii of Kepler-62e and Kepler-62f plus an estimate of their mass places them in a region (*blue areas*) where it is highly probable for them to be earth-like planets, that is: planets with a solid (if possibly covered in water) surface. Kepler-11f, on the other hand, is a Mini-Neptune, showing clearly that a comparatively low mass does not necessarily make for a solid planet.

0.63 solar radii). The stellar system is oriented in such a way that, from the point of view of an observer on Earth, its planets periodically pass in front of their host star, blocking a tiny fraction of its light. This is how the Kepler space telescope, which is capable of particularly precise measurements of changes in brightness, detected the telltale signs of five planets that orbit Kepler-62: Kepler-62b, c, d, and f.

One overarching theme of exoplanet research is the search for planets that might be capable of supporting life – a key step towards actually detecting life on other planets. This is where Kepler-62e and Kepler-62f become really interesting, and it is also why the Kepler scientists decided to involve MPIA's Lisa Kaltenegger, who is an expert on the atmospheres of exoplanets. Kaltenegger was given the task to see whether or not Kepler-62e and Kepler-62f could indeed fall into their star's life-friendly, habitable zone: the zone around a star where liquid water can exist on a planetary surface; which is the prerequisite for life as we know it.

The answer, it turns out, is that they do indeed – and also that they are quite special, being the smallest planets that have yet been found inside the habitable zone of a star: Kepler-62e has a radius 1.61 times that of the Earth, Kepler-62f 1.41 times. Previously, the smallest planet with known radius inside a habitable zone had been Kepler-22b, with a radius of 2.4 times that of the Earth.

The fact that these planets were detected with the transit method offers a significant advantage: That method yields a direct estimate for the planet's radius, which is a useful quantity for estimating the planet's density. In particular, a small radius (2 Earth radii) is a strong indicator that the planet in question is indeed rocky, like the Earth – except in the special case of a very young host star.

The most interesting confirmed candidates for habitable planets so far (GJ 667 Cc, Gl 581 d, HD 85512 b, and Gl 163 c) had all been detected with the radial velocity method, which deduces a planet's presence from certain periodic changes in the host star's spectrum. This method can be used to obtain a lower limit for a planet's mass, but does not yield information about its radius. The planet's true mass is likely to lie within a factor 2 of the lower limit deduced from radial velocity measurements. For the previous candidates, this translates to a range of masses that allows for rocky planets as well as miniature

Credit: MPIA/L. Kaltenegger

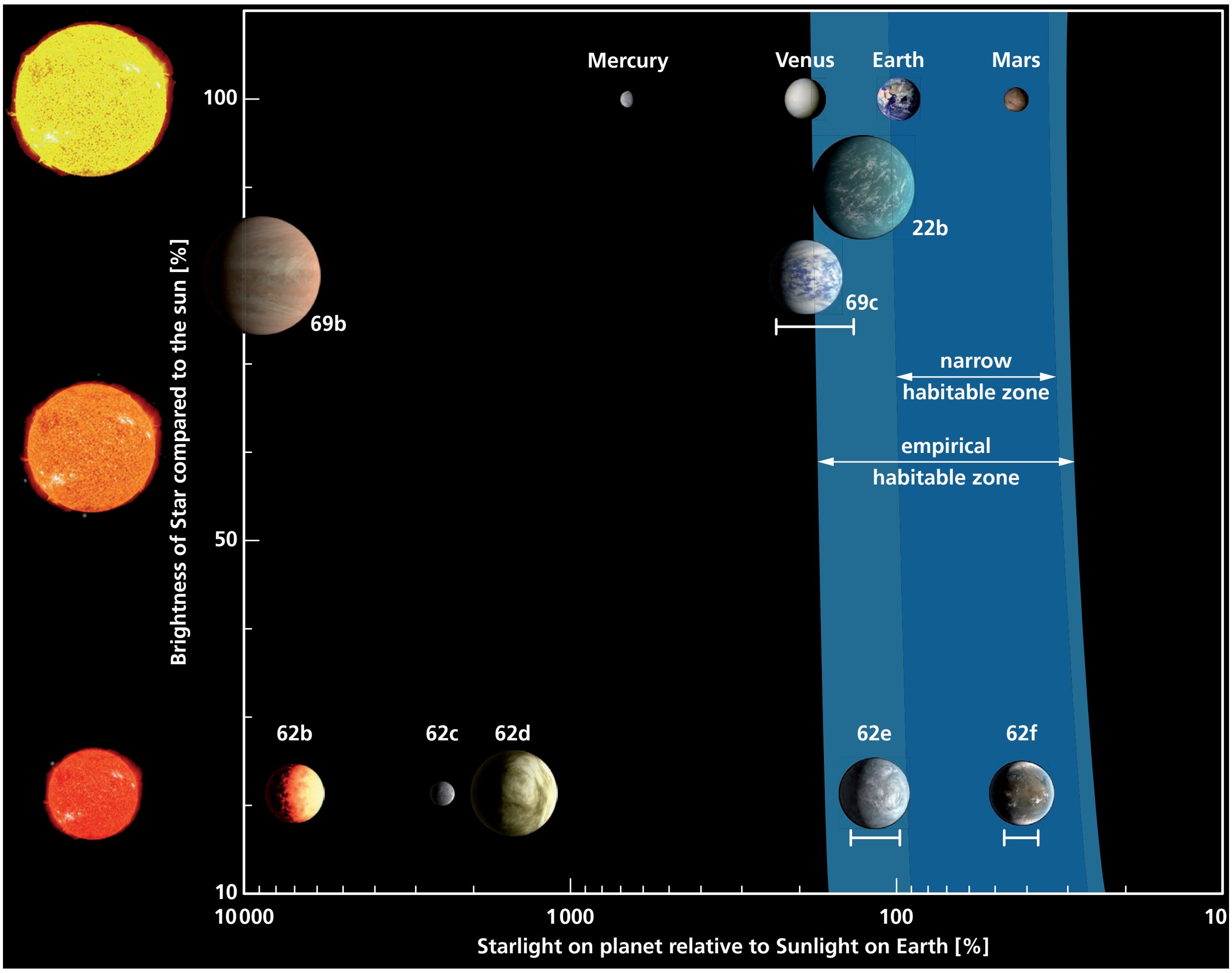


Fig. II.5.3: The habitable zone (in which liquid water on a planet's surface can exist) for different types of stars. The inner planets of our Solar System are shown on top, with Earth and Mars in the habitable zone. Kepler-62 is a notably cooler star, and Kepler-62e and -62f are in its habitable zone. For Kepler-69c, another planet announced by NASA, the error bars for the star's radiation are such that it could possibly in the habitable zone as well. Kepler-22b, the smalles planet found in a habitable zone before the recent discoveries, is very likely a Mini-Neptune, and not a solid planet. In what is denoted the empirical habitable zone, liquid water can exist on the surface of a planet if that planet has sufficient cloud cover. In the narrow habitable zone, liquid water can exist on the surface even without the presence of clouds.

versions of Neptune. One planet that is known to be a mini-Neptune, and provides a cautionary example, is Kepler-11f, with a mass around 2.3 times that of the Earth, but 2.6 times the Earth's radius.

The habitability analysis assumes that the planets Kepler-62e and -62f are indeed rocky, as their radius would indicate. If one now additionally assumes that water exists on their surface, and that their atmospheric composition is similar to that of Earth, dominated by nitrogen, and containing water and carbon dioxide, it is possible to make deductions about the planet's habitability: Under those assumptions, both planets could have liquid water on their surface, if certain additional conditions were to be met: Kepler-62f receives less radiation energy from its host star than the Earth from the Sun and therefore needs more greenhouse gases (such as carbon dioxide) than Earth to remain unfrozen. Kepler-62e, on the other hand, is closer to its star, and would need an increased cloud cover – sufficient to reflect some of the star's radiation – to allow for liquid water on it's surface.

Whether or not a planet could harbor life is judged by the possibility of liquid water existing on the planet. The astronomical criterion of habitability goes one step further and demands the possibility of water on the planet's *surface* – necessary for future remote observations to be able to detect whatever life might exist on the planet.

Habitability does not imply that the planet will be the spitting image of Earth. Notably, for planets with larger radii than Earth's, as in the case of these two new planets, the same relative chemical make-up would likely result in a water world, covered by a deep global ocean.

Habitability analysis does not prove that the planet in question is indeed habitable; it only shows whether or not, given suitable atmospheric conditions, the planet could be. Proof positive will be left to future telescopes, larger than those currently available, which should be able to analyze (spectroscopically) the “chemical fingerprints” of planetary atmospheres. An important part of the work of Kaltenegger and her collaborators involves model calculations that predict those chemical fingerprints for specific kinds of planets, such as Kepler-62e and Kepler-62f.

Eventually, such observations could even show chemical signatures characteristic of life on another world. Until these direct tests of habitability become available, we can only estimate planetary habitability on the basis of all available data– and on that score, the two newly discovered planets lead the field.

Lisa Kaltenegger

in collaboration with
William J. Borucki et al. (Kepler Science Team)

William J. Borucki et al.: “Kepler-62: A Five-Planet System with Planets of 1.4 and 1.6 Earth Radii in the Habitable Zone”. In: *Science* **340** (2013), pp. 587–590. DOI: 10.1126/science.1234702

Kaltenegger, L., D. Sasselov, S. Rugheimer: "Water Planets in the Habitable Zone: Atmospheric Chemistry, Observable Features, and the case of Kepler-62e and -62f". In: *Astrophysical Journal Letters* 775, 2, L47, 5, 2013

II.6 Star-formation like there is no tomorrow: NGC 253 and the limits to galactic growth

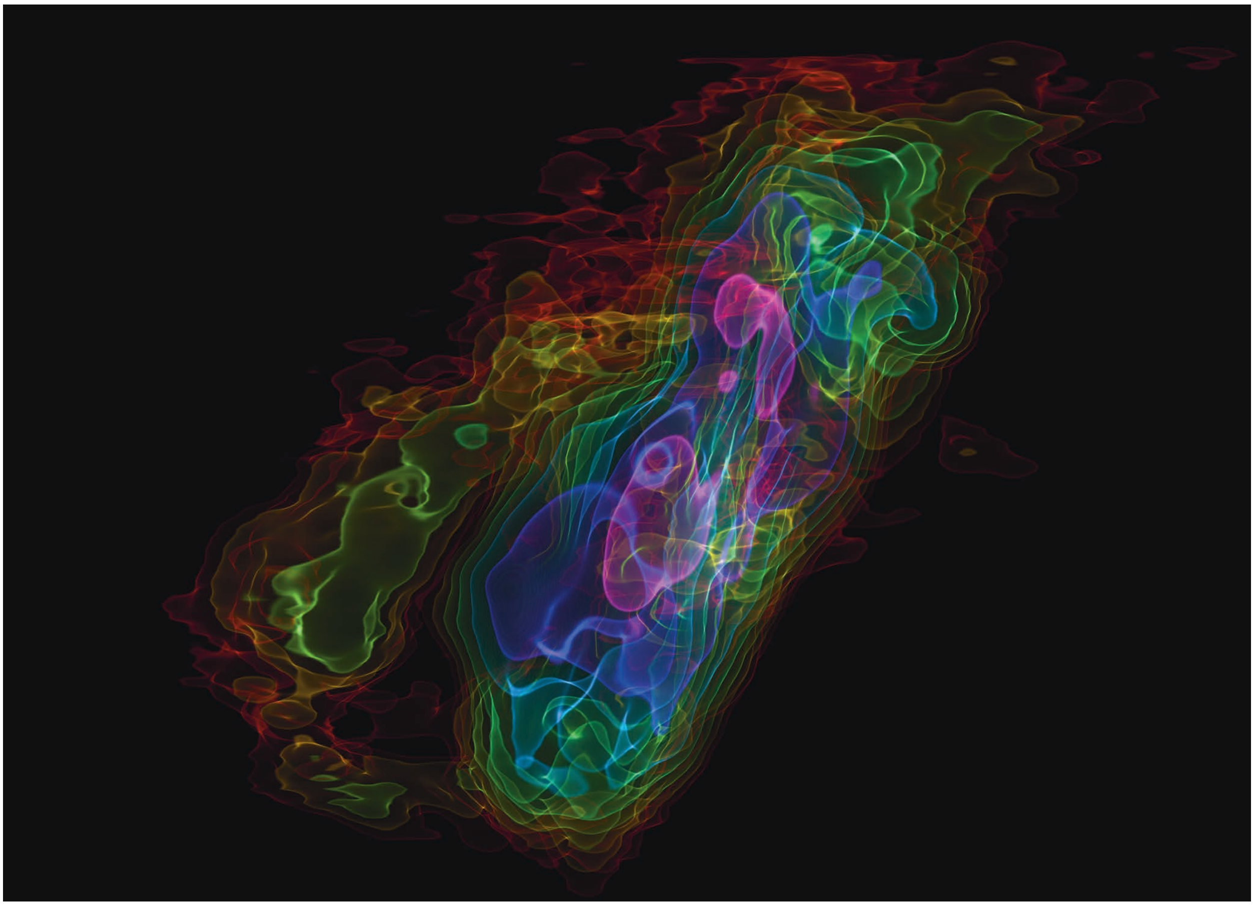
It havs long been assumed that when a galaxy produces too many stars too quickly, it greatly reduces its capacity for producing stars in the future. Astronomers including Fabian Walter from the Max Planck Institute for Astronomy were able to obtain the first detailed images of this type of self-limiting galactic behavior.

Galaxies – systems that contain up to hundreds of billions of stars, like our own Milky Way galaxy – are the basic building blocks of the cosmos. One ambitious goal of contemporary astronomy is to understand the way that galaxies evolve from the first proto-galaxies shortly after the big bang to the present. A key question concerns star formation: what determines the number of new stars that will form in a galaxy?

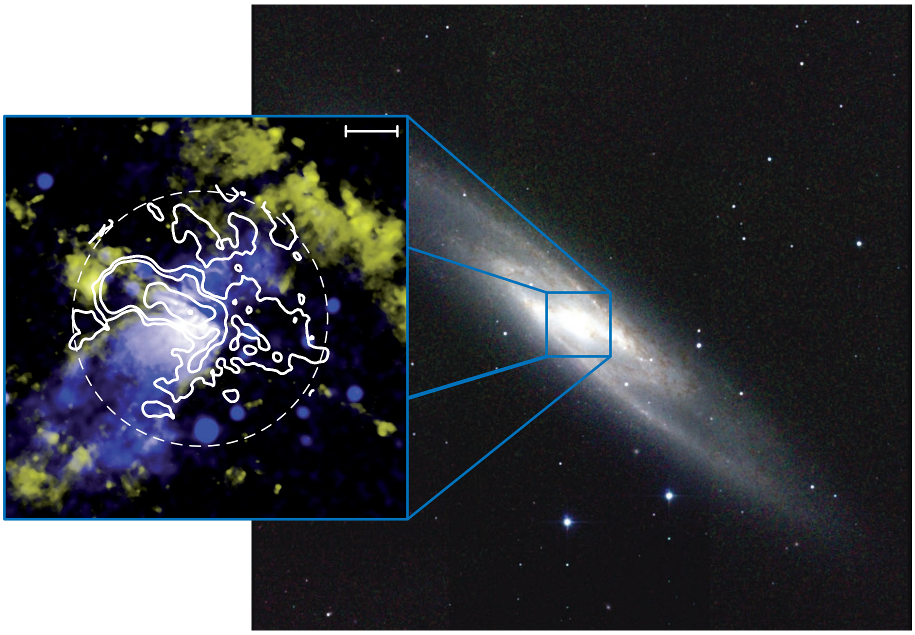
A key ingredient of current models of galaxy evolution are mechanisms by which ongoing star formation can actually inhibit future star formation: When new stars are formed, a certain fraction of them are very massive. Massive stars shine brightly, and their intense radiation drives "stellar winds", outflows of gas and plasma that can be sufficiently strong to push gas out of the galaxy altogether. Also, massive stars end their comparatively brief lives in spectacular explosions (supernovae), flinging their outer shells – and any additional material that might be in their way – out into space.

In consequence, intensive star formation, known as a "starburst", and the resulting formation of many massive stars, can hamper the growth of future generations of stars. After all, molecular gas that has been flung out of a galaxy cannot serve as raw material from which to fashion that galaxy's new stars. There is a limit to galactic growth.

Fig. II.6.1: False-color visualization of the data collected by ALMA of the starburst galaxy NGC 253. The color encodes information about the intensity of light received from the gas, from fainter light shown in red to brighter radiation in blue. This and similar visualizations helped the astronomers to identify the molecular outflow emerging from the central starburst in this galaxy. This image is the cover image of the July 25, 2013 issue of the journal *Nature*.



Credit: E. Rosolowsky (University of Alberta)



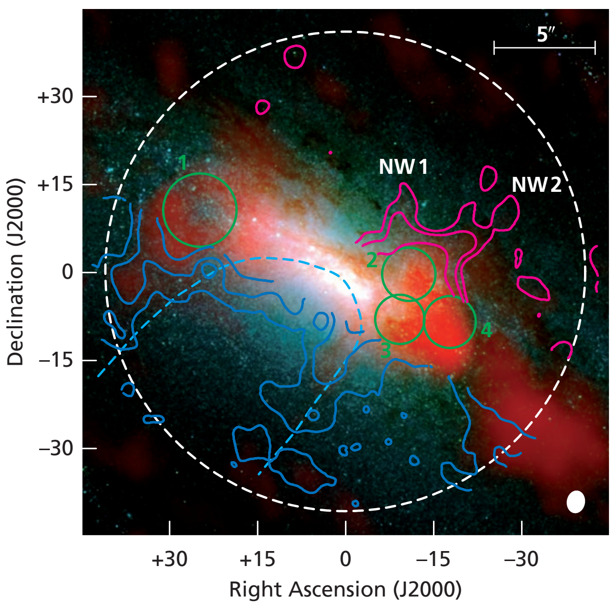
Credit: A. Bolatto (University of Maryland) / Background image: 2MASS / UMass / IPAC-Caltech / NASA / NSF

Fig. II.6.2: The spiral galaxy NGC 253. The inset is a false-color image which combines a wealth of information obtained from astronomical observations of the galaxy's central region. Blue color indicates X-ray emission from very hot plasma, which is ejected by the intense star-forming activitiy (starburst) that takes place in several places within the central region. Yellow indicates light that is characteristic for hydrogen (more precisely: ionized hydrogen recombining); it shows both plasma in the galactic wind and star-formation activity in the centre and the spiral arms of NGC 253. The white contour lines represent radiation from the molecular gas, as seen by ALMA. There is a concentration of gas in the very centre, which represents the raw material for the starburst. The smoking gun, however, is the extended molecular gas present along the edges of the outflow (whose X-ray emissions are shown in blue). Evidently, the central starburst activity is able to push large amounts of molecular gas away. This gas will not be available for star formation in the immediate future.

Outflows of molecular gas, resulting from starbursts, had been postulated for a long time. Observational evidence, however, was missing. This changed recently, when a team of astronomers led by Alberto Bolatto observed the starburst galaxy NGC 253. Bolatto, who is based at the University of Maryland at College Park, was also a long-term visitor at MPIA this year, with funding from the Alexander von Humboldt Foundation.

NGC 253, also known as the "Sculptor Galaxy", is a spiral galaxy located in the constellation Sculptor in the Southern sky. With a distance of 11 million light-years it is one of our closer intergalactic neighbors and the closest starburst galaxy visible from the southern hemisphere.

The astronomers observed NGC 253 using the international telescope array ALMA (Atacama Large Millimeter/Submillimeter Array), which was at the time still under construction in the Atacama desert in Chile. ALMA allows astronomers to map radiation with wavelengths in the millimeter/submillimeter range with un-



Credit: A. D. Bolatto et al.

Fig. II.6.3: Reconstructed molecular wind emission in NGC 253. The background image is a color composite of observations with the Hubble Space Telescope in the infrared bands J (blue) and H (green) and ALMA observations of carbon monoxide (red). The dashed white circle shows the field mapped with ALMA, while the filled white ellipse shows the resolution of the ALMA observations. The Cyan dashed line indicates the orientation of the outflow towards the south. The blue contour lines show the CO emission of the approaching part of the outflow (v = 73 to 273 km/s), while the magenta contour lines show the receeding part (v = 208 to 356 km/s). The contour levels correspond to 5, 10 and 30 Jansky km/s per beam. The green circles show the location and size of expanding molecular shells, presumably driven by combined stellar winds and, at later stages, by supernova explosions.

precedented detail. The astronomers mapped radiation from carbon monoxide molecules, which are closely associated with the molecular hydrogen that is essential to form new stars.

Additional data was taken with the 22-metre Mopra Radio Telescope, located near Coonabarabran, New South Wales, and for comparison, data obtained with the NASA/ESA Hubble Space Telescope, NASA's Chandra X-Ray Satellite, and at Cerro Tololo Inter-American Observatory was utilized.

In the central regions of NGC 253, where the most intense production of new stars takes place, the astronomers found indeed what they had been looking for: a telltale outflow of molecular gas at right angles to the galactic disk. Earlier studies using X-ray observations had already shown very thin and hot gas streaming out of those regions. But this was the first direct evidence that large amounts of molecular gas, the raw material for star formation, are caught up in the exodus – and thus the first direct evidence that these outflows indeed limit the galaxy's capacity for future star formation. The astronomers estimate that each year the galaxy ejects gas with a total mass of nine times that of our Sun. The ejected mass is about three times larger than the total mass of all stars produced by NGC 253 each year (which, in turn, is several times larger than the mass of all stars produced in our home galaxy, the Milky Way, each year).

The new results are also a prime example of how the availability of new and better instruments shape the future of astronomy. Astronomers had been studying the starburst region of NGC 253 and other nearby starburst galaxies for almost ten years. But before ALMA, there was no way for detailed observations like those that have now produced the "smoking gun" for NGC 253's self-limiting behavior.

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in collaboration with
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Adam K. Leroy (National Radio Astronomy Observatory [NRAO]),
Sylvain Veilleux (UMD),
Eve C. Ostriker (Princeton University),
Jürgen Ott (NRAO),
Martin Zwaan (European Southern Observatory),
David B. Fisher (UMD),
Axel Weiss (Max Planck Institute for Radio Astronomy),
and Erik Rosolowsky (University of British Columbia)

Alberto D. Bolatto et al.: "Suppression of star formation in the galaxy NGC 253 by a starburst-driven molecular wind" in *Nature* **499** (2013), pp. 450–453. DOI: 10.1038/nature12351

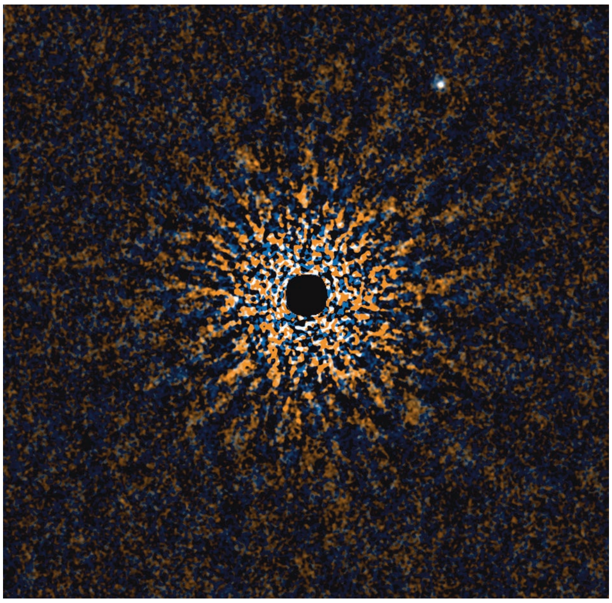
II.7 One step closer to imaging distant Solar systems: Subaru telescope snaps image of "cold Jupiter" GJ 504 b

Using the Subaru telescope on Hawai'i, a group of astronomers including MPIA scientists has taken an image of the jupiter-like planet GJ 504b. This is the first image of a planet orbiting a Sun-like star (spectral type G), and it is the coldest and could also be the lightest planet yet imaged – a key step towards the long-term goal of imaging star systems similar to our own Solar system.

As of 2013, astronomers had confirmed the existence of more than 900 exoplanets (that is, planets orbiting stars other than the Sun). But almost all of them had been detected indirectly – for instance by the pull they exert on their host star, or when they block part of their host star's light.

If hypothetical extraterrestrial astronomers were to observe our own Solar System with those indirect methods, they would miss out on a number of its most intriguing aspects. In particular, they would be likely to miss the slow-moving outer planets. This is where methods such as direct imaging of exoplanets – observations producing images on which the planet is clearly identifiable – come in. Such images also yield information about a planet's temperature and atmosphere. Whenever the image is accompanied by a spectrum, the result could be detailed information about the chemical composition of the planet's atmosphere; direct spectroscopy of exoplanets is, however, still in its infancy.

Fig. II.7.1: Near-infrared color composite images of a "second Jupiter" around the Sun-like star GJ 504 taken with the Subaru telescope. Light from the star, which would be in the center, has been suppressed mechanically and by image analysis methods. The planet is the little dot in the top right corner. This is the coldest and possibly the lightest exoplanet ever imaged, and the first image of a planet orbiting a Sun-like (G type) star.



Credit: NAOJ

For these reasons, astronomers (here on Earth) are keen on developing methods for direct imaging of exoplanets, and such methods are a key element of the long-term strategy to detect and examine distant analogues of our own Solar System. Obtaining such direct images is, however, a difficult task. Stars are much brighter than their planets (typically by a factor of a billion or more); using traditional observational techniques, the planet will be hidden in the glare of its host star. Only with sophisticated tricks – such as blocking out the star's light mechanically (coronagraphy) and combining several images in just the right way to reduce spurious signals – can astronomers obtain these images at all.

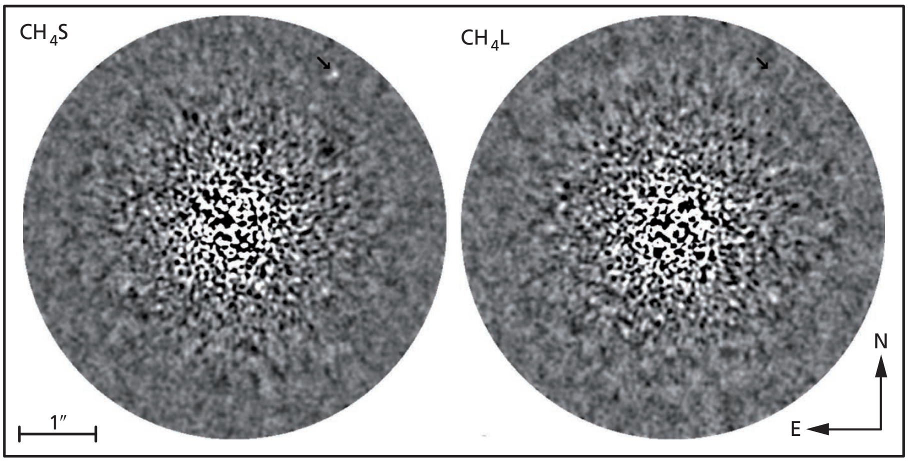
Now a group of astronomers led by Motohide Tamura (National Observatory of Japan [NAOJ] and Tokyo University), which includes several MPIA astronomers, has come an important step closer to detecting far-away analogues of our own planetary system. Using the Subaru Telescope in Hawai'i, they were able to obtain direct images of a Jupiter-like planet, GJ 504b. The 8.2 meter telescope is operated by the National Astronomical Observatory of Japan (NAOJ) and located on top of Mauna Kea, Hawai'i. The observations were made using the HiCIAO high-contrast imaging instrument and the IRCS infrared camera.

The planet orbits the star GJ 504 in the constellation Virgo, about 60 light-years from Earth. The distance of GJ 504b from its star amounts to 44 times the distance between the Earth and the Sun (44 AU). The planet's location within its star system is thus comparable to Netpune's position within our own Solar System.

This is the first image of a planet orbiting a Sun-like star (that is, a star of spectral type G); previous observations had targeted more luminous stars, which tend to host more massive planets, which in turn tend to be hotter and thus more easily detectable.

Estimates of the planet's mass are linked to estimates of the age of its host star. The estimate favored by most of the researchers would put the mass in the region of 3 Jupiter masses, which would make this the lightest planet yet imaged. Going by the observations, this is also the coldest exoplanet yet detected in an image.

The low temperature, and indications of fewer clouds, indicate that GJ 504b represents a new class of planetary atmosphere, which is expected to be similar to that of late T-type brown dwarfs in the same temperature range. The similarity can be expected to extend to the presence of



Credit: M. Janson et al.

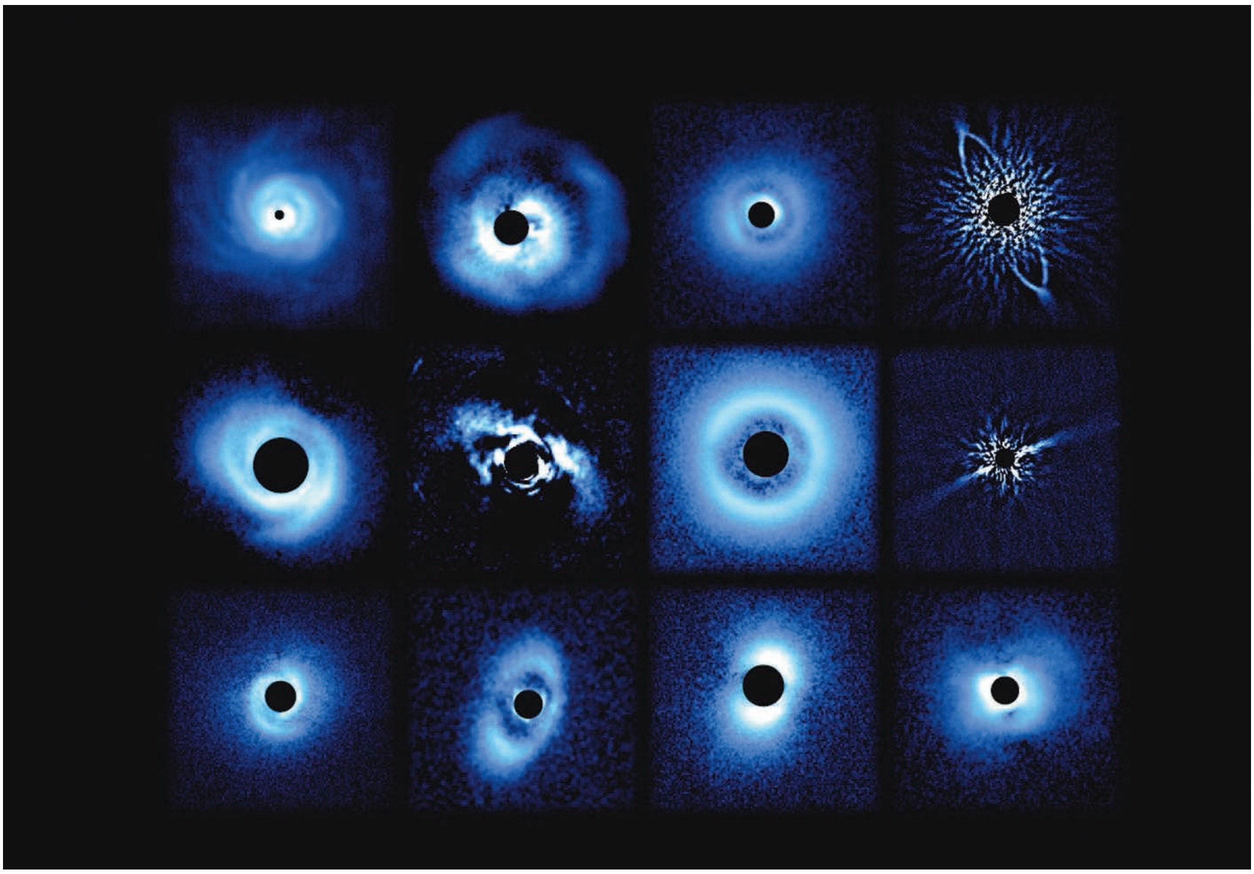
Fig. II.7.2: Image showing methane absorption in GJ 504b. The left image was taken through the CH_4S filter, outside the methane absorption band, the right through the CH_4L filter inside the absorption band. The planet is clearly visible in top right corner of the left image, but completely invisible in the right image, indicating significant methane absorption.

significant methane absorption. Indeed, in later study led by Markus Janson and again using the imaging capabilities of HiCIAO, deep methane absorption was detected in the planet's atmosphere.

The discovery was made as part of the SEEDS project ("Strategic Explorations of Exoplanets and Disks"). It comes at a time when SEEDS is looking back on completing the first half of the project's observing program – which has yielded remarkable images not only of planets, but also of the disks of gas and dust that surround young stars.

The Max Planck Institute for Astronomy is one of the co-founders of the SEEDS survey; part of its contribu-

Fig. II.7.3: Gallery of images of disks around young stars, imaged in the near-infrared by the Subaru telescope as part of the SEEDS project. Understanding these disks is an important part of understanding how planets form around stars.



Credit: NAOJ

tion is expertise in using 10 m-class-telescopes for this type of high-contrast imaging, which includes observing strategy and data reduction: the first such survey was performed with the NACO instrument at the European Southern Observatory's Very Large Telescope in Chile; NACO was co-developed at MPIA. The Planet & Star Formation department at MPIA also provides expertise in the physical modeling of exoplanets, which is used in interpreting the high-contrast images contained, and in deducing the planet's physical parameters.

Beth Biller, Thomas Henning (SEEDS Co-PI),
Wolfgang Brandner, Markus Feldt

in collaboration with
Masayuki Kuzuhara (University of Tokyo, NAOJ & Tokyo Institute of Technology),
Motohide Tamura (SEEDS PI, NAOJ),
Markus Janson (Princeton University)
and the SEEDS team

M. Kuzuhara et al.: "Direct Imaging of a Cold Jovian Exoplanet in Orbit around the Sun-like Star GJ 504". In *Astrophysical Journal* **774**, article id. 11, 2013. DOI: 10.1088/0004-637X/774/1/11

Markus Janson et al.: "Direct Imaging Detection of Methane in the Atmosphere of GJ 504 b". In: *Astrophysical Journal Letters* **778**, article id. L4, 2013. DOI: 10.1088/2041-8205/778/1/L4

II.8 Astronomers Observe Distant Galaxy Powered by Primordial Cosmic Fuel

Astronomers have detected cold streams of primordial hydrogen, vestigial matter left over from the Big Bang, fueling a distant star-forming galaxy in the early Universe. Profuse flows of gas onto galaxies are believed to be crucial for explaining an era 10 billion years ago, when galaxies were copiously forming stars. The discovery made use of a bright, distant quasar acting as a "cosmic lighthouse".

In the current narrative of how galaxies like our own Milky Way formed, cosmologists postulate that they were once fed from a vast reservoir of pristine hydrogen in the intergalactic medium, which permeates the vast expanses between galaxies. Approximately ten billion years ago, when the Universe was just one fifth of its current age, early proto-galaxies were in a state of extreme activity, forming new stars at nearly one hundred times their current rate.

Because stars form from gas, this fecundity demands a steady source of cosmic fuel. In order to be useful for star formation, gas needs to be comparatively cool. Gas will only collapse under its own gravity, forming a star, at temperatures not far above absolute zero, with typical temperatures around 10 – 100 K (about – 260 to 170 degrees Celsius); in warmer gas, collapse will be prevented by internal pressure of the gas.

That is why studies of star formation logistics are interested in cold and in cool gas, where cool gas in this context means gas with temperatures of up to tens of thousands of Kelvin. That might seem hot by everyday

Fig. II.8.1: Image of a galaxy (*center*) with incoming cold gas flow, produced by rendering the gas distribution in a supercomputer simulation of a forming galaxy. A stream of primordial inflowing gas is illuminated from behind by a distant background quasar (*lower left*; quasar added by an artist, along with the starry background). Using data collected from the largest optical telescopes in the world, researchers led by Neil Crighton (MPIA and Swinburne University of Technology) have now made the first unambiguous detection of this accretion of pristine gas onto a star-forming galaxy, that was previously theorized to exist based on cosmological simulations of galaxy formation. This simulation shown here was run by the Making Galaxies in a Cosmological Context (MaGICC) project in the GC theory group at MPIA.

Credit: MPIA/G. Stinson, A. V. Macciò

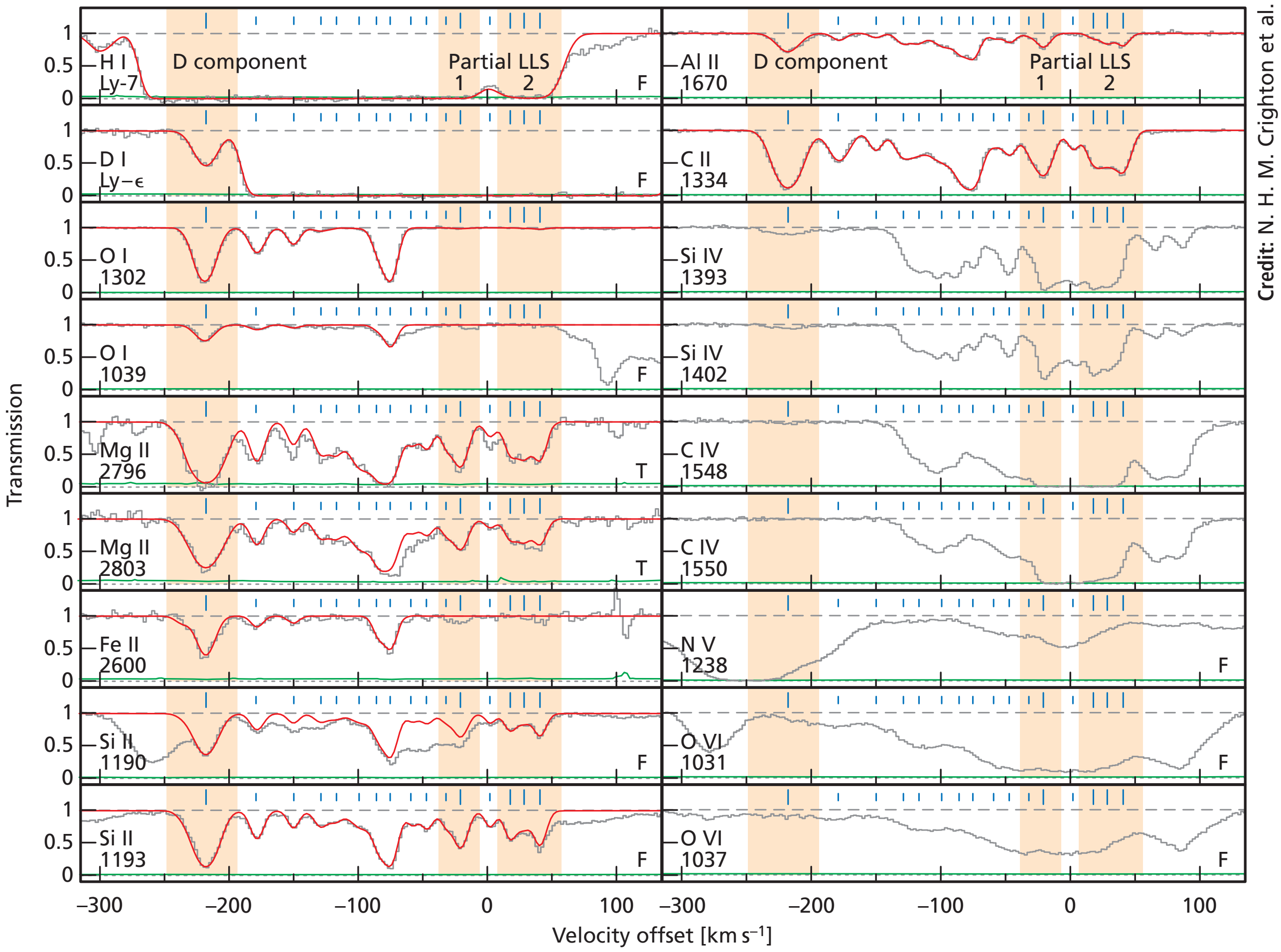


Fig. II.8.2: Spectra taken with the HIRES instrument at the Keck I telescope, showing metal transitions for the absorption system at $z = 2.44$. Wavelengths are given in terms of Doppler shifts relative to $z = 2.4391$. Shown are both the data and the best-fitting model. „F“ indicates blending with Lyman α-Forest, while „T“ indicates blending with spectral features of the Earth's atmosphere (telluric lines). Shaded regions were used to determine the amount of absorbing matter (column densities); greyed-out lines show regions that are heavily mixed with unrelated spectral lines.

standards – tens of thousands degrees Celsius! – but is still much colder than the temperatures of hot gas with temperatures of millions of Kelvins and above, which is thought to be the typical temperature of the majority of the gas around proto-galaxies.

This distinction is important: for hot gas to cool down sufficiently to serve as the raw material for star formation, inordinate amounts of time are needed – possibly even longer than the present age of the universe. Cool gas accreting from the intergalactic medium takes much less time to cool down to star-production levels, and supplies of cool gas thus play a fundamental role for star formation within the past billions of years.

But when gas from the intergalactic medium flows towards a galaxy, it will generally heat up considerably. As an analogy, imagine a public square full of people, and imagine that all those people suddenly rush towards a central location. As the crowd converges on their goal, it grows ever more densely packed, and people cannot help jostling each other. In a similar manner, infalling gas will, in general, grow ever more dense as it approaches a galaxy, its atoms jostling each other, raising the temperature of the gas in the process ("shock heating"). It takes such a long time for the resulting hot gas, heated to more than a million degrees Kelvin, to cool down that it is unlikely to play a significant role in fueling star-formation.

However, there is a different mode of gas flow. On scales of about ten million light-years and above, matter in the universe is not distributed homogeneously. Instead, the predominant matter component, dark matter, forms a complex network of long, thin filaments joining thickened nodes which is known as the cosmic web. The nodes of this web house the largest galaxies and their entourage of smaller companion galaxies.

Gas flowing along the filaments can avoid the crowding effects that lead to heating. In our human crowd analogy, this corresponds to a column of people marching towards a common goal in an orderly queue. The result are dense and narrow streams called "cold-accretion flows" of intergalactic matter onto galaxies, supplying the galaxies with cool gas that, after a modicum of further cooling, can serve as the raw material for star formation.

Supercomputer simulations performed over the past decade have predicted exactly that: galaxies forming, and being fed, as gas funnels onto galaxies along thin "cold streams". Like streams of snow melt feeding a mountain lake, those cold streams channel cool gas from the surrounding intergalactic medium onto galaxies, continuously topping up their supplies of raw material for star formation.

Testing these predictions has proven to be extremely challenging, because such gas at the edges of galaxies is so rarefied that it emits very little light. But there is a certain type of cosmic situation where, purely by coincidence, a distant object of a completely different type – a quasar – can be used to detect the presence of the gas.

Quasars constitute a brief phase in the galactic lifecycle, during which they shine as the most luminous objects in the Universe, powered by the infall of matter onto a supermassive black hole. From our perspective on Earth, there will be rare cases where a distant background quasar and a stream of primordial gas near a foreground galaxy are exactly aligned on the night sky. As light from the quasar travels toward Earth, it passes by the galaxy and through the primordial gas, before reaching our telescopes.

The cosmic gas selectively absorbs light at very specific frequencies which astronomers refer to as "absorption lines". The pattern and shape of these lines provide a cosmic barcode, which astronomers can decode to determine the chemical composition, density, and temperature of the gas.

Suitably exact alignments, which allow for the detection of absorption lines, are comparatively rare. To find them, the ENIGMA research group at MPIA has been conducting a large survey, led by ENIGMA group leader Joseph Hennawi. The survey comprises observations with the Large Binocular Telescope on Mount Graham in Arizona and with the FORS2 instrument at the European Southern Observatory's Very Large Telescope, and it also includes archival data: For many of the largest astronomical telescopes, observational data is archived and, after a certain time period that allows the principal observers exclusive access to their data, it is made publicly accessible.

The survey yielded a particularly interesting candidate: A galaxy, denoted Q1442-MD50, which is so distant that it took 11 billion years for its light to reach us, and signs of primordial infalling gas. The gas resides a mere 190 000 light-years from the galaxy – nearby, on galactic length-scales – and is revealed in silhouette in the absorption spectrum of the more distant background quasar QSOJ1444535+291905.

Hennawi's group then began to analyze the system in detail, with Neil Crighton (formerly a postdoc at MPIA; now at Swinburne University of Technology, Melbourne) taking the lead. Their analysis used archival observations of the background QSOJ1444535+291905 taken with the HIRES echelle spectrograph at the 10m (segmented mirror) Keck I telescope on Hawai'i. The foreground galaxy had been discovered by Charles Steidel, Gwen Rudie (California Institute of Technology) and collaborators using the LRIS spectrograph on the same telescope.

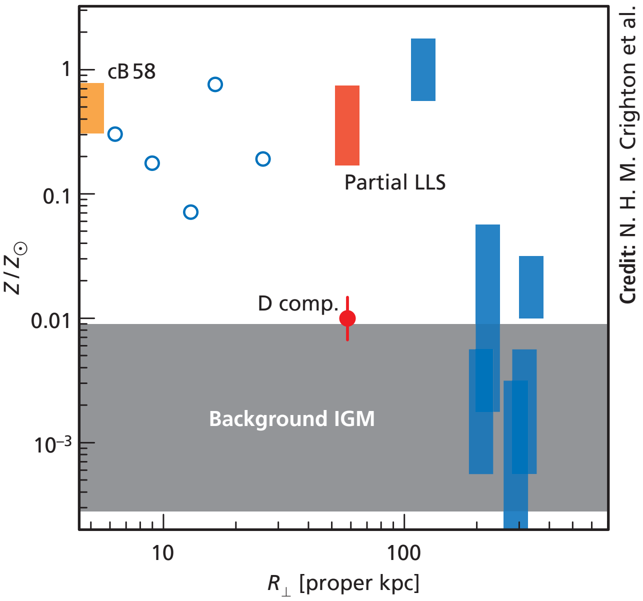


Fig. II.8.3: Metallicity (fraction of elements heavier than helium) for various gas clouds at similar redshifts $z = 2.5$ as the system studied here, ordered by their transverse distance from the source providing the backlight. Yellow: Interstellar medium of the lensed star-forming galaxy (Lyman-break galaxy) cB58. Red: the two components of the system under study here; the red circle corresponds to the low-metalllicity component, probably corresponding to the stream of primordial fuel.

The absorption lines from the gas show the cloud's chemical composition. In particular, they show the presence of heavier chemical elements. Astronomers collectively call these heavier elements – that is everything other than hydrogen and helium – "metals". What these metals have in common is that all of them are produced by nuclear fusion inside stars or by nuclear processes in supernovae explosions. Pristine gas, left over nearly unchanged from the big bang phase, will contain next to none of these heavier elements; gas that has formed stars in a galaxy will contain a significant amount.

The gas studied by Crighton et al. has several different components moving at different speeds towards or away from us, which shows that these must be different gas clouds along our line of sight. One of the clouds contains very few heavier elements – between 0.7 and 1.5% the amount found in our Sun – and, crucially, it contains significant amounts of the hydrogen isotope deuterium (hydrogen with one extra neutron in the nucleus). Because the hostile physical conditions in the centers of stars would destroy the fragile deuterium isotope, the gas can never have been part of a star. In other words: The discovery of deuterium in the gas confirms that the gas falling onto the galaxy is indeed pristine material left over from the Big Bang.

Compared with similar observations over the last years, the new discovery is a significant step forward. While in 2011, Fumagalli, O'Meara and Prochaska had reported the detection of pristine gas clouds (no discernible elements other than hydrogen) via absorption lines in the light of a distant quasar, there was no nearby galaxy involved.

While in July 2013, Nicolas Bouché and collaborators had published an observation of an absorption system consisting of a gas cloud, an associated galaxy, and a background quasar illuminating the gas cloud, there was no way of telling whether or not that gas was indeed pristine: The kinematics of the cloud were consistent with accreting gas, but that gas contains a factor of ten higher proportion of heavy elements (metals) than the Crighton et al. system. Therefore, it may have been produced by gas stripped from the nearby galaxy, or gas inside a smaller satellite galaxy.

The new system is the first discovery in which all the elements fit together: The galaxy is vigorously forming stars, and the gas properties clearly identify the gas as pristine – left over from the early universe shortly after the big bang.

The fact that this was not a chance discovery, but instead the result of a systematic search, is significant as well, as it allows the researchers to estimate how common such coincidences are. In this case, the astronomers had to search a mere 12 quasar-galaxy pairs to find their example. This rate is in rough agreement with the predictions of supercomputer simulations of galaxy formation.

The astronomers' long-term goal is to find about ten similar examples of these cold flows, which would allow for a much more detailed comparison of their observations with the predictions of numerical models. To this end, they are currently searching for more quasar-galaxy pairs using the Large Binocular Telescope in Arizona and the Very Large Telescope of the European Southern Observatory (ESO) in Chile. But even on its own, the discovery and analysis have provided a key piece of the puzzle that is galaxy formation.

Neil Crighton (now Swinburne University)
and Joseph F. Hennawi

in collaboration with
J. Xavier Prochaska
(University of California at Santa Cruz)

Neil H. M. Crighton, Joseph F. Hennawi & J. Xavier Prochaska: "Metal-poor, Cool Gas in the Circumgalactic Medium of a $z = 2.4$ Star-forming Galaxy: Direct Evidence for Cold Accretion?". In: *Astrophysical Journal Letters* **776**, article id. L18, 2013. DOI: 10.1088/2041-8205/776/2/L18

II.9 Blurring the lines between stars and planets: Lonely planets offer clues to star formation

Astronomers have captured an image of an unusual free-floating planet. As the object has no host star, it can be observed and examined much easier than planets orbiting stars, promising insight into the details of planetary atmospheres. Can an object with as low a mass as this have formed directly, in the same way that stars form? Independent observations of a similar but much younger free-floating object show that it has indeed a substantial disk of at least 10 Earth masses and is drawing material from its surroundings just like a young star.

For the ancients, the distinction was clear: planets are the "wandering stars", while fixed stars form a fixed pattern. Those simple times are long gone, though. Take our modern view of stars: gigantic incandescent nuclear furnaces, emitting substantial amounts of light. These can be distinguished from planets, which have considerably lower masses than stars, and which do not themselves shine brightly, but instead reflect their host stars' light. Stars are formed in the collapse of gigantic clouds of gas; planets are formed in disks of gas and dust around their nascent host stars. In between, however, is the somewhat more ambiguous class of brown dwarfs: intermediaries between planet and star, more massive than a planet, but with insufficient mass for nuclear fusion to ignite in the object's core, turning it into a star.

Now, two new discoveries have blurred the border between these kinds of object even further. They show that free-floating objects with planet-like masses very likely form in the same way as stars.

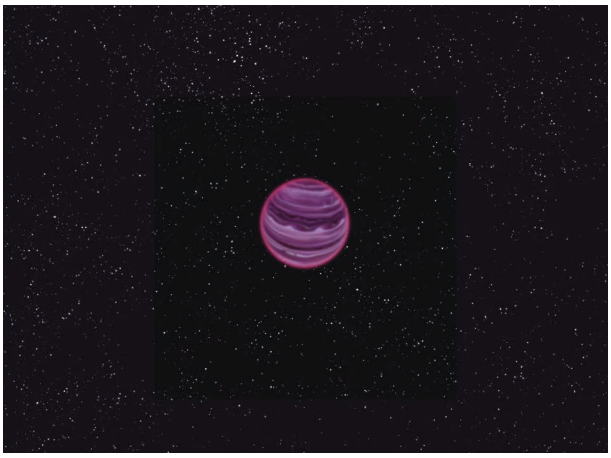
The first discovery was made by an international team of astronomers led by Michael Liu from the University of Hawaii: an exotic young object PSO J318.5-22, with a mass six to eight times that of the gas giant Jupiter, which is floating in space on its own – no host star in sight.

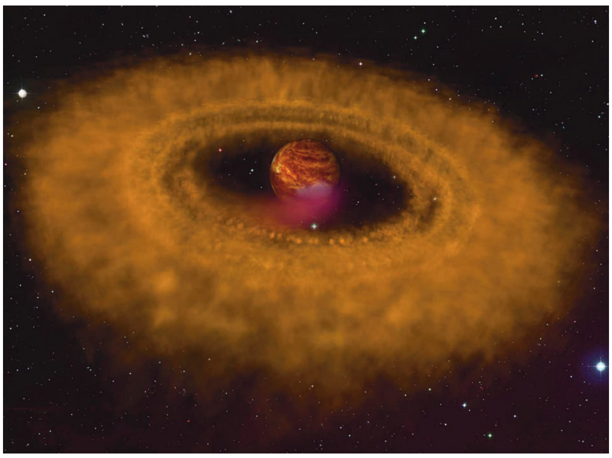
The object was discovered during a systematic search for brown dwarfs using the Pan-STARRS 1 (PS1) wide-field survey telescope on Haleakala, Maui. PS1 was, at the time, engaged in a survey which scanned the sky every night, producing the equivalent of 60 000 iPhone photos each time. The total dataset at the time amounted to about 4000 Terabytes. MPIA was one of the partners in that survey.

For the brown dwarf search, it was crucial that PS1 employed a suitably sensitive camera. Due to their relatively cool temperatures, brown dwarfs are very faint and have very red colors; the PS1 camera was sufficiently sensitive to detect the faint heat signatures of these objects. This was also the way PSO J318.5-22 was identified. From the very first, it stood out as an oddball, redder than even the reddest known brown dwarfs.

Intrigued, Liu and his colleagues, including MPIA's Niall Deacon, followed up the PS1 discovery with multiple telescopes on the summit of Mauna Kea on the island of Hawaii: Infrared spectra taken with the NASA Infrared Telescope Facility and the Gemini North Telescope

Fig. II.9.1: *Left:* Artists impression of the solitary object PSO J318.5-22 discovered by a group of astronomers led by Michael Liu from the University of Hawaii, and including Niall Deacon from the Max Planck Institute for Astronomy. The planet has six times the mass of Jupiter, and does not orbit a star – making it an ideal target for detailed study. *Right:* Artists impression of the solitary object OTS 44. Detailed studies by a team led by Viki Joergens showed that this object is forming in the same way stars do – by accreting matter at significant rates from a massive surrounding disk.





Credit: MPIA/V. Ch. Quetz (left), A. M. Quetz (right)

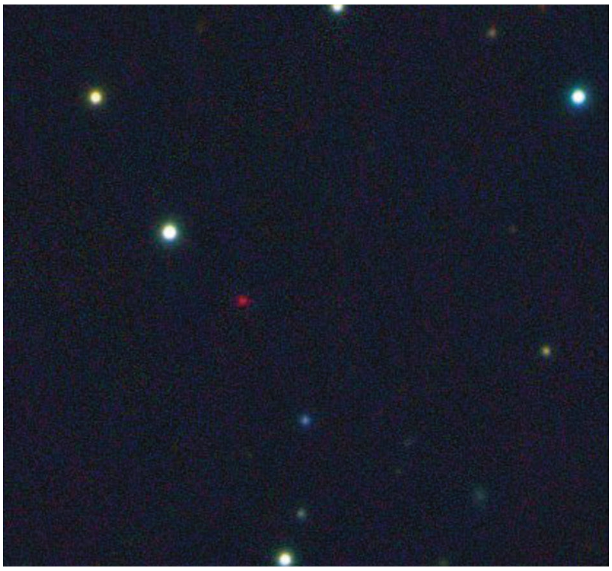


Fig. II.9.2: Discovery image of the solitary object PSO J318.5-22 observed (reddish dot) by a group of astronomers led by Michael Liu from the University of Hawaii, and including Niall Deacon from the Max Planck Institute for Astronomy. (Image size: 125 arc seconds on a side.)

showed that PSO J 318-22 was likely not a brown dwarf, based on signatures in its infrared light that are best explained by it being young and low-mass.

PSO J318.5-22 is located in the constellation Capricorn, and by regularly monitoring its position for over two years with the Canada-France-Hawaii Telescope, the astronomers were able to measure directly its distance from Earth. Based on this distance, about 80 light-years, and the object's motion through space, the team concluded that PSOJ318-22 belongs to a collection of young stars called the Beta Pictoris moving group, which formed about 12 million years ago. In fact, the eponymous star of the group, Beta Pictoris, is orbited by its own young gas-giant planet.

What is special about the new-found object are not its physical properties – it's its solitary status. After all, between 1995 and 2013, astronomers had found nearly a thousand extrasolar planets – but mostly by indirect methods, detecting a wobbling or dimming of the host stars induced by the planet. Only a handful of planets have been directly imaged, all of which are around young stars (less than 200 million years old).

PSO J318.5-22 is very similar in mass, color, and energy output to those few directly imaged planets. But it is much easier to study. For ordinary planets, the host star's glare makes detailed direct observations highly challenging. PSO J318.5-22 has no such handicap, and the researchers hope it will provide an unprecedented view into the inner workings of gas-giant planets like Jupiter in an early phase of their evolution.

With just six to eight times the mass of Jupiter, PSO J318.5-22 is one of the lowest-mass free-floating objects known, perhaps the very lowest. Ordinary planets are formed in a disk of gas and dust surrounding the embryo of the star they will eventually orbit. But how do solitary objects like this come into existence?

Can objects this low-mass – free-floating planets and brown dwarfs in general – form in the same way as ordinary stars? An in-depth study of a different object, published at the same time by another group of astronomers which is led by MPIA's Viki Joergens, provides valuable evidence that they do.

Joergens and her team studied an object called OTS 44, which is only about 2 million years old – in terms of stellar or planetary time-scales a newborn baby.

This object had first been identified as very low-mass object by Oasa, Tamura and Sugitani in 1999; the abbreviation 'OTS' used in the name corresponds to these researchers' combined initials. OTS 44 was first unambiguously identified as a substellar object by Kevin Luhman in 2004. Luhman showed that it has a mass close to the planetary border, which was confirmed later by Mickaël Bonnefoy (MPIA). It is at the moment not possible to determine the exact mass of OTS 44; estimates are in the range of 6 to 17 Jupiter masses with an average of 12 Jupiter masses (marginally more massive than PSO J318.5-22).

OTS 44 is also floating through space without a close companion – but in a particularly interesting part of space: OTS 44 is a member of the Chamaeleon star forming region in the Southern constellation Chamaeleon, at a little over 500 light-years from Earth, where numerous new stars are born from the collapse of dense clouds of gas and dust. And interestingly, just like a young star, OTS 44 is itself surrounded by a disk of gas and dust.

As Joergens and colleagues were able to show, the birth of this object isn't quite over yet: When the astronomers observed OTS 44 in the near-infrared using the SINFONI spectrograph at ESO's Very Large Telescope in Chile and discovered strong Hydrogen emission in the so-called Paschen beta line, which is evidence that OTS 44 is drawing material from the surrounding disk at a significant rate.

They also found that the amount of material that is accumulated by the object varies with time. The team analyzed in addition an optical spectrum of OTS 44 taken by Kevin Luhman with the IMACS spectrograph at the Magellan I telescope. They find also in this spectrum strong Hydrogen emission of OTS 44 – in this case in the so-called H-alpha line. This is further evidence that material is still falling onto OTS44 from its disk.

Furthermore, the team combined data from numerous telescopes including data taken with the Herschel Space Observatory by Paul Harvey, Thomas Henning (MPIA) et al. and carefully studied the amount of light coming from OTS 44 at all wavelengths from the optical to the near-infrared and far-infrared. They carefully constructed a model of the free-floating planetary mass

Credit: M. C. Lin et al.

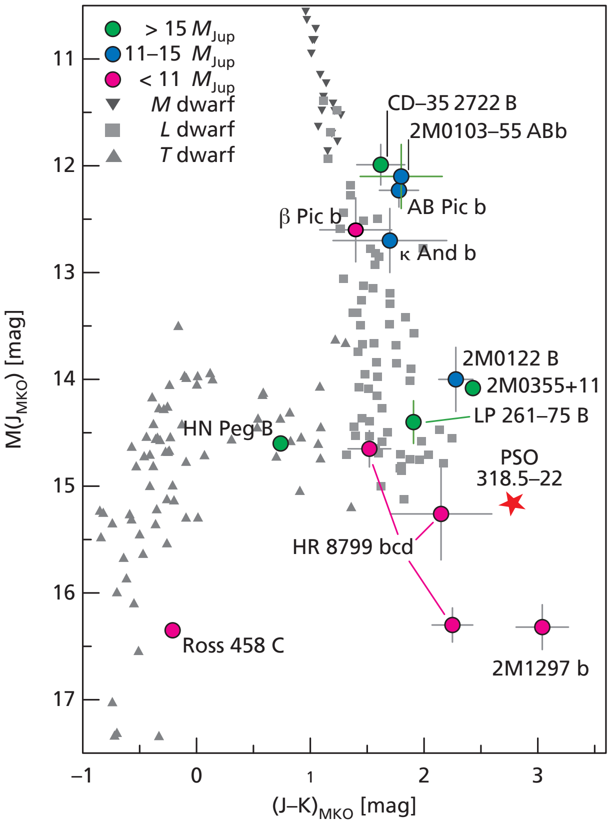


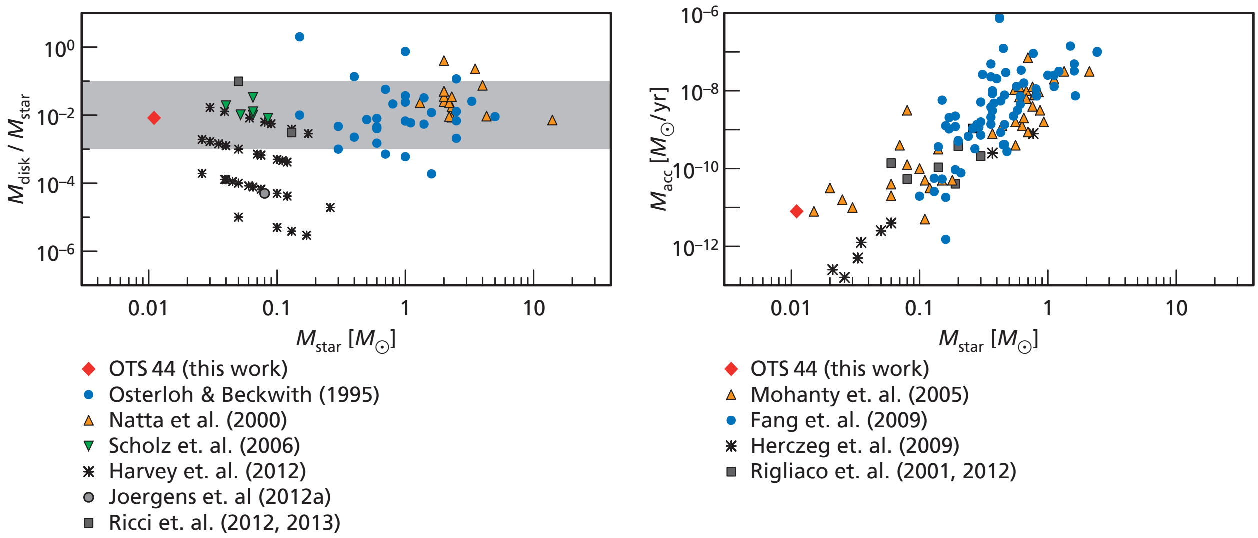
Fig. II.9.3: Comparison between the newly discovered PSO J318.5-22 with other substellar objects (based on compilations by Dupuy & Liu 2012, Bowler et al. 2013, and references therein; AB Pic b from Biller 2013). On the x axis, a specific infrared color; on the y axis: each object's absolute brightness (magnitude) in one specific infrared band (J_{MKO}). PSO J318.5-22 is very red and faint compared to field L dwarfs, with magnitudes and colors comparable to the planets around HR 8799 and 2MASS J1207-39. (The measurement error for PSO J318.5-22 is smaller than the symbol representing the object.)

object and its surrounding material and showed that the disk surrounding OTS 44, traces of which had been found earlier by Luhman with the Spitzer telescope, is quite substantial, with at least 10 times the mass of the Earth. In this effort, they used theoretical models devised by France Allard for the contribution of the central object and models by Sebastian Wolf and Yao Liu for the contribution of the disk.

Both the substantial disk and the infalling material (accretion) are telltale signs of the standard mode of star formation – an indication that there is no fundamental difference between the formation of a low-mass objects such as OTS 44 and an ordinary star. OTS 44 probably has the lowest mass of all objects where disk and infalling material have been detected, indicating that, when it comes to star formation, the same processes appear to be at work all the way down to planetary mass scales.

Such objects do not fall clearly into any of the existing categories. A star is an object sufficiently massive that, after it is formed, nuclear fusion (hydrogen burning) starts in the object's core. A brown dwarf is an object that does not reach the required mass and, hence, does not experience substantial hydrogen burning in its core – a "failed star". It does, going by a definition set by the International Astronomical Union, have sufficient mass, though, for heavy hydrogen (deuterium) to start fusion reactions in its outer layers – for a limited time. This distinguishes brown dwarfs from planets, in which no such fusion reactions take place. The minimum mass for deuterium fusion to happen is thought to lie around 13 Jupiter masses. By that definition, both OTS 44 and PSO J 318.5-22 could be high-mass planets, albeit of an unusual, lonely type, without a host object. If you want to play it safe, you can talk, more generally, about free-floating planetary-mass objects.

Fig. II.9.4: *Left:* Relative disk mass (ratio of disk mass and stellar mass) vs. mass of the central star for stars and brown dwarfs including OTS 44 (*red diamond*). *Right:* Mass accretion rate versus central mass of stars and brown dwarfs including OTS 44 (*red diamond*).



Credit: V. Joergens et al.

A number of astronomers have argued for a different definition, going by the way these objects are formed. For them, brown dwarfs are distinguished in that they form in the same way as stars – from the collapse of a cloud of gas and dust; not inside a disk surrounding a young star. By that definition, OTS 44 and PSO J 318.5-22 would both be extremely low-mass brown dwarfs. In any case, the situation has turned out much more complicated – and intriguing! – than our ancestors could have imagined.

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in collaboration with Yao Liu (Purple Mountain Observatory), Sebastian Wolf (University of Kiel), Gael Chauvin (Institute of Planetology & Astrophysics Grenoble), Patricio Rojo (University of Chile), Michael Liu, Eugene Magnier (both IfA), Katelyn Allers (Bucknell University), Trent Dupuy (Harvard-Smithsonian Center for Astrophysics), and Michael Kotson and Kimberly Aller (University of Hawaii at Manoa)

Michael C. Liu et al.: "The Extremely Red, Young L Dwarf PSO J318.5338-22.8603: A Free-floating Planetary-mass Analog to Directly Imaged Young Gas-giant Planets". In: *Astrophysical Journal Letters* **777**, article id. L20, 2013. DOI: 10.1088/2041-8205/777/2/L20

Viki Joergens et al.: "OTS 44: Disk and accretion at the planetary border". In: *Astronomy and Astrophysics* **558**, article id. L7, 2013. DOI: 10.1051/0004-6361/201322432

II.10 Most distant gravitational lens helps weigh galaxies – but also deepens a galactic mystery

Astronomers have found the most distant gravitational lens yet – a galaxy that, as predicted by Albert Einstein's general theory of relativity, deflects and intensifies the light of an even more distant object. The discovery provides a rare opportunity to directly measure the mass of a distant galaxy. It also indicates that astronomers might have well have underestimated quite substantially the number of small, very young galaxies in the early universe.

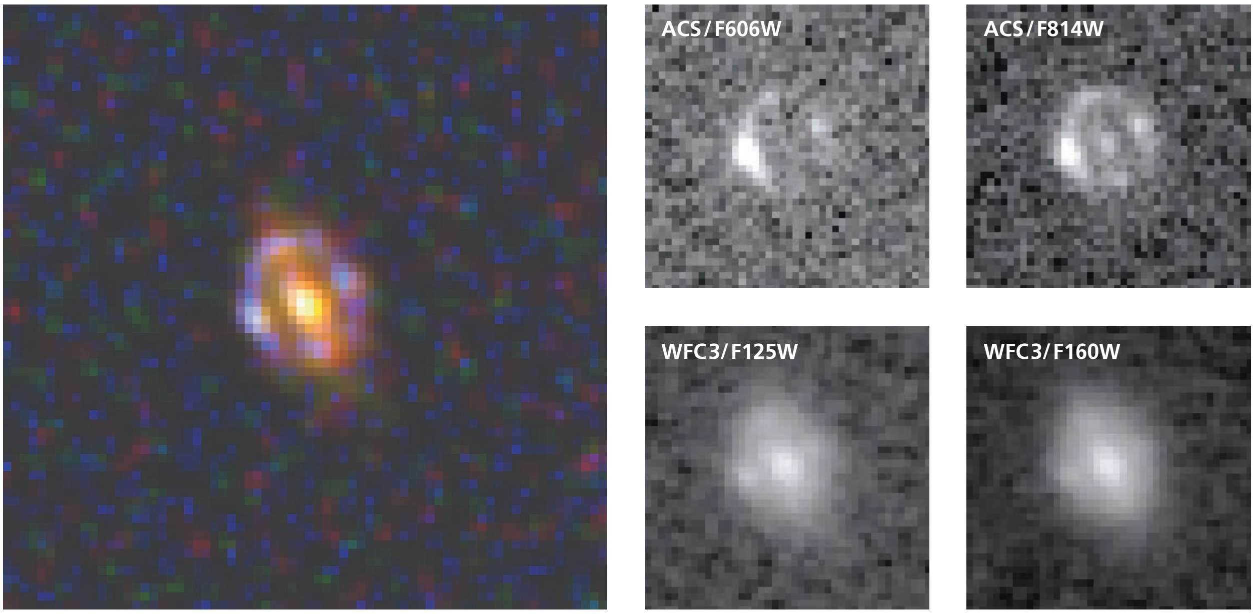
Light is affected by gravity, and light passing a distant galaxy will be deflected as a result. Since the first find in 1979, numerous such gravitational lenses have been discovered. In addition to providing tests of Einstein's theory of general relativity, gravitational lenses have proved to be valuable tools. Notably, one can determine the mass of the matter that is bending the light – including the mass of the still-enigmatic Dark Matter, which does not emit or absorb light and can only be detected via its gravity. Also, the lens magnifies the background light source, acting as a "natural telescope" that allows astronomers a more detailed look at distant galaxies than what is normally possible.

Gravitational lenses consist of two objects: One that is further away and supplies the light, and the other, the lensing mass or gravitational lens, which sits between us and the distant light source, and whose gravity deflects the light. When the observer, the lens, and the distant light source are precisely aligned, the observer sees an "Einstein ring": a perfect circle of light that is the projected and greatly magnified image of the distant light source. If the alignment is less than precise, the result are multiple images of the distant source, often distorted into arcs.

All the configurations where an Einstein ring, multiple images or arcs are visible are known as strong gravitational lenses. On a cosmological scale, weaker distortion effects ("weak lensing"), caused by the large-scale inhomogeneities of matter distribution in the universe, but not traceable to specific objects, can be detected.

Finding the most distant strong gravitational lens known to astronomy was a chance discovery by MPIA's Arjen van der Wel, who had been reviewing observations from an earlier project. The observations had been made with the LUCI near-infrared imager / spectroscope at the

Fig. II.10.1: *Left:* quadruple gravitational lens J 1000+0221 with an Einstein radius of 0.″35. The false-color image is generated using HST/WFC3 imaging from CANDELS (F125W in green, and F160W in red) and HST/ACS imaging from COSMOS and CANDELS (F814W in blue). These individual images were processed with the Lucy–Robertson deconvolution algorithm. The lensing galaxy is a flattened galaxy with little or no star formation and a stellar mass of $\sim 6 \times 10^{10} M_\odot$. Its redshift of $z = 1.53 \pm 0.09$ makes this galaxy the most distant strong galaxy lens discovered to date. The source, magnified by a factor 40, is a young, strongly starbursting galaxy with a very small stellar mass ($\sim 10^8 M_\odot$). *Right:* HST/ACS and HST/WFC3 images (2.″4 × 2.″4) of the lens–source system. A Sérsic model is produced based on the F160W image, masking the annulus containing the source images. This Sérsic model is scaled and subtracted from the other images.



Credit: MPIA / A. van der Wel et al.

Large Binocular Telescope (LBT) in Arizona, for which MPIA is one of the partners. The project's goal had been to measure masses of old, distant galaxies by looking at the motion of their stars. Among the galaxy spectra – the rainbow-like split of a galaxy's light into myriads of different shades of color – he noticed a galaxy that was decidedly odd. It looked like an extremely young galaxy, but at an even larger distance than the project's search criteria – in other words: this particular object shouldn't even have been part of the observing program in question.

Van der Wel followed up on the spectra by looking at images taken with the Wide Field Camera 3 and the Advanced Camera for Surveys on board the Hubble Space Telescope (HST/WFC3 and HST/ACS) as part of the CANDELS survey, and at HST/ACS images from the COSMOS survey. He applied particularly sophisticated algorithms to remove the distortion by the telescope optics ("deconvolution") to obtain the clearest images possible.

The object looked like an old galaxy, a plausible target for the original observing program, but with some irregular features which, he suspected, meant that he was looking at a gravitational lens. Combining the available images and removing the haze of the lensing galaxy's collection of stars, the result was very clear: an almost perfect Einstein ring, indicating a gravitational lens with very precise alignment of the lens and the background light source (0.01 arcseconds).

Based on distance measurements of the lens and the background source, van der Wel concluded that 11.8 billion years ago a very young galaxy emitted light roughly in our direction. Then, 2.4 billion years later, a massive galaxy acting as gravitational lens, deflected the path of the light by 0.35 arcseconds, and another 9.4 billion later the light reached our telescopes. The light deflection happened such that 40 times more light arrived than would have been the case in the absence of the lens. The 9.4 billion year light travel time, corresponding to redshift $z = 1.53$, turns out be the largest for any known galaxy lens, breaking the previous record for a strong gravitational lens by almost 2 billion years.

The previous record holder, the triple radio source MG 2016+112, had been found thirty years ago (Lawrence et al. 1984; Schneider et al. 1986), and it took less than 8 billion years for its light to reach us ($z = 1$). Since then, a large number with redshifts z around 1 had been discovered, but none that were further distant; in this, we are not counting a handful of tentative $z \sim 1.2$ candidates (More et al. 2012) for which it is doubtful whether or not they are gravitational lenses at all.

Not only is this a new record, but the object also serves an important purpose: The mass of a lensing system can be deduced from the distortion of the lensed image. This provides an independent test for astronomers' usual methods of estimating distant galaxy masses, which are based on colors/luminosities of galaxies; those quantities, in turn, are related to the total mass of the galaxies'

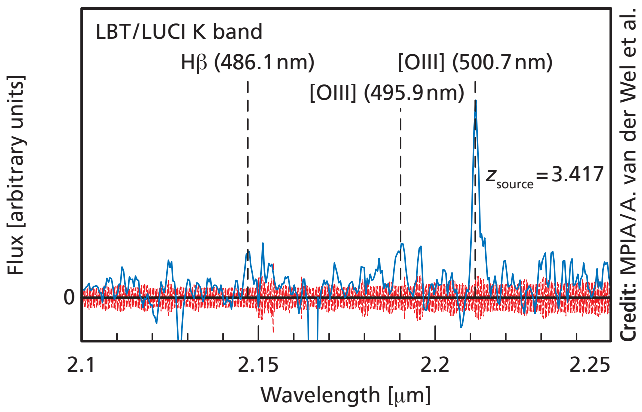


Fig. II.10.2: Infrared (K band) spectrum of J 1000+0221 taken with the LUCI instrument at the Large Binocular Telescope. The continuum, barely above zero, is from the lens at redshift $z = 1.53$. The three emission lines indicated by the dashed lines, all detected with great certainty (confidence of 10σ or better) are from the source at a redshift of $z = 3.417$. The strength of the emission lines and the ratio of the [OIII] line strength relative to that of Hβ imply a very young (10 million years), starbursting system. Given the magnification factor of 40, the measurement implies a stellar mass of about ten million solar masses.

stars. The total mass including not only stars, but also gas and dark matter is then estimated using relations derived from galaxies that are less distant, and whose mass can be measured by other means. This is potentially problematic because of the intervening billions of years of galaxy evolution. Thus, van der Wel's discovery provided a way to put standard methods of galaxy mass determination to the test – showing that those methods are indeed on the right track.

On the other hand, the discovery poses a puzzle. Gravitational lenses are the result of a chance alignment. In this case, with an Einstein ring, the alignment is very precise. Not only are such very accurate alignments very rare – they are even less probable for objects in the early universe, compared to later times. And to make matters worse, the magnified object is a so-called star-bursting dwarf galaxy: a comparatively light galaxy (only about 100 million solar masses' worth of stars), but extremely young (about 10–40 million years old) and producing new stars at an enormous rate. The chances for such peculiar galaxies to be gravitationally lensed are very small.

By chance, one would expect about five gravitational lenses showing galaxies of this kind in the whole area covered by the CANDELS survey – and there is only a chance of 1 in 200 to find one so precisely aligned as the one actually found.

Yet, within a few years, this is the second star-bursting dwarf galaxy found to be lensed! Just in 2012, a group of astronomers including van der Wel and other MPIA colleagues had announced the first such find (Brammer et al. 2012).

Either the astronomers have been phenomenally lucky. Or else, chance alignments with these components – in particular the distant starburst dwarf galaxy – are much more probable than previously thought, due to the fact that the distant starburst dwarfs are much more numerous than estimated based on current observations. If the latter, then there could be a whole population of such galaxies just below the detection threshold of the CANDELS survey. The existence of this population could force major revisions of our current models of the early stages of galaxy evolution.

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Arjen van der Wel et al.: "Discovery of a Quadruple Lens in CANDELS with a Record Lens Redshift $z = 1.53$". In: *Astrophysical Journal Letters* **777**, article id. L17, 2013. DOI: 10.1088/2041-8205/777/1/L17

II.11 A rare snapshot of a planetary construction site

Planets are born in disks of gas and dust, surrounding a young star. Now, combined observations with the compound telescope ALMA and the Herschel Space Observatory have produced a rare view of a planetary construction site in an intermediate state of evolution. This first direct observation of such a "hybrid disk" is likely to require some revision within current models of planet formation.

When a star similar to our Sun is born, it is surrounded by a disk of dust and gas. Within that disk, the star's planetary system begins to form: The dust grains stick together to build larger, solid, kilometer-sized bodies known as planetesimals. Those either survive in the form of asteroids and comets, or clump together further to form solid planets like our Earth, or the cores of giant gas planets.

Current models of planet formation predict that, as a star reaches the planetesimal stage, the original gas should quickly be depleted. Some of the gas falls into the star, some is caught up by what will later become giant gas planets like Jupiter, and the rest is dispersed into space, driven by the young star's intense radiation. After 10 million years or so, all the original gas should be gone.

But now a team of astronomers from the Netherlands, Hungary, Germany, and the US which includes MPIA's Thomas Henning has found what appears to be a rare hybrid disk, which contains plenty of original gas, but also dust produced much later in the collision of planetesimals. As such, it qualifies as a link between an early and a late phase of disk evolution: the primordial disk and a later debris phase.

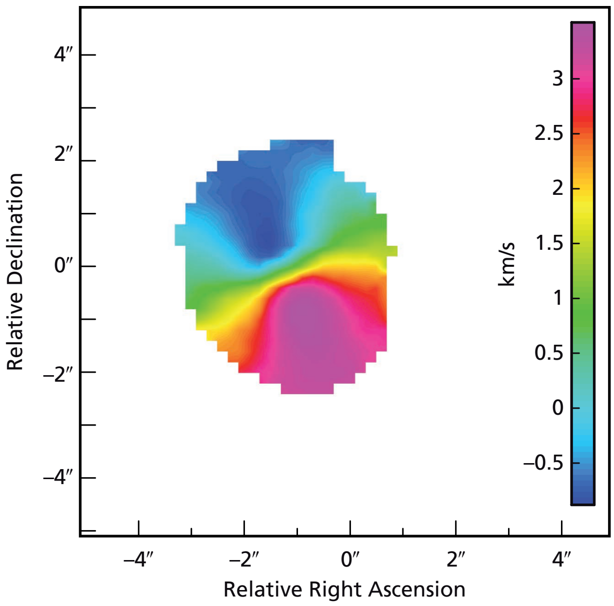
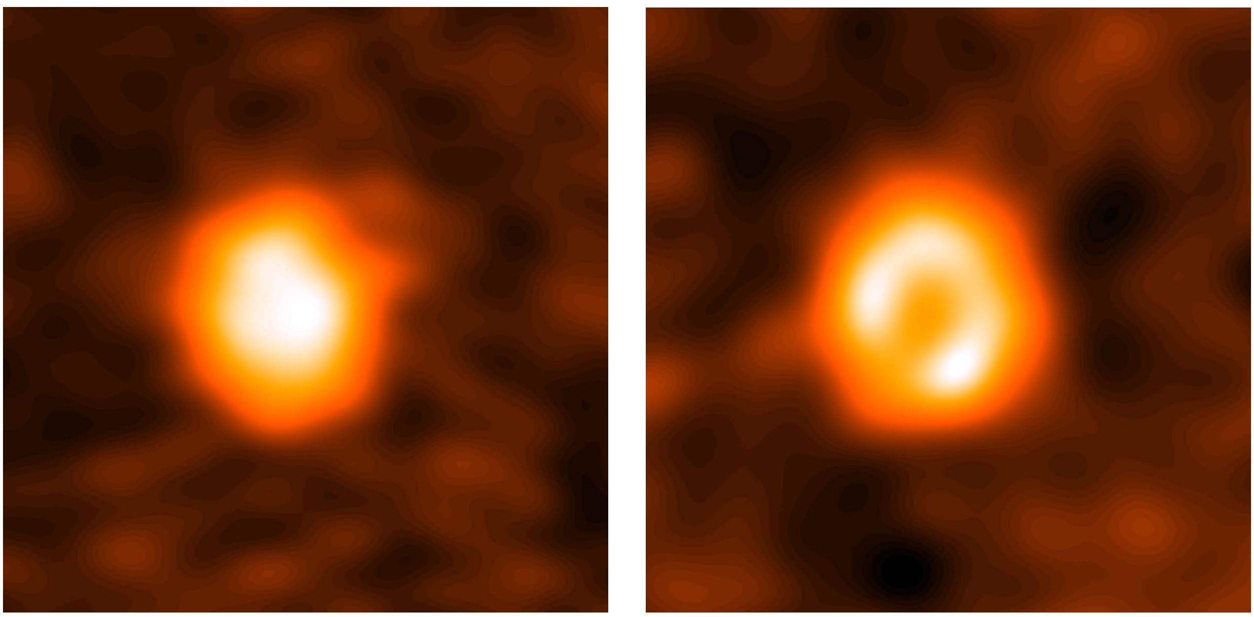
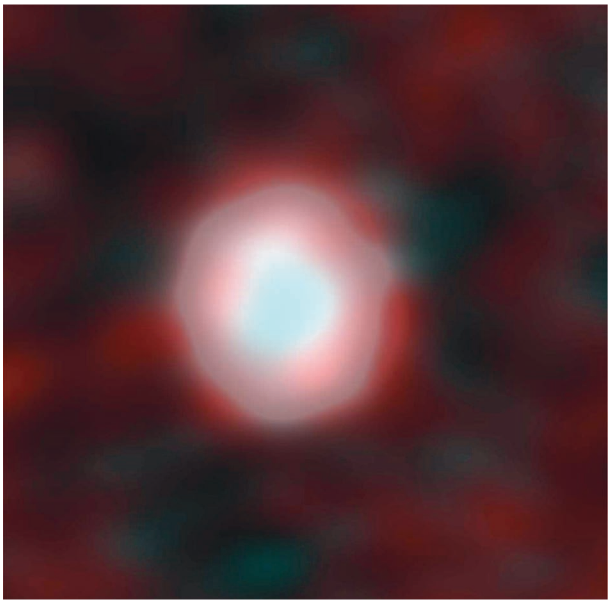


Fig. II.11.1: ALMA images of the disk around HD 21997. The *bottom left* image shows the emission of cold dust grains, situated in a ring around the central star. The *bottom right* image displays the emission from carbon monoxide, and shows that gas can also be found closer to the star than dust. The *top right* image depicts the velocity of the gas. The red-colored parts of the disk move away from us, while the blue-colored parts move towards us, indicating that the gas is rotating/orbiting around the central star.



Credit: Á. Kóspál (ESA) and A. Moór (Konkoly Observatory)



Credit: MPIA

Fig. II.11.2: Color composite of the cold dust grain image (*figure 1, bottom left*) and the emission from carbon monoxide (*figure 1, bottom right*). Dust appears in red while gas appears blue. White parts show the presence of both, gas and dust.

Fig. II.11.3: Antennas of the Atacama Large Millimeter/submillimeter Array (ALMA), a compound telescope on the Chajnantor Plateau in the Chilean Andes. The final ALMA configuration has 66 antennas acting like a single telescope.

The astronomers studied the disk around the star HD 21997, which lies in the Southern constellation Fornax, at a distance of 235 light-years from Earth. HD 21997 has 1.8 times the mass of our Sun and is around 30 million years old.

Their observations of HD 21997 used two of the most sensitive instruments ever built to detect far-infrared and millimeter-wave radiation: The PACS and SPIRE instruments aboard ESA's Herschel Space Observatory were used to measure radiation emitted by the dust. The Herschel measurements revealed that the typical temperature of the dust grains, which range in size between several micrometers and a few millimeters, is about 60 Kelvin (−210 degrees Celsius).

The Atacama Large Millimeter/submillimeter Array (ALMA), which combines the signals from a network of radio antennas, made it possible to spatially resolve the emission of both the dust grains and the gas molecules, in other words: to reconstruct the spatial structure of the two disks.

Both the Herschel and the ALMA observations show a broad dust ring surrounding the star at distances between about 55 and 150 astronomical units (one astronomical unit is the average Earth-Sun distance). But the ALMA observations also show a gas ring, and surprisingly, the two do not coincide: The inner edge of the gas ring is closer to the central star than the inner edge of the dust. Had the dust and the gas been produced by the same physical mechanism, they could be expected to coincide.

Credit: ESO/C. Malin

This has a direct bearing on an ongoing discussion in the planet formation community: In many evolved systems, the collisions of planetesimals produce fresh dust that forms a tevnuous disk around the star. According to the current paradigm, these so-called debris disks should be practically free of gas.

Thus, it was a surprising discovery when a handful of debris disk systems – β Pictoris, HD 32297, 49 Ceti, HD 172555, HD 32297 – were found to host small amounts of gas as well. The origin of gas in these disks was the subject of lively debate: it could have been continuously produced from the planetesimals, just like the debris dust. Alternatively, we could be dealing with leftover material from the primordial disk that survived for much longer than expected – from model calculations, bolstered by observations, gas in this kind of disk around a young star should be depleted within about 10 million years; the age of HD 21997, for instance, is estimated as about 30 million years.

Even so, the new results from the disk of HD 21997 strongly suggest leftover gas from a primordial disk: For one, the dust disk and the gas disk do not coincide, as one would expect if both had been produced as debris from planetesimal collisions. Also, the total gas mass is too large to have been produced in such collisions. With this discovery, the discussion enters a new stage. Now, the scientists will need to take a closer look at how to reconcile current models with the unexpected longevity of primordial gas.

The new observations have another interesting consequence: They indicate that previous studies had grossly underestimated the amount of gas present in the disk. This concerns a fundamental problem for such mass estimates: In molecular clouds and the circumstellar disks around young stars, hydrogen is the most abundant molecule. But unfortunately, hydrogen is practically inaccessible to direct observation (due to its lack of a permanent dipole moment).

Fortunately, hydrogen in these situation is usually accompanied by other molecules in minute amounts. These can be used as tracers. Carbon monoxide, for instance, has several spectral lines falling conveniently in the millimeter wavelength range, where they can be observed with telescopes like ALMA. If you can detect carbon monoxide then, using empirical conversion formulae, you can estimate the amount of hydrogen molecules present.

For HD 21997, it had long been known that the star has a debris disk, because the thermal emission of the dust grains was detected in infrared light. Carbon monoxide was not detected until 2011, by the same team whose research is described here. This is when HD 21997 became particularly interesting to the astronomical community.

A surprising part of the new results reported here is that the researchers detected not only normal carbon monoxide (CO), but also its less abundant isotopologues – molecules containing carbon or oxygen atoms whose atomic nuclei have more neutrons than is usual. In the original estimate (Moor et al. 2011), the researchers had assumed that they were “seeing” contributions from all the molecules in the disk, and that the disk was transparent to those molecules’ radiation.

The detection of the much rarer isotopologues invalidates that assumption: If such rare varieties of molecules are sufficiently abundant as to be detectable, the total CO mass must be much higher than originally estimated. Evidently, the disk is opaque for normal CO, after all. An estimate using the rarest of the isotopologues detected, $C^{18}O$, shows that the original estimate of carbon monoxide gas in the disk must have been too low by a factor of the order 100. The more precise estimate puts the amount of carbon monoxide at 0.06 Earth masses, and the estimate for the total mass of the gas, including hydrogen, at 30–60 Earth masses. The dust ring weighs one tenth of the Earth’s mass, distributed in small dust grains that have sizes between several micrometer and a few millimeter. The mass value is another indication that the gas disk is made of primordial material – gas set free in collisions between planetesimals could never explain this substantial quantity.

The team is currently working on finding more systems like HD 21997 for further studies of hybrid disks, and to find out how they fit within the current paradigm of planet formation – or the ways in which the models need to be changed.

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Ágnes Kóspál et al.: “ALMA Observations of the Molecular Gas in the Debris Disk of the 30 Myr Old Star HD 21997”. In: *Astrophysical Journal* **776**, article id. 77, 2013. DOI: 10.1088/0004-637X/776/2/77

Attila Moór et al.: “ALMA Continuum Observations of a 30 Myr Old Gaseous Debris Disk around HD 21997”. In: *Astrophysical Journal Letters* **777**, article id. L25, 2013. DOI: 10.1088/2041-8205/777/2/L25

II.12 Cloud atlas reshapes astronomers' views of stellar birthplaces

A multi-year study of the Whirlpool galaxy (M51) has shaken up astronomers' views of the properties of giant molecular clouds. The new study, which has mapped 1500 such clouds, shows that such clouds are embedded in a kind of fog of molecular hydrogen much more dense than anyone expected, which permeates the whole of the galactic disc. Pressure exerted by this fog is crucial in determining whether or not new stars will form within the clouds.

Most of a galaxy's stars are born within giant molecular clouds – accumulations of hydrogen molecules with total masses between a thousand and several million times that of our Sun. As a region within such a cloud collapses under its own gravity, it contracts until pressure and temperature are high enough for nuclear fusion to set in: a new star is born. Now, a new study challenges astronomers' traditional views about these stellar birthplaces.

The study is a result of the PdBI Arcsecond Whirlpool Survey, PAWS for short, an astronomical survey targeting the Whirlpool Galaxy M 51 with a resolution on the arcsecond-level, using the Plateau de Bure Interferometer (PdBI). PAWS is led by MPIA's Eva Schinnerer.

Over the past four years, the PAWS team created the most complete map yet of giant molecular clouds in M 51, reconstructing the amounts of hydrogen molecules and correlating them with the presence of new or older stars. The galaxy M 51 is located in the constellation Canes Venatici ("Hunting dogs"). It is a particularly suitable candidate: It is very similar to our home galaxy, the Milky Way. It is not overly far away (around 23 million light-years from Earth), so that individual giant molecular clouds can be detected, and it has been observed previously in many different wavelengths. Also, we see

Fig. II.12.1: Molecular hydrogen in the Whirlpool Galaxy M 51. The blueish features show the distribution of hydrogen molecules in M 51, the raw material for forming new stars. The PAWS team has used this data to create a catalogue of more then 1500 molecular clouds. The reddish structures show the distribution of hydrogen atoms. The background is a color image of M 51 by the Hubble Space Telescope. Superimposed in blue is the CO(1–0) radiation emitted by carbon monoxide (CO) molecules, as measured for the PAWS study using the millimeter telescopes of the Institut de Radioastronomie Millimétrique. The CO molecules are used as tracers for molecular hydrogen. The red structures show the HI line emissions of atomic hydrogen.

Credit: PAWS team/IRAM/NASA HST/ T. A. Rector (University of Alaska Anchorage)

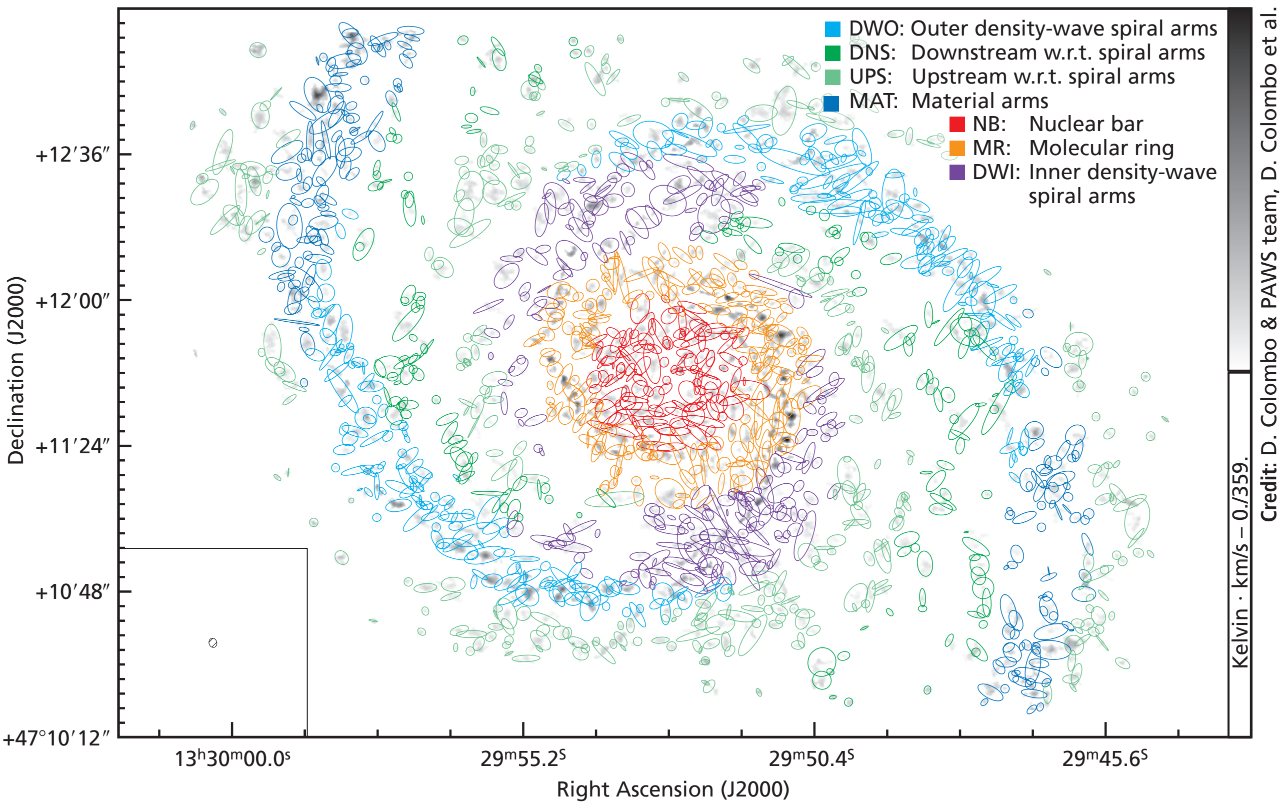
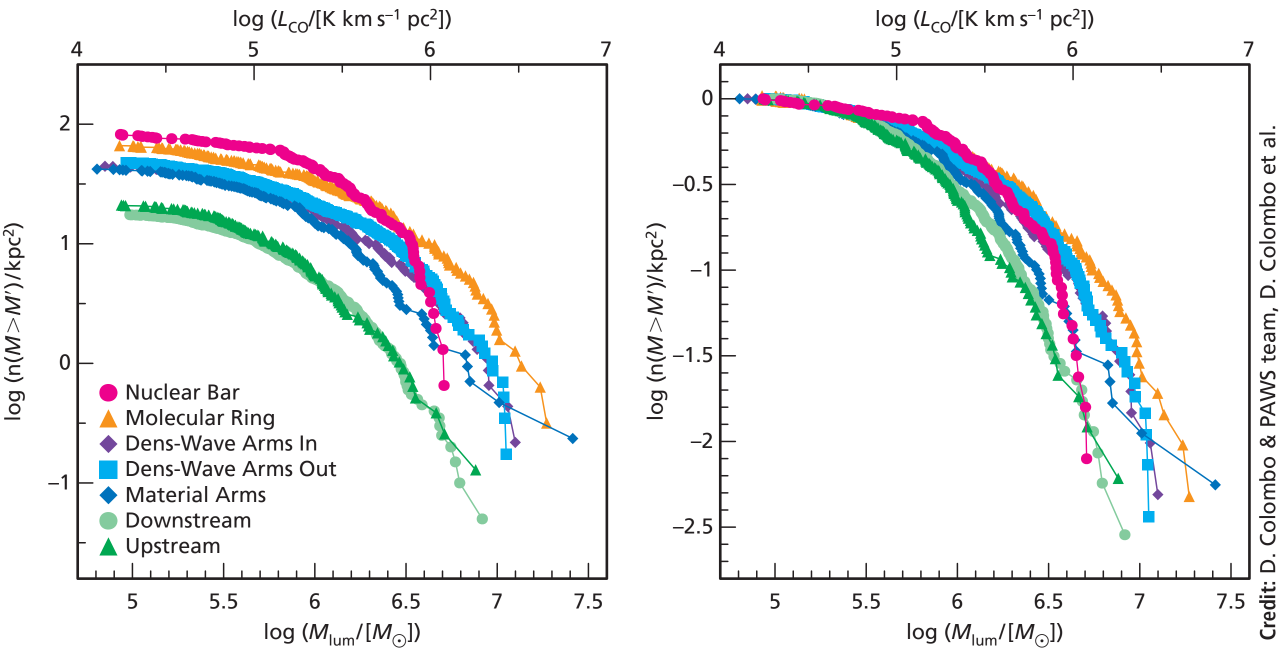


Fig. II.12.2: Distribution of giant molecular clouds in the PAWS field of M51, superimposed on a greyscale map showing the combined CO intensity of identified objects (sidebar shows scale in K km/s). The clouds are represented as ellipses approximating their measured shape and orientation; clouds that appear overlapping are actually distinguished by different velocities (and likely at different distances from us). The colors indicate the environment in which the cloud has been found. In the bottom left, the beam size (about one arc second, corresponding to 40 parsec, or 130 light-years) is indicated.

Fig. II.12.3: Cumulative mass distribution for giant molecular clouds in the different environents of M51. In the figure on the left, the mass is normalized by the area covered by the respective environment (in square kiloparsec); the vertical offset corresponds to a different number density of the respective GMCs, the horizontal offset to different maximum cloud masses. In the right figure, the distribution is normalized by the number of clouds for each environment. In both cases, the equivalent CO luminosity is noted on the top axis.



the galaxy face-on which, given that stars and gas are distributed within a rather thin disk in such spiral galaxies, means an optimal overview.

Data for PAWS was taken between August 2009 and June 2010 with the Plateau de Bure Interferometer (PdBI) in the French Alps and the IRAM 30 m telescope in the Spanish Sierra Nevada. Both are operated by the Institut de Radioastronomie Millimétrique, which is headquartered in Grenoble. The PdBI consists of six radio antennas, each 15 meters in diameter, which can be placed up to 760 meters apart and are wired together so as to act as a single, gigantic radio telescope. The size of this virtual telescope is such that it allows astronomers to observe minute details even in a galaxy like M 51, which is 23 million light-years away: PdBI achieves a resolution of about 1″ which, at the distance of M 51, corresponds to around 130 light-years, or 8 million times the Sun-Earth distance.

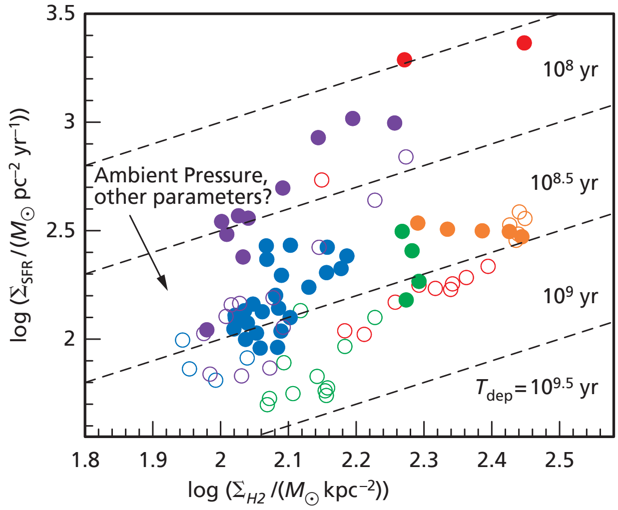
Resolution this high is a prerequisite for imaging the separate giant molecular clouds as distinct entities, and an unprecedented 169 hours of PdBI observation time was the key element of the production of the PAWS cloud atlas. The IRAM 30 m radio telescope was used to complement the small-scale details with maps showing the galaxy as a whole.

Observations were made of the CO(1–0) transition of carbon monoxide (CO). CO molecules are standard tracers for hydrogen molecules: Hydrogen molecules hardly emit any electromagnetic radiation, and thus are difficult to observe. But they are usually found in the company of CO molecules, which can be readily detected in the radio and infrared region of the spectrum. The CO data were used to create a complete atlas of giant molecular clouds, with the smallest features that could be differentiated around 50 light-years in size.

The analysis also included existing data about ionized and atomic gas, the different types of stars and in particular the presence of young, newly-formed stars in M51. This data was taken from archived observations from the 2MASS survey, with the Hubble Space Telescope, the infrared space telescope Spitzer, the infrared Herschel Space Observatory, the GALEX ultraviolet space telescope, and the THINGS survey of atomic hydrogen.

Reconstructing the overall distribution of molecular hydrogen (deduced from the distribution of CO), correlating with the known distribution of atomic hydrogen, dust, and the different types of stars, and identifying individual giant molecular clouds, was a massive feat of analysis which took more than three years. The result was a molecular cloud atlas encompassing more than 1500 separate clouds.

The effort was rewarded by a number of surprises that have reshaped the view of what giant molecular clouds are, and under what conditions they form stars. The first surprise was that so much of the molecular hydrogen – about 50%! – is not in giant molecular clouds, but in a diffuse, disk-shaped hydrogen fog permeating the galaxy. Previously, the common view of molecular clouds had pictured them as solitary objects, drifting within the surrounding interstellar medium of rarified gas in isolated splendor; the main repository of a galaxy's supply of hydrogen molecules.



Credit: S.E. Meidt & PAWS team, Meidt et al

Fig. II.12.4: Plot of the star formation rate versus the molecular hydrogen gas density for M51. The so-called Kennicutt-Schmidt relation postulates that the star formation rate is proportional to the gas density to some nth power. The color of the points in the diagram varies from red to green to purple with increasing distance from the galactic center. Open circles mark regions where streaming motions are larger than average (.15 km/s), reducing the ambient pressure of the interstellar medium. The dotted lines give the corresponding times it would take to use up the entire gas through star formation (gas depletion times). Overall, the gas depletion time for regions with larger-than-average motion falls near the typical value of 2 billion years, but there is a large scatter from region to region, which correlates with radial changes in the pressure exerted by the ambient interstellar medium.

With this unexpected distribution, the influence of external pressure from this fog on the molecular clouds, previously thought to be completely unimportant, turns out to play a role in whether or not a cloud begins to collapse to form new stars: reduce the external pressure, and there will be no significant star formation.

This, in turn, explains another unusual result of the study. Previous thought held that the key to star formation in giant molecular clouds was density: Make a cloud dense enough, and you will form stars. In spiral galaxies, the zones of higher density are the spiral arms – density patterns moving through the galactic disk similar to sound waves or ripples on a lake. The spiral arms are somewhat more densely filled with stars and gas than the rest of the galactic disk. By the old way of thinking, you would expect to find increased star formation everywhere within the spiral arms, and less star formation everywhere else.

The new study, however, shows that there is a blatant exception in M 51: In one large region in both spiral arms of M 51, there is hardly any star formation at all. The explanation lies in the role of external pressure: Reconstructing the galactic dynamics, the region in question turns out to be a location in which the fog, and the molecular clouds contained within, are moving relative to the spiral arms at a speed of 15–20 km/s. When the molecular fog moves relative to the galaxy's spiral arms, the pressure it exerts on any clouds within is reduced, in line with a physical law known as Bernoulli's principle.

Incidentally, Bernoulli's law is also thought to be responsible for part of the well-known shower-curtain effect: shower curtains blowing inward when one takes a hot shower, another display of reduced pressure.

Clouds feeling this reduced pressure are unlikely to form new stars. External pressure, exerted by the surrounding molecular "fog", appears to be a key factor in determining star formation rates – and it is one that, before this study, had been neglected. In the new picture suggested by the PAWS results, interactions between clouds, fog, and overall galactic structure appear to hold the key to whether or not a cloud will form new stars.

All in all, the study is an excellent example of how a systematic, long-term study can serve to change the way we see and understand an important class of astronomical objects – in this case, the birthplaces of stars.

M51, which has now been studied in great detail, is only one example of spiral galaxy. The logical next step for the members of the PAWS team is to find out whether their results can be generalized to other spiral galaxies – or whether there are interesting differences. An obvious next target are barred spiral galaxies, which have an oblong stellar feature (the "bar") in their central regions, as the physical conditions in the gas flowing along the stellar bars are thought to be even more extreme compared to the one in the spiral arms.

For future studies, two future telescopes are of particular interest: The NOEMA extension of the Plateau de Bure interferometer will allow for more detailed studies. And with the recently inaugurated ALMA compound telescope, which consists of more than 60 separate antennas, studies similar to PAWS will be possible in a fraction (10 %) of the time. Both are suitable tools for in-depth studies of more distant spiral galaxies, including the creation of cloud atlases.

Eva Schinnerer, Dario Colombo,
Annie Hughes, and Sharon Meidt

in collaboration with
Clare Dobbs (University of Exeter),
Gaëlle Dumas (IRAM Grenoble),
Santiago García-Burillo
(Observatorio Astronómico Nacional, Madrid),
Carsten Kramer (IRAM Granada),
Adam Leroy (National Radio Astronomy Observatory),
Jerôme Pety (IRAM Grenoble),
Karl Schuster (IRAM Grenoble),
and Todd Thompson (Ohio State University)

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Dario Colombo et al.: "The PdBI Arcsecond Whirlpool Survey (PAWS): Environmental Dependence of Giant Molecular Cloud Properties in M51". In: *Astrophysical Journal* **784**, article id. 3, 2014. DOI: 10.1088/0004-637X/784/1/3

III. Instrumental Developments and Projects

The development and construction of high-tech astronomical instrumentation for large ground-based telescopes and for space based observatories is one of the major activities of the MPIA. The institute develops instrumentation for high-resolution imaging (including techniques like adaptive optics and interferometry), for spectroscopy and survey tasks with a focus on near-infrared astronomy. Projects are frequently carried out in international consortia.
In chapter III.2 and III.3, we report on activities belonging to our instrumentation projects and related technical developments. Since the number of projects is rather large, we are only presenting a selection of our current activities. Since this selection varies over the years, we encourage the reader to have also a look into other MPIA Annual Reports.

III.1 Instrumentation projects currently under development or in operation

The following list provides not a complete compilation of all instruments ever built at MPIA but an overview of those instrumentation projects which are currently under development or in operation.

Current main Ground-based Telescopes and Instrumentation

Under development
Operational

ESO / Paranal-Observatory (VLT/VLTI)		
SPHERE	Spectroscopic and polarimetric high-contrast exoplanet finder	Installation in spring 2014
MATISSE	Mid-infrared imaging spectro-interferometer for the VLTI	Under development, installation spring 2016 (→ **see chapter III.3**)
GRAVITY	Adaptive Optics assisted near-infrared instrument for precision narrow-angle astrometry and interferometric phase referenced imaging of faint objects. It will coherently combine all four beams from the VLT unit telescopes	Under development, installation in steps from spring 2015 to fall 2016
ESPRI / PRIMA	Differential Delay Line project for PRIMA (Phase-Referenced Imaging and Micro-arcsecond Astrometry)	Differential delay lines installed in 2008, integration and tests of other subsystems in 2009, commissioning ongoing, to become operational mid-2014
MIDI	Mid-infrared Interferometric Instrument for VLTI	Operational
PARSEC	Laser guide star facilty for the VLT	Operational
NACO	NAOS-CONICA adaptive optics system, IR camera	Operational

ESO / La Silla Observatory		
WFI	Wide field imager (ESO/MPG 2.2 m telescope)	Operational
AstraLux Sur	Lucky Imaging Camera (3.5 m NTT)	Operational

ESO – European Extremely Large telescope (E-ELT)		
METIS	Mid infrared Imager and Spectrograph, AO supported diffraction limited direct imaging, low resolution longslit spectroscopy, high resolution IFU spectroscopy in the thermal infrared at 3 – 5.5 µm and 8 – 14 µm	Phase A study completed in Dec 2009. Project starts probably in 2015

MICADO	Adaptive optics imaging camera that will provide diffraction limited imaging over a $1' \times 1'$ field of view	Phase A study completed in Dec 2009. Project start probably in 2015

Large Binocular Telescope (LBT) / Mt. Graham		
ARGOS	Laser Guide Star System for Ground Layer Adaptive Optics	Under development, First tests at LBT (→ **see chapter III.2**)
LINC-NIRVANA (LN-Pathfinder)	LBT Interferometric Camera and Near-Infrared / Visible Adaptive Interferometer, imaging beam combiner for the LBT	Under development, the Pathfinder experiment was installed in spring 2013 (→ **see chapter III.2**), installation of the full instrument in 2015
LUCI 1, LUCI 2	Two Near-Infrared-Imager and Multi Object Spectrographs	operational
OVMS	Optical Path Difference and Vibration Monitoring System	Operational, (→ **see chapter III.2**)

Calar Alto Observatory		
CARMENES	High-Resolution Near-infrared and Optical Echelle Spectrograph (3.5 m-Telescope)	Under development
PANIC	Panoramic near-infrared camera (2.2 m-Telescope)	Under development. Installation in fall 2014
LAICA	Large Area Imager (3.5 m-Telescope)	Operational
MOSCA	Multi Object Spectrograph (3.5 m-Telescope)	Operational
OMEGA 2000	Near Infrared Wide-Field Prime Focus Camera (3.5 m-Telescope)	Operational
TWIN	Double spectrograph (3.5 m-Telescope)	Operational
AstraLux	Lucky Imaging Camera (2.2 m-Telescope)	Operational
CAFOS	Faint Object Spectrograph and Imager (2.2 m-Telescope)	Operational
MAGIC	Near-Infrared Camera (2.2 m-Telescope)	Operational
CCD-Imager	CCD-Camera (1.2 m telescope)	Operational

WISE Observatory		
LAIWO	Large Area Imager	Operational

Current Space-Telescopes and Instrumentation

HERSCHEL		
PACS	Photodetector Array Camera and Spectrometer	launched 14th May 2009. **Operation ended April 2013**

James Webb Space Telescope (JWST)		
MIRI	Mid-Infrared Instrument	Under development
NIRSPEC	Near Infrared Spectrograph	Under development

EUCLID		
NISP	Near Infrared Spectrophotometer	Under development

III.2 News from LBT

First Light for LINC-NIRVANA Pathfinder – with Adaptive Optics!

The mere fact that the Large Binocular Telescope (LBT) in Arizona features two 8.4 meter diameter mirrors on a single mount is impressive enough. But this telescope is designed to be so much more: With the help of the near-infrared camera LINC-NIRVANA (LN) the two mirrors will be linked to act like a single, much larger telescope. LN, whose components are in final assembly, integration, and verification at the MPIA, will use so-called Multi – Conjugate Adaptive Optics and (eventually) an interferometric combination of the optical paths of the two 8.4m mirrors of the LBT. This will deliver high-resolution images that are effectively undisturbed by atmospheric turbulence.

The technology used by LN is cutting-edge. Implementing such a large and complex instrument successfully at LBT requires carefully planning and on-site experimentation. In order to accelerate the final deployment of this complex instrument, the scientists and engineers working on the project have developed the Pathfinder experiment. Pathfinder is used as a test system on one of the LBT mirrors to demonstrate in advance the performance of LN systems in interaction with the telescope and its environment. Pathfinder was constructed in an intensive development program, and left the MPIA in spring 2013 for shipping to Arizona and installation at the LBT on Mount Graham.

On November 17, LN-Pathfinder was successfully tested. The Pathfinder team succeeded not only in acquiring the instrument's first observation of a celestial object – its so-called "First Light" – but also in commissioning of the control loop for the adaptive optics. Only 35 minutes after Pathfinder saw starlight for the first time, the team was able to activate the adaptive optics – a particularly important milestone.

Credit: MPIA

Fig. III.2.1: Computer rendering of the Pathfinder experiment mounted at the LBT.

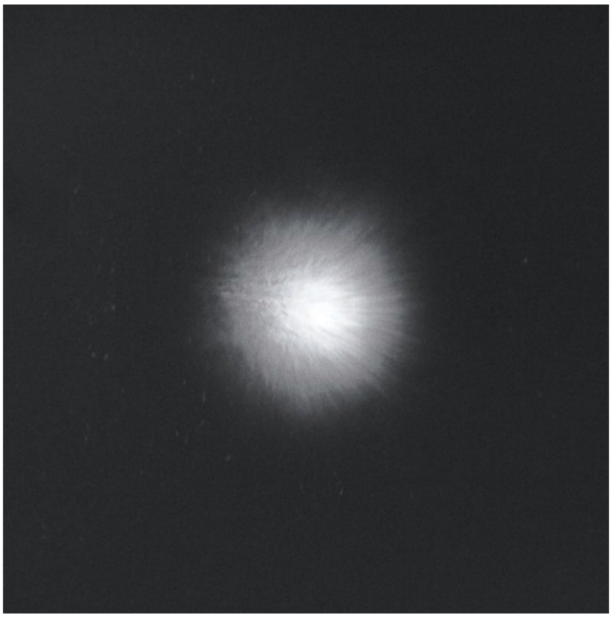
Credit: MPIA

Fig. III.2.2: The Pathfinder shipment arrives at the basecamp of the Large Binocular Telescope.

Credit: MPIA

Fig. III.2.3: The Pathfinder team celebrates first light for LINC-NIRVANA Pathfinder.

Fig. III.2.4.: Image of the star Epsilon Aurigae before activation of the adaptive optics. The fuzzy blob arises due to turbulence in Earth's atmosphere.



Credit: Tom Herbst

Fig. III.2.5.: The same star, but now after activation of the adaptive optics. Although this picture was taken during 2.3 arcsecond seeing (which indicates very bad turbulence) and in visible light (where adaptive optics never works well – the LN camera will operate at infrared wavelengths), it shows a dramatic improvement in sharpness and intensity.

LINC-NIRVANA is designed and built by an international consortium led by MPIA. The partners include institutions in both Italy and Germany. The LBT is a joint project of American, Italian and German institutions.

The Team:
Tom Herbst (Principal Investigator),
Martin Kürster (Project Manager),
Ralph Hofferbert (Project Control Manager),
Harald Baumeister, Thomas Bertram, Jürgen Berwein,
Henrik Beuther, Peter Bizenberger, Armin Böhm,
Michael Böhm, José L. Borelli, Florian Briegel,
Fulvio de Bonis, Albert Conrad, Dimitrios Gouliermis,
Wolfgang Gässler, Armin Huber, Frank Kittmann,
Derek Kopon, Julia Krambs, Werner Laun, Ulrich Mall,
Tobias Maurer, Daniel Meschke, Lars Mohr,
Vianak Naranjo, Mark Norris, Johana Panduro,
Aleksei Pavlov, Jörg-Uwe Pott, José Ramos,
Hans-Walter Rix, Ralf-Rainer Rohloff, Eva Schinnerer,
Clemens Storz, Jan Trowitzsch, Glenn van de Ven,
Zhaijun Yan, Xianyu Zhangen

ARGOS laser made the first test on LBT

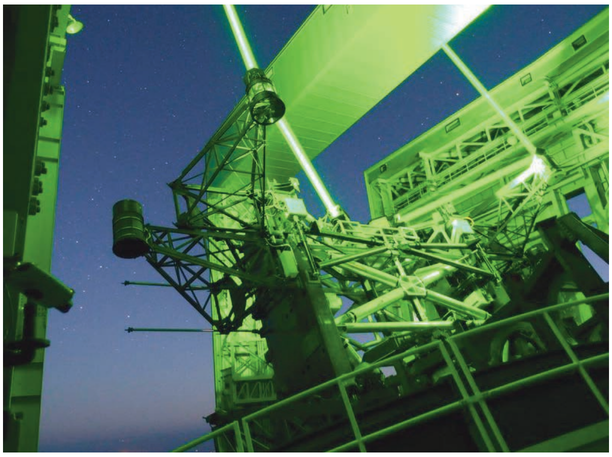
In November 2013, the ARGOS laser systems at the Large Binocular Telescope (LBT) made the first successfully test. Two beams were projected from the secondary mirrors of the telescope at the night sky and produced their first artificial guide stars by Rayleigh scattering in the Earth's upper atmosphere.

Such guide stars are used to correct the blurring of astronomical images of ground-based telescopes, which is caused by the turbulent atmosphere. They are necessary because not always sufficiently suitable real stars are found in the field of view of a telescope.

A total of six powerful pulsed Neodym-YAG lasers delivering up to 18 W – three laser beams for each of the two 8.4m mirrors of the LBT. In this arrangement the backscattered light is particularly suitable for the measurement of the turbulences in the vicinity of the telescope (the "ground layer"). The laser tests with ARGOS were the first step on achieving image correction over a relatively large field of view with the adaptive secondary mirrors of the LBT. Construction and commissioning of the system including the installation of wavefront sensors will extend beyond 2014. Then the scientific operation can be undertaken with the fully functional "Ground Layer Adaptive Optics System". Thanks to ARGOS the two LBT multi-object spectrographs – LUCI1 and LUCI2 – yet will deliver sharper images and better spectra than previously.

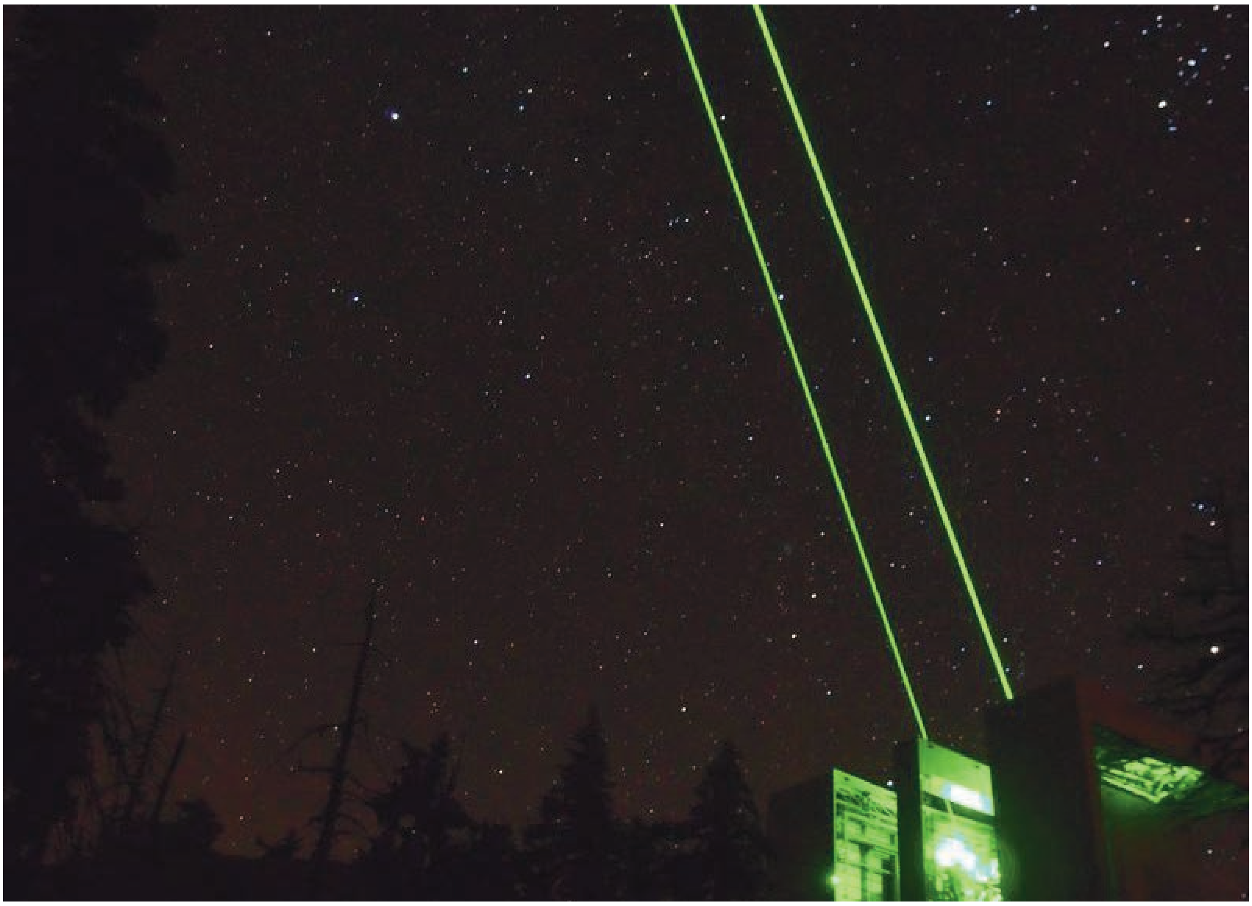
ARGOS is being developed under the direction of the MPE (Garching) together with the other LBT partners MPIA, LSW (both Heidelberg), AIP (Potsdam), MPIfR (Bonn), INAF (Arcetri in Italy) and UoA (USA).

The Team:
Wolfgang Gässler, Thomas Bluemchen, José Luis Borelli, Martin Kulas, Michael Lehmitz, Diethard Peter



Credit: MPE Garching

Fig. III.2.6 and Fig.III.2.7: ARGOS in action: The strong lasers produce artificial guide stars for adaptive optics in the sky above the telescope.



Credit: MPE Garching

Bringing the telescope jitters under control: a unique service at the LBT

Large mechanical structures such as the Large Binocular Telescope (LBT) are susceptible to vibrations. As the telescope is moved, but also as it is influenced by wind, the structure begins to oscillate slightly. Yet even very slight vibrations can jeopardize one of the LBT's key objectives: to combine the two 8.4 m primary mirrors on the LBT mount to act like a single, much larger telescope. In this mode, achieved by what is called interferometry, the LBT could discern details otherwise accessible only to a telescope with a giant 23 meter mirror. Structural vibrations can all but spoil the interferometric combination, severely limiting the achievable resolution, and leading to a substantial loss of detail.

Installed in late March and now officially handed over to the LBT observatory, "OVMS", the "Optical path difference and Vibration Monitoring System", with its 30 vibration sensors delivers high-precision measurements of the vibration-induced movements of the telescope mirrors. The measurements can be used to control the optical instruments installed at the LBT for astronomical observations, correcting for the vibrations' deleterious effects, and they are particularly suitable for controlling the LBT interferometers.

OVMS was developed in collaboration between MPIA and Steward Observatory in Tucson, Arizona. The scientists and engineers involved are mainly those who are building the interferometric cameras LINC-NIRVANA and LBTI (the German-Italian and US-American interferometers for the LBT, respectively). From its inception, the project was also supported by the LBT observatory. The collaboration is led by the MPIA/LINC-NIRVANA team, which is responsible for the overall project coordination. The MPIA team also undertook the development of the software components, including the data acquisition system, while the LBTI / Steward team saw to the development, procurement, and installation of the hardware.

Credit: MPIA

Fig. III.2.8: Five vibration sensors on the mount structure of one of the two adaptive secondary mirrors of the LBT.

Now that the innovative vibration measurement system has been handed over to the LBT observatory, its data will be available to all LBT users as a service provided by the observatory. In particular, these data will make sure that interferometers will be able to take full advantage of the unique potential for high-resolution interferometry provided by the LBT.

The Team:
Martin Kürster, Thomas. Bertram, José Borelli, Mario Brix, Wolfgang Gässler, Tom Herbst, Vianak Naranjo, Jörg-Uwe Pott, Jan Trowitzsch

III.3 Special Developments in the technical Departments

New instrument control system – introduced for MATISSE

Prior to programmable logic controllers (PLCs), control tasks for scientific instruments were often performed by contactors, control relays, and other electromechanical devices with intricate interconnecting wires. Although hard-wired control solutions are capable of performing many of the same tasks as software-based solutions, they are generally more difficult to design, install, and maintain. In addition, the process of making even simple modifications to a hard-wired control solution can be difficult because the logic of the control system is determined by the interconnection of control wires and components.

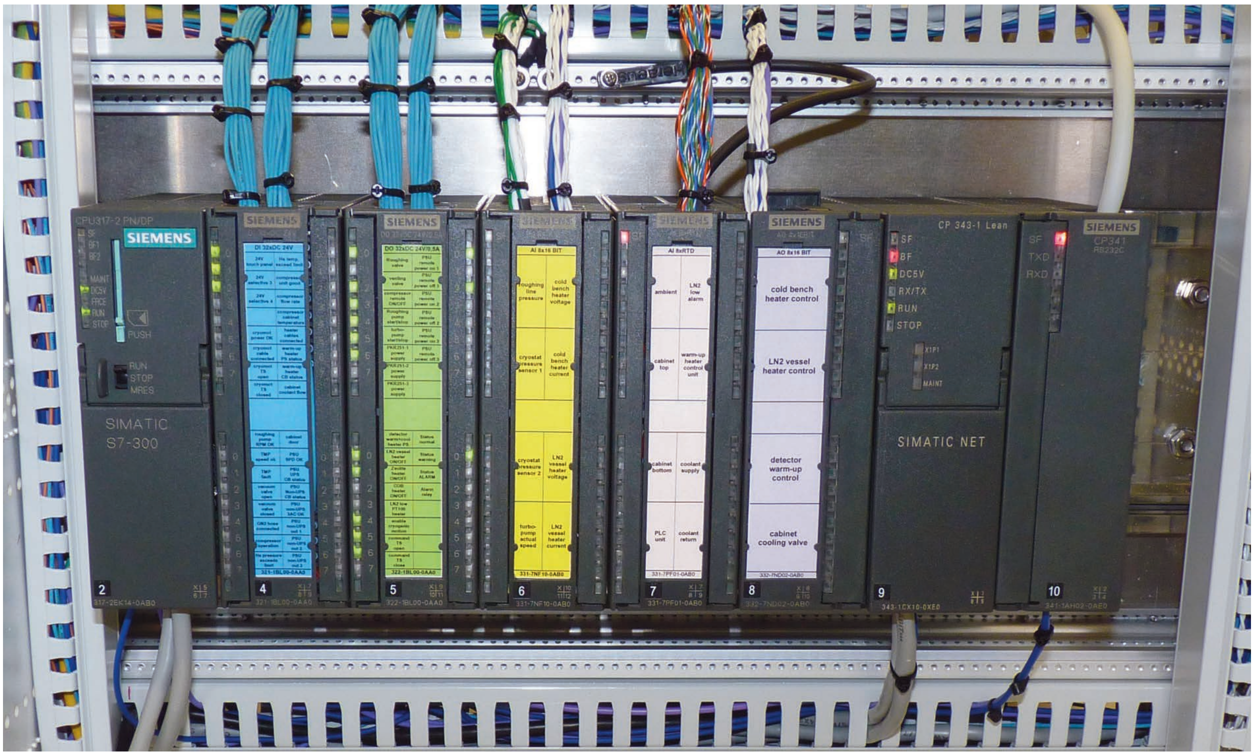
With the growing complexity of scientific instruments and their equipment, there was a steady growth in demand for sophisticated control systems. For MATISSE, the Multi-AperTure mid-Infrared SpectroScopic Experiment for the Very Large Telescope, MPIA has introduced PLCs for the control of the two cryostats, calibration sources, and the readout of sensors on the warm optics table.

A programmable logic controller (PLC) is a type of computer commonly used in commercial and industrial control applications. PLCs differ from office computers in the types of tasks that they perform and the hardware and software they require in performing these tasks. While the specific applications vary widely, all PLCs monitor inputs and other variable values, make decisions based on a stored program and control outputs to automate a process or machine.

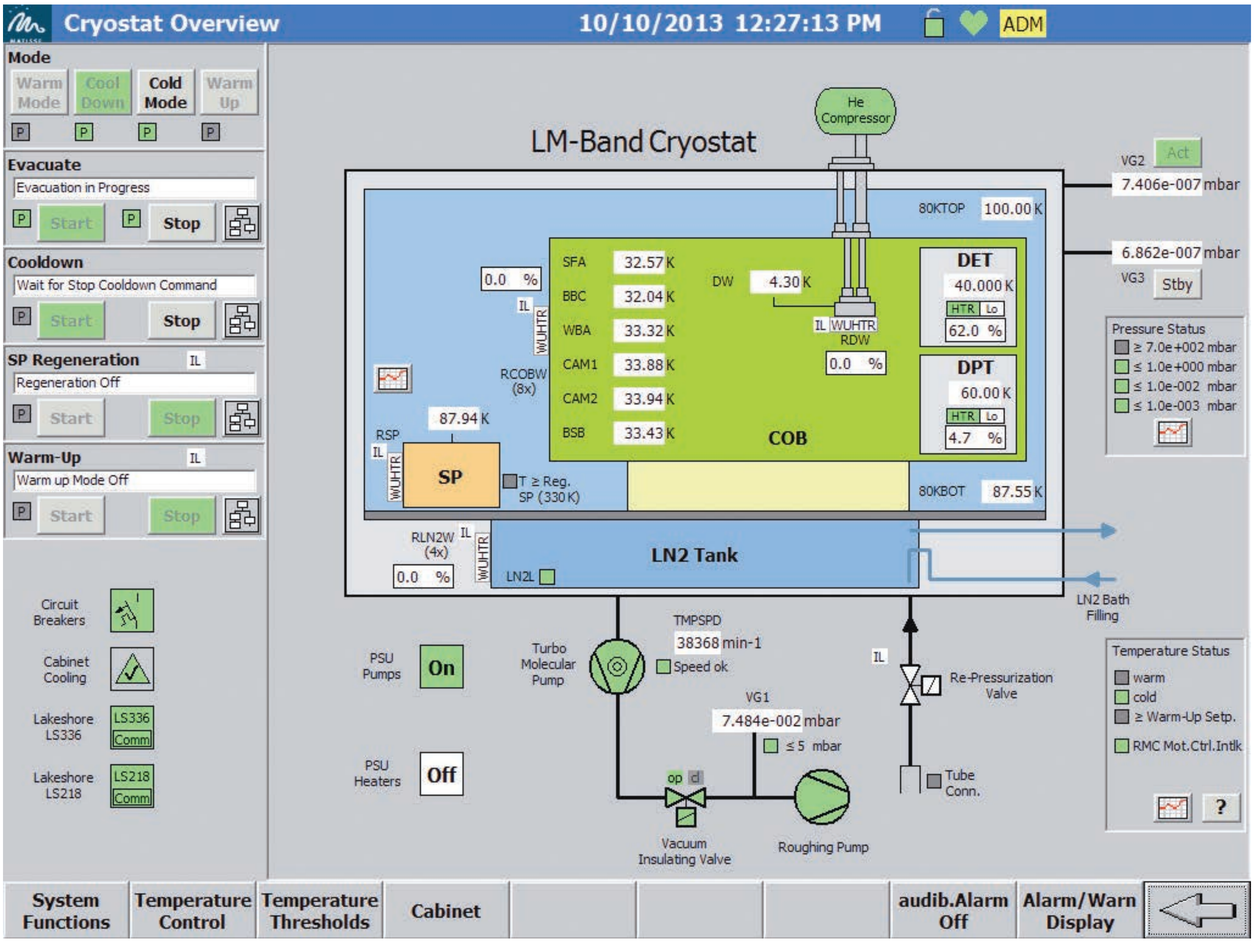
PLCs are not only capable of performing the same tasks as a hard-wired control, but can also carry out many more complex applications, like PID (Proportional-Integral-Derivative) control. In addition, the PLC program and electronic communication lines replace many of the interconnecting wires required by hard-wired controls. Therefore, hard-wiring, though still required to connect field devices, is less intensive. This also makes correcting errors and modifying the application easier.

PLCs are small in physical size, and provide integrated diagnostics and override functions. In addition, applications can be developed faster and more easily, are less expensive, and can be quickly documented using the configuration and programming software. By implementing control functions in encapsulated modules they can eas-

Fig. III.3.1: MATISSE – cryostat control PLC.



Credit: MPIA



Credit: MPIA

Fig. III.3.1.: PLC touchpanel – GUI example.

ily be adapted and reused for future projects. Since the selection of the MATISSE hardware components is based on standards of the observatory, the number of individual spare parts has decreased significantly.

The PLC system for MATISSE will control the following main parts:

- Cabinet and service connection point coolant monitoring;
- Temperature monitoring and control;
- Compressor for the pulse tube cooler;
- Roughing pump, turbo-molecular pump, valves, and direct readout of pressure gauges;
- Cryostat temperature monitoring (via LakeShore 218 monitor);
- Interlocks, warnings, and alarms;
- Control logic and power monitoring for the warm-up heaters;
- Interconnection to the observatory alarm system;
- Control of calibration source devices;
- Ethernet connection to global observatory network

A touch panel connected via Ethernet to the PLC will show the status of the vacuum, temperatures, pumps and coolers, and other components related to the cryogenic environment. In addition, it will be used as an input device for user-interaction, e.g. starting of cool down or alarm acknowledgement. The Ethernet interface is used as connection to the CPU.

Michael Lehmitz,
Lars Mohr, Frank Wrhel

High quality static and active metal optics for use at cryogenic temperatures – MOT

In the middle of 2013 the MOT project already described in annular report 2009 was completed successfully. Fitted onto a polishable Electroless Nickel Layer (NiP) an ALSi40 mirror substrate shows considerably less deformation at cryogenic temperatures than conventional Aluminum 6061 with NiP (Fig. III.3.3). The achieved results with respect to accuracy of shape, micro-roughness and reflectivity now permit the use of metal optics for diffraction-limited imaging systems even in the visual wavelength region. In the course of the project we did not only produce prototypes for demonstration purposes, but we also put various applications into practice. Furthermore, we performed a thorough study of different types of deformable mirrors for use at cryogenic temperatures.

Ralf-Rainer Rohloff

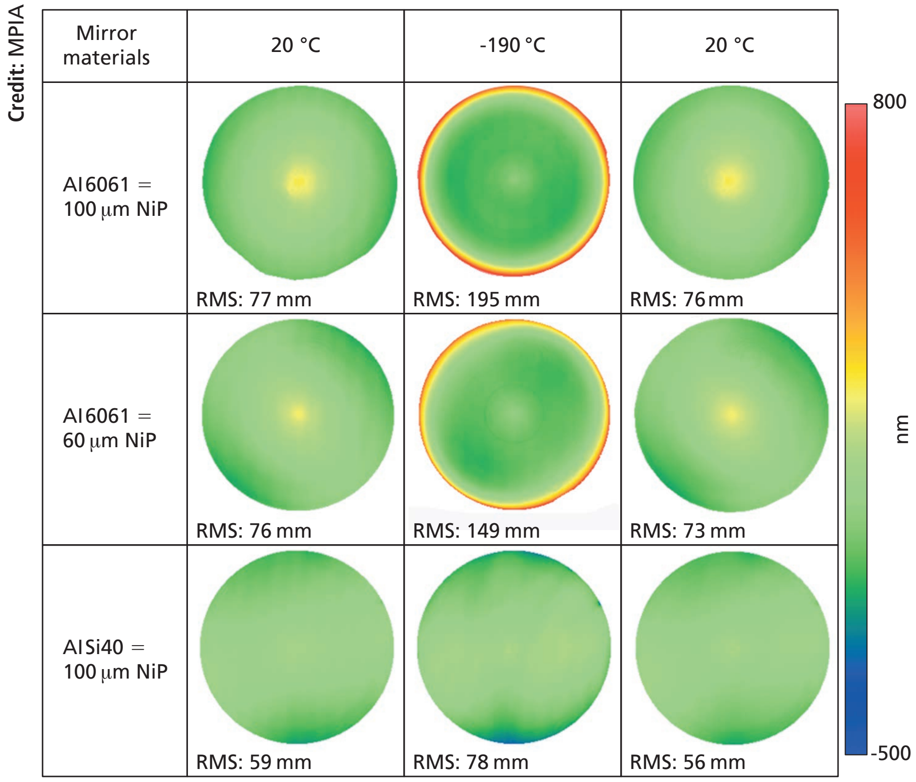
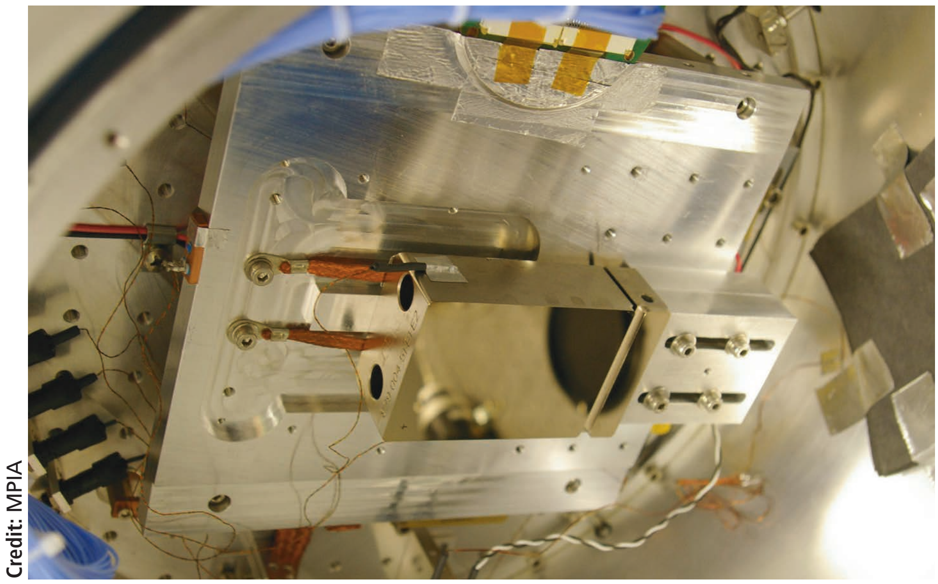


Fig. III.3.3: *(Top)* Surface deformation of AlSi40 mirror with NiP layer and Al6061 mirror with NiP layer by comparision.

Fig. III.3.4: *(Bottom)* METIS M4 prototype mirror made of AlSi40 + NiP in the MPIA test cryostat.

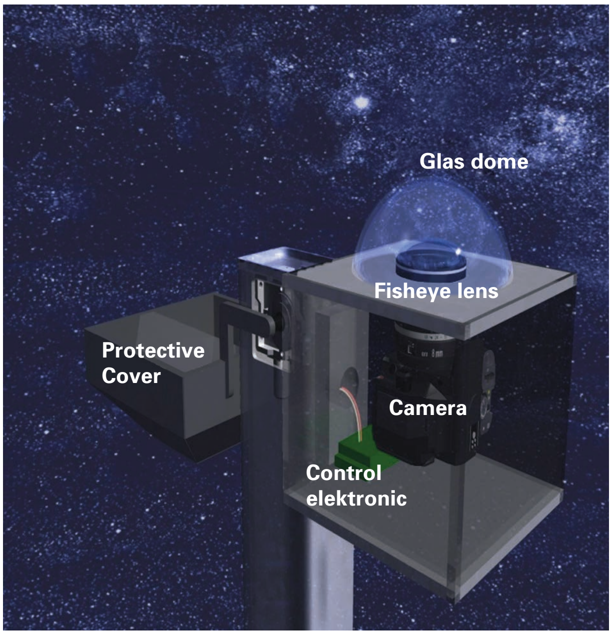


Vocational training in the precision mechanics workshop

The precision mechanics workshop has eight positions for apprentices who are trained to become professional precision mechanics. For its innovative training concept, both in the technical and in the administrative sector, the MPIA was awarded with the Apprenticeship Prize of the Max Planck Society (MPS) already in 2012. In 2013 the third trainee in sequence from the precision mechanics workshop was awarded with the yearly MPS Apprenticeship Prize for metal works.

The duration of workshop apprentice programs is three and a half years during which the trainees learn techniques ranging from operating a CAM-controlled five-axes CNC milling machine to various coating processes (CAM = computed-aided manufacturing; CNC = computerized numerical control). They also become familiar with the complete range of activities that take place in the workshop. These include the manufacturing of complex custom-made scientific devices as well as the repair, commissioning, and maintenance of scientific apparatus. Furthermore, the precision mechanics department offers advice and support for the astronomical instrumentation projects in all mechanical matters including material selection and questions of metal composition, welding work and innovative processing techniques such as 3D and five-axes machining, micro-milling or laser machining.

Fig. IIi.3.5: Milling work on the housing of the all-sky camera.



Credit: MPIA

Fig. III.3.6: 3D model of the all-sky camera.

Special team projects serve to foster and strengthen interpersonal skills. In particular, the MPIA supports interdisciplinary projects that are conducted by the technical apprentices together with the apprentices from the administration sector.

Under supervision, the technical apprentices also interact directly in ongoing scientific projects and often contribute to their success. Together with a physics stu-

Credit: MPIA

dent, who carried out this project within the framework of his Bachelor's thesis, they built an automatic all-sky camera based on a commercial digital reflex camera (Canon 5D KMIII). The all-sky camera enables astronomers to notice the presence of clouds, to evaluate the sky transparency (important for photometric observations), and to find transient phenonema; for example to rapidly detect aircraft which is important, if artificial laser guide stars are used that might confuse pilots.

Armin Böhm, Mario Heitz, Tobias Maurer, Stefan Meister, Klaus Meixner, Tobias Stadler (precision mechanics department), Ferdinand Brezinski, Kim Abel, Jan-Philipp Kugler, Julian Baldauf, Nico Mayer, Lukas Reichert, Christoph Schwind, Alexander Specht, Matthias Schend, Felix Sennheim (apprentices), Martin Kürster

IV. People, Events and Outreach Activities

IV.1 Honours, Grants and Awards

In 2013, MPIA staff members received several important awards covering both scientific and administrative achievements.

Lisa Kaltenegger receives $1 million award from Simons Foundation

Lisa Kaltenegger, group leader at MPIA and research associate at the Harvard-Smithsonian Center for Astrophysics, has been named as one of the investigators of the Simons Collaboration on the Origins of Life. The Investigator Award of the Simons Foundation based in New York City amounts to $1 million and will allow her to explore what the "chemical fingerprint" of an exoplanet's atmosphere could tell us about the planet's properties, including its habitability.

The Simons Collaboration on the Origins of Life will bring together researchers from fields as far apart as astrophysics and molecular biology to tackle questions as diverse as those about the astronomical context of the emergence of life on Earth and the chemical processes that produced the first self-replicating protocells. The Simons Collaboration is co-chaired by biologist and Nobel Laureate Jack Szostak and astronomer Dimiter Sasselov, Director of Harvard University's Origins of Life Initiative. It includes experts such as the British Astronomer Royal, Martin Rees, and distinguished Harvard chemist George Whitesides.

Lisa Kaltenegger is a specialist for those exoplanets that are most interesting for the search for life on other worlds: earth-like, rocky planets with just the right characteristics to allow for the existence of liquid water – a precondition for life as we know it. The award will enable her to study models for the "spectral fingerprints" of exoplanet atmospheres – the minute traces left by different chemical elements in those atmospheres in light received from those distant planetary systems. In modelling spectral fingerprints for earth-like planets, which are currently beyond the range of observation, and exploring the effect of living organisms, but also of different geological features on these spectral fingerprints, Kaltenegger will prepare the ground for future observations that might one day find hints for life on those yet undiscovered worlds.

Fig. IV.1.1: Lisa Kaltenegger

Credit: Elisabeth Schuh

Harold C. Urey Prize for Anders Johansen

The Division for Planetary Sciences (DPS) of the American Astronomical Society (AAS) awarded Anders Johansen the Harold C. Urey Prize for his outstanding achievement in planetary research. In the official statement of AAS, his work was recognized as follows: "Dr. Anders Johansen's pioneering work on planetesimal accretion and more recently on giant planet core formation has provoked paradigm shifts in a field which for years had been plagued by long-standing problems. By filling not one but two major gaps in one of the most difficult areas of solar system studies, Dr. Johansen's findings represent one of the most significant contributions to the field."

Anders Johansen finished his PhD thesis in 2007 in the Planet and Star Formation Department (PSF) at MPIA and some of his most important papers were related to his work at the institute. In the meantime, Anders Johansen is Associate Senior Lecturer at the University of Lund in Sweden.

Credit: MPIA / M. Nielbock

Fig. IV.1.2: Anders Johansen, winner of the Harold C. Urey Prize, at the large Protostars & Planets IV conference in Heidelberg.

Royal Astronomical Society honours the SAURON team

At the UK National Astronomy Meeting in St. Andrews, the Royal Astronomical Society presented its Group Achievement Award to the SAURON team, including MPIA scientists Remco van den Bosch and Glenn van de Ven.

This prize honours research groups that have made outstanding contributions to astronomy and which are distinguished by excellent teamwork, project strategy and project organization.

SAURON stands for Spectrographic Areal Unit for Research on Optical Nebulae and refers to an integral field spectrograph which operates at the 4.2-meter William Herschel Telescope on La Palma (Spain). The instrument allows “imaging spectroscopy”, that is, simultaneous measurement of individual spectra over a panoramic field of view. These spectra allowed the SAURON team to perform a detailed analysis of the kinematics and stellar composition of 72 carefully selected nearby galaxies. The study was particularly targeted at understanding the formation and evolution of elliptical galaxies.

Fig. IV.1.3: Glenn van de Ven *(left)* and Remco van den Bosch

Credit: MPIA

Reimar Lüst Fellowship for Christoph Mordasini

At the general MPG-assembly in Potsdam, Christoph Mordasini from MPIA was awarded as Reimar Lüst Fellow 2013 of the Max Planck Society. He will use the two year fellowship to continue his research on the statistical properties of planets around other stars (exoplanets). Mordasini is an expert on simulations of exoplanet properties. Based on current models of planet formation, these simulations tell us how many planets with different properties – from giant gas planets with different masses down to rocky planet like our Earth – planet hunters should expect to find. This so-called “population synthesis” creates a crucial link between research on planet formation and the discoveries of hundreds of exoplanets that were made over the last decade.

The two-year Reimar Lüst Fellowship, which is awarded annually, is financed by a foundation that was created in 1983 on the occasion of the 60th birthday of former MPG president Reimar Lüst. The foundation’s endowment consists of donations from German companies.

Fig. IV.1.4: Christoph Mordasini

Credit: MPIA

Credit: MPIA

Fig. IV.1.5: Hubert Klahr

Hubert Klahr nominated as 2013 Russell Severance Springer Professor in Berkeley

Hubert Klahr was nominated by the Mechanical Engineering faculty of the University of California at Berkeley as the Distinguished Russell Severance Springer Professor for 2013. Klahr, who is an expert in the theory of planet formation, visited Berkeley in September 2013 to present a course of lectures to Berkeley students and hold a Department Colloquium. Klahr works on simulations that show how planets – including our Earth – form around young stars. The simulations performed by Klahr and his group involve fluid dynamics over a sizeable range of length scales, and include an impressive variety of physical effects. The techniques they developed are of interest not only in astronomy, but also for simulations of fluids in other contexts, including mechanical engineering.

Patzer Prize 2013

The annually presented Ernst Patzer Prize was donated by the art-lover and philosopher Ernst Patzer and established by his widow. The Foundation awards its prizes to young researchers at MPIA and other institutes in Heidelberg and wishes to support research particularly in the field of astronomy. The Prizes are honouring the best publications produced in the course of doctoral studies or in the first three years of the following postdoc phase. The publications must have been published in a refereed journal. The selection committee consists of two scientists from MPIA and one additional external scientist from Heidelberg.

This years Patzer prize winners are:

- **Siddharth Hegde** (MPIA) for his article “Colors of extreme Exo-earth environments”, 2013, Astrobiology, 13, 1. Siddharth Hegde’s paper is one of the first contributions where signatures of extreme environments on earth are extrapolated to observational signatures around extrasolar systems. It forms a base which will certainly be strongly built on in the future.

Fig. IV.1.6: Siddharth Hegde

Credit: MPIA

Credit: MPIA

Fig. IV.1.7: Annie Hughes *(left)* and Robert Singh.

Credit: MPIA

Fig. IV.1.8: Julian Baldauf *(at left)* receives the certificate of the MPG Trainee Award from MPIA director Hans-Walter Rix.

- **Annie Hughes** (MPIA) for her article "Probability distribution functions of 12CO(1–0) brightness and integrated intensity in M 51, The PAWS view", 2013, Astrophysical Journal, 779, 44.
  In this work, Annie Hughes analyzes the molecular cloud properties in the external Whirlpool galaxy and sets them into context with local cloud models. Among other results, she finds that the cloud properties strongly depend on the galactic environments.

- **Robert Singh** (MPIA) for his article "The nature of LINER galaxies", 2013, Astronomy & Astrophysics, 558, A43. So called LINER galaxies were for decades considered to be a subgroup of Active Galaxies. That means that parts of their emission is excited by a central Active Galactic Nucleus. Robert Singh showed that this is a misconception and that the emission in these galaxies is often produced by a population of evolved stars.

Further awards for Julian Baldauf and Anica Till

For the seventh time, the Max Planck Society (MPG) has awarded the Trainee Prize for outstanding achievements in vocational training. The winner 2013 was Julian Baldauf from MPIAs precision engineering department. With the prize, MPG recognizes not only the outstanding professional and academic performance during the training, but also the personal development and the social commitment of the trainees. Julian Baldauf has shown excellent performance since the beginning of his training in 2010 in the precision engineering department of the Institute and has worked on many different projects. Particularly, he had a large share in the realization of the All Sky Camera.

Credit: MPIA / D. Anders

Fig. IV.1.9: Anica Till.

For her excellent written work, Anica Till – trainee in the MPIA administration to become an office clerk – received 2013 three awards. Anica Till was reviewed with "excellent" in all subjects of the commercial vocational school and received the "Förderpreis 2013 des Unternehmenskreises Mosbach". Furthermore, she was awarded with the "Preis des Fördervereins für Bürokaufleute der Ludwig-Erhard-Schule" as well as with the "Mosbach-Urkunde der Ludwig-Erhard-Schule" for outstanding school achievements.

Klaus Jäger, Markus Pössel,
Axel M. Quetz, Henrik Beuther

IV.2 Special Events and Conferences

As in recent years, we organized a variety of events on the MPIA campus or at external locations. The most important ones are listed in this summary. More details on a number of activities related to public outreach can be found also in Chapter IV.3 about the Haus der Astronomie (HdA).

Abb. IV.2.1: Exactly 852 astronomers joined the conference "Protostars and Planets VI" in the Heidelberg Convention Center between July 15 and 20. The photo shows the huge crowd in the backyard of the Convention Center. At that time this small spot harbored the highest density of astronomers on earth.

The beginning of the year was marked by intense preparation for the Scientific Advisory Board (Fachbeirat). The Evaluation Committee visited MPIA from February 27 to March 1 for the first time since 2010 and the staff was delighted that once again, the Institute's scientific performance was assessed as outstanding.The Board of Trustees also visited us once more on December 2. As a governing body, the Board provides important support to the Institute in questions of academic policy, public perception and contacts in society. The Institute management provided detailed information on special developments in the Institute at both meetings with a particular emphasis on science and instrumentation projects.

It has long been an important issue for MPIA to inspire young people for physics and astronomy and this was also one reason for the institute management to stand up for the HdA several years ago. Thus, the Institute and the HdA organized again a local program during the GirlsDay (April 25) and provided (together with the ZAH institutes) a one-week internship for pupils from high school (October 14 – 18).

MPIA and HdA also took part in supervising schoolchildren during a practical training module of the International Science School Heidelberg (ISH) in July and August. The ISH is a student exchange project of the city of Heidelberg in collaboration with its partner cities. In addition to participating in educational activities, the MPIA is a member of the ISH scientific council.

Like every year, MPIA scientists organized local and external conferences or participated significantly in the

Protostars & Planets VI

15 – 20 July 2013
Heidelberg, Germany

Organizers

Henrik Beuther (MPIA)
Ralf Klessen (ZAH)
Cornelis Dullemond (ZAH)
Thomas Henning (MPIA)

Scientific Advisory Committee

Philippe André (CEA / SAp Saclay)
Javier Ballesteros-Paredes (UNAM)
Isabelle Baraffe (Univ. of Exeter)
Alan Boss (Carnegie Inst.)
John Bradley (LLNL)
Nuria Calvet (Univ. of Michigan)
Gael Chauvin (IPAG)
Therese Encrenaz (Obs. de Paris)
Guido Garay (Univ. de Chile)
Tristan Guillot (Obs. de la Côte d'Azur)
Nader Haghighipour (IfA)
Shigeru Ida (Tokyo Inst. of Technology)
Ray Jayawardhana (Univ. of Toronto)
Willy Kley (Univ. of Tübingen)
Alexander Krot (IfA)
Katharina Lodders (Univ. in St. Louis)
Karl Menten (MPIfR)
Michael Meyer (ETH)
Alessandro Morbidelli (Obs. de la Côte d'Azur)
Ralph Pudritz (McMaster Univ.)
Bo Reipurth (IfA)
Dimitar Sasselov (CfA)
Motohide Tamura (NAOJ)
Ewine van Dishoeck (Leiden Obs.)
Stephane Udry (Univ. of Geneva)
Alycia Weinberger (Carnegie Inst.)

Image Credit: NASA / ESA / Mario Livio and the Hubble 20th Anniversary Team

Image credit: Christoph Reindel

www.ppvi.org

Abb. IV.2.2: Poster of the huge conference "Protostars and Planets VI" which was held at the Heidelberg Convention Center. 850 Wissenschaftler came to Heidelberg between July 15 and 20 to take part on one of the largest astronomical meetings woldwide, to present and discuss the state of play in reasearch about evolution of stars and planets.

organization and management of other meetings: The most important meetings in 2013 were:

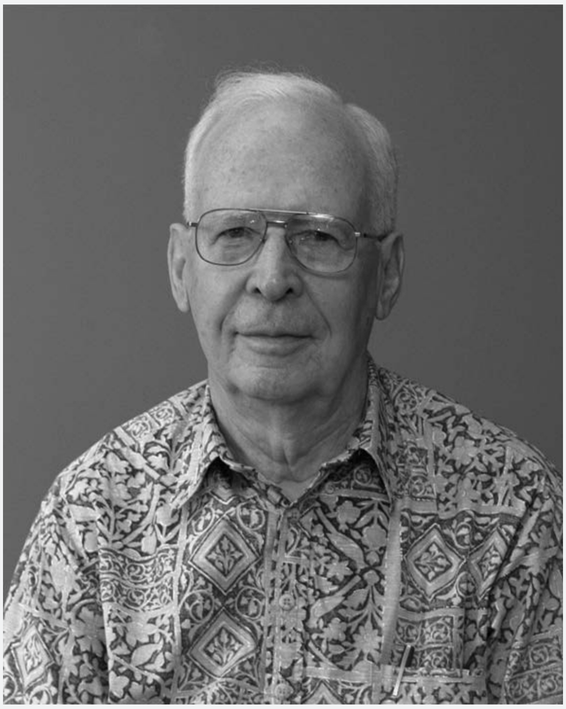
- the workshop "Regulation of star formation in molecular gas: from galactic to sub-cloud scales", June 23 – 29 at Ringberg Castle;
- the "8th Heidelberg IMPRS Summer School" at the Max Planck House Heidelberg (September 9 – 13). This time, the workshop was about High Energy Astrophysics;
- the large conference "Protostars and Planets VI" (July 15 – 20) at the Heidelberg Convention Center;
- the conference "Dust Growth in Star- and Planet-Forming Environments" (July 22 – 25) at MPIA;
- the MPIA Summer Conference "Phases of the ISM" (July 29 – August 1) at the HdA;
- the "MegaSAGE Meeting" (September 23 – 27) at the HdA.

MPIA was also heavily involved in the Fall Meeting of the German Astronomical Society (AG) through organizational support – in particular regarding the events related to the 150 years anniversary of the society – but also through scientific presentations, teacher training, and a special meeting for "Public Outreach in Astronomy". Also a splinter session on "The Legacy of the Herschel Space Observatory" was organized. The conference entitled Waves and Particles: Multi-Messengers from the Universe was held in Tübingen between September 24 and 27.

The MPIA continued also its program of guided tours through the Institute and the HdA, thanks to the generous involvement of students and staff. School and college groups accounted for more than half of these tours. But there were also a number of tours and talks for special guests and in terms of special events where the Institute management was involved. Examples are the visits of the Industrie und Handelskammer/Chamber of Commerce, of the Rotary Club and the Heidelberg Fire Department, or special events like the HdA Space Day, a colloquium for the retirement of Josef Fried and Rainer Lenzen, the Patzer Prize Colloquium, the Astronet-PR-Workshop at HdA, or a UNAWE-conference (for more details see Chapter IV.3).

Again this year employees of MPIA/HdA were very active in order to present astrophysics to a broader public by giving talks at schools, education centers and planetaria (see also Chapter V.3). They also appear at press conferences or on radio and television programs and in 2013 MPIA published 11 press releases and 18 News releases.

Bereavement



Besides all these positive events, there was unfortunately cause for mourning. On October 13, 2013, Dr. George H. Herbig, astronomer emeritus at the University of Hawaii at Manoa and an emeritus external scientific member of the Max Planck Institute for Astronomy, died at the age of 93 in Honolulu. Dr. Herbig was widely known for his pioneering studies of star formation and his scientific work on the properties and evolution of young stars. We will keep him in our thoughts.

Klaus Jäger, Thomas Henning, Markus Pössel, Axel M. Quetz, Hans-Walter Rix, Mathias Voss

IV.3 Haus der Astronomie – Center for Astronomy Education and Outreach

Throughout 2013, our Center for Astronomy Education and Outreach, Haus der Astronomie (HdA; literally "House of Astronomy") remained on course to fulfil its mission: to communicate the fascination of astronomy to the general public, to support astronomy education, and to foster the exchange of knowledge between scientists. Particularly successful events included a "Space Day" with three astronauts, a career event featuring Nobel laureate Brian Schmidt, and several large-scale in-service training events for teachers and educators.

Haus der Astronomie is an unusual institution at the interface between science and the public. Its custom-built, galaxy-shaped building hosts an active team of astronomers and astronomy educators, dedicated to developing and producing materials and resources for the public or for use in schools. In 2013, the HdA building received almost 11 000 visitors: members of the general public taking guided tours or listening to popular talks, student groups from kindergarden to university level, educators and teachers participating in workshops or lectures, and astronomers and engineers attending meetings or conferences.

Astronomy for the public

Our outreach activities for the general public combine the tools of classic PR, online outreach, and the organization of public events. As German node of the ESO Science Outreach Network, we provide support for the German-language outreach activities of ESO, the European Southern Observatory.

This year's highlight event was our "Space Day" on July 3, featuring ESA astronauts Jean-François Clervoy and Claude Nicollier (both of whom participated in repair missions for the Hubble Space Telescope) and NASA astronaut John-David Bartoe (the research manager for the International Space Station). In parallel sessions for elementary school students, high school students, young astronomers and the general public, the three astronauts interacted with a total of more than 400 visitors.

Other special public events this year included a cooperation with Kurpfälzisches Museum, Heidelberg, featuring four talks on the history of astronomy (with one talk at HdA), and with Reiss-Engelhorn-Museen Mannheim on the occasion of their exhibition "The Medici – People, Power and Passion", to which HdA contributed two public talks and a student workshop on the subject of Galileo Galilei and his discoveries.

On a more regular basis, we continued to offer public talks as part of our monthly lecture series "Fascinating Astronomy" (14 talks; organization: Liefke) and, in the summer, under the heading of "Sunday a.m. Astronomy" (4 talks; organization: Pössel), with a total attendance of more than 2000.

Guided tours of Haus der Astronomie as well as the surrounding astronomical institutes were offered both by MPIA students and by HdA staff for more than 100 groups, with a total attendance of nearly 3000.

The partners and the team

Haus der Astronomie is the result of a partnership between the Klaus Tschira Foundation, which has financed and built the spectacular HdA building, the Max Planck Society operating the HdA (via MPIA), and the City of Heidelberg and the University of Heidelberg supporting our operations with staff positions.

Our team consists of: Markus Pössel as the HdA's Managing Scientist (funded by Max Planck Society); Olaf Fischer (funded by the City of Heidelberg's Foundation for Youth and Science), our resident specialist for high-school astronomy; Carolin Liefke (funded by the Klaus Tschira Foundation and Baden-Württemberg's Ministry of Science and Research), whose focus areas include student research and university teaching for future physics teachers; Cecilia Scorza, who specializes in middle school astronomy education and astronomy for younger children, funded by the Special Research Programme SFB 881 "The Milky Way System" and EU-UNAWE; Natalie Fischer, who specializes in astronomy for elementary schools and kindergardens, also funded by EU-UNAWE, and Jakob Staude, one of the driving forces behind the HdA project as a whole, continues to accompany and advise us. Also, we are fortunate to have three teachers (Gymnasium and Realschule), on loan from Baden-Württemberg's Ministry of Education: Alexander Ludwig, Matthias Penselin and Tobias Schultz, who spent most of their time in their respective schools and some of their time here at HdA. Scientific and student assistants complete our roster.

Credit: HdA/O. Fischer

Fig. IV.4.1: A spiral galaxy in winter: South view of the HdA building.

We also participated in this year's edition of "Explore Science", the Klaus Tschira Foundation's five-day family science festival, held in late June and attended by more than 50 000 visitors, with hands-on stations about planetary atmospheres, the Sun, and our home planet, the Earth. HdA staff also gave more than a dozen public talks in various locations throughout Germany.

Scientific Exchange

To foster scientific exchange, the Haus der Astronomie serves as a meeting place, with the central auditorium and the workshop rooms suitable for hosting meetings and conferences for up to 80 participants.

Our largest conference this year was the 2nd MPIA Summer Conference, held from July 29 to August 1 on the subject "Phases of the Interstellar Medium", organized by MPIA's Brent Groves, Karin Sandstrom and colleagues, and attended by 90 participants. Additional larger meetings were the 22nd meeting of the Instrument Control Centre (ICC) of the Herschel-PACS instrument and the meeting of MegaSAGE, a collaboration of researchers using Spitzer and Herschel data to study our nearest galactic neighbours: the Magellanic Clouds.

An unusual event took place on April 26, with a talk by Nobel Laureate Brian Schmidt (Physics 2011) for astronomy students from the Heidelberg Graduate School in Fundamental Physics and from the IMPRS (organization: N. Christlieb, Landessternwarte). Schmidt's career advice to young astronomers had the title "How to win a Nobel Prize (or to be a happy astronomer if you don't)".

HdA also hosted meetings on the subject of astronomy education and outreach, notably the Astronet II Workshop "Astronomy Education and Public Outreach:

Fig. IV.4.2: Prof. Tim de Zeeuw, Director-general of the European Southern Observatory (ESO) talks about ESO's history and future plans in the HdA's central auditorium, April 16, 2013.

Credit: HdA/M. Pössel

the European Perspective" (co-organized by M. Pössel) and the EU Universe Awareness International Workshop "Astronomy to Inspire and Educate Young Children" (co-organized by N. Fischer and C. Scorza).

In addition, there were 46 smaller scale scientific meetings and gatherings with a total of 460 participants.

Astronomy for schools and kindergardens

On the educational side, our flagship remains »Wissenschaft in die Schulen!« (literally "Science into the schools!", abbreviated WIS) in cooperation with "Spektrum der Wissenschaft Publishing", and in particular the popular astronomy magazine "Sterne und Weltraum". HdA senior staff member Olaf Fischer, in charge of WIS-Astronomy, and his team of (mostly external) authors created 16 sets of curricular materials helping teachers bring cutting-edge astronomy into their classrooms. Each set is directly linked to an article or news item in a current issue of "Sterne und Weltraum". The HdA's activities for WIS-Astronomy are kindly supported by the "Reiff Foundation for Amateur Astronomy".

Development of educational material for secondary schools focused on the collaboration with the Collaborative Research Center "The Milky Way System" (SFB 881) at Heidelberg University, for which HdA is a key outreach partner. Notably, we developed exercises based on real astronomical data, such as the determination of the distance to the Small Magellanic Cloud (SMC) by means of the Cepheid L-P relation, and an estimate for the Milky Way's rotation curve. These exercises, which are now being tested in several schools, complement the hands-on experiments and models of the Milky Way Kit (which is aimed at somewhat younger students, ages 14–15). Translations of these resources into Spanish and English are being prepared and will be distributed 2014 to our cooperation partners in the Andean countries (Venezuela, Colombia, Ecuador, Peru, Bolivia and Chile) and in South Africa.

65 Universe in a Box kits, developed at the HdA (Scorza, N. Fischer) for the work with young children, were produced and distributed to kindergarten and primary school teachers all over Germany as well as to Leiden University (N. Fischer). The EU-UNAWE International Office built and tested additional prototypes of the box in cooperation with UNAWE partners worldwide (Scorza), in preparation of large-scale international distribution under the auspices of the International Astronomical Union.

Almost 2000 pupils and pre-school children visited the HdA directly this year, for a total of 96 workshops for various age groups. Such workshop typically involve hands-on activities, make use of our digital planetarium, and are often used to field-test newly developed materials.

HdA staff, in turn, participated in a number of external events. This year's highlight was our trip to South Africa in spring as part of our project for the German-South African Year of Science 2012/2013, funded by the federal research ministry. We were accompanied by the winners of our partner school competition –

Fig. IV.4.3: Event for elementary school children in the central Klaus Tschira Auditorium of HdA: ESA astronaut Claude Nicollier with a UNAWE Earth Ball, demonstrating astronomical sizes and distances. Nicollier's talk, which also touched upon his repair missions to the Hubble Space Telescope, was part of HdA's first "Space Day" on July 3 in cooperation with the XXVI Planetary Congress.

Credit: HdA/M. Pössel

three teachers, six pupils. The trip included a visit to South Africa's National Science Festival in Grahamstown (where Natalie Fischer held several workshops on the subject of "water rockets" and a teacher training for educators from South-African science centers), visits to the South African partner schools as well as additional schools, and a trip both to the South African National Observatory's Sutherland observing station and to the future site of the Square Kilometer Array in the Karoo semi-desert.

Additional external events included astronomy courses for the Hector Kinderakademie (N. Fischer), the Deutsche Schülerakademie (O. Fischer), and the JuniorAkademie Baden-Württemberg in Adelsheim (Liefke).

Reaching out to communicators and educators

Teachers and educators play a key role in science outreach – helping them develop a passion for cutting-edge research, and giving them the right tools to pass this passion (and the science itself!) on to their students, is probably the most effective outreach strategy there is. Our activities in training teachers – and aspiring teachers – as well as educators span the whole spectrum from initial teacher education to in-service training.

Pre-service training included two seminars at the University of Heidelberg ("Nobel Prizes in Astronomy and Astrophysics" and "Life of Stars", Liefke/O. Fischer), while N. Fischer held one lecture on "Basic Astronomy in School" at Heidelberg's University of Education (Pädagogische Hochschule). Olaf Fischer, Cecilia Scorza and Markus Pössel (co-)advised a total of six "Staatsexamensarbeiten", the research-oriented theses aspiring teachers need to write as a requirement for their degree. Typically, some of the results of these theses will also find their way into the HdA's educational activities.

This summer, the HdA became trilingual as 50 teachers, astronomers and student teachers from Germany and Italy converged on the first of four German-Italian Summer Schools on Astronomy, funded by the Wilhelm and Else Heraeus foundation. For a total of nine days, the participants explored the concepts and observations modern cosmology as well as practical questions of including astronomy in the two country's high-school curricula. After Heidelberg, the summer school will move to Padua in 2014, Jena in 2015, and Florence in 2016.

This year also saw the first of what is planned as an annual series of three-day teacher training schools, open to teachers throughout Germany. The first of these "Wilhelm und Else Heraeus Teacher Trainings in Astronomy", funded by the Wilhelm und Else Heraeus foundation, took place November 7–9. Titled "Hitchhiker's Guide to the (Milky Way) Galaxy", the school included workshops on exoplanets, infrared astronomy and remote observing as well as presentations of astronomy-related ideas by the attending teachers.

For the lower end of the age spectrum, there was a week-long "Universe Awareness" training for elementary school teachers and educators attended by 50 participants from all parts of Germany. The participants created their own "Universe in a Box" kits, and founded the German UNAWE network.

Additional teacher training events at HdA were a one-day training event "Measuring the Milky Way", a three-day event "Introduction to Astronomy: the Sun and its dependants" for the Baden-Wurttemberg ministry of education, as well as six training sessions with primary school and kindergarten teachers. HdA staff also participated in more than a dozen external teacher training activities as far apart as Saarland, Thuringia, and Hamburg. This year's mobile teacher training, supported by the Reiff Foundation, took place in Mecklenburg-West Pomerania (Schwerin, Malchow, Neustrelitz, Pasewalk, Ahlbeck, Greifswald, Gingst, Rostock; O. Fischer/E. Sellentin). Special mention needs to be made of the teacher training "A Driver's licence for Telescopes" in Adelsheim (O. Fischer/Liefke) qualifying teachers for the use of small telescopes in school, which also serves as the necessary qualification for teachers who want to take advantage of the HdA's telescope lending program.

Research with high-school students

A key component of science literacy is first-hand research experience for high-school students. To this end, we continued our collaboration with the International Astronomical Search Collaboration (IASC) on the IASC-Pan-STARRS asteroid search (high-school students searching for asteroids in Pan-STARRS image data, with a realistic chance of discovering previously unknown main belt asteroids; Liefke), supporting a total of 18 German high-school groups participating in two search campaigns. On 19 July 2013, IASC initiator Patrick Miller honored the

Fig. IV.4.4: Prof. Tim de Zeeuw, Director-general of the European Southern Observatory (ESO) talks about ESO's history and future plans in the HdA's central auditorium, April 16, 2013.

Credit: HdA/M. Pössel

Credit: HdA/O. Fischer

Fig. IV.4.5: HdA abroad: Teacher training for Chilean teachers in Santiago de Chile in January 2013. This and other workshops for teachers throughout Chile were organized by HdA's Olaf Fischer and Cecilia Scorza in cooperation with the Heidelberg Center Latin America of the University of Heidelberg.

participants of the year's spring campaign at a meeting at the HdA.

A highly promising area of growth is remote observing: astronomical observations using telescopes that can be controlled via the Internet (Liefke). We extended our collaboration with the Faulkes Telescope Project; a first teacher training enabling more German teachers to access the two remotely operated 2 meter Faulkes Telescopes took place on 7 September 2013. On 8 January 2013 HdA partner teachers Martin Metzendorf and Matthias Penselin, coordinated by Carolin Liefke, used the two Faulkes telescopes to measure the parallax of asteroid Apophis, determining the asteroid's distance to Earth with an accuracy of 0.3 percent.

Further activities with remote telescopes for educational purposes focus on the 60 cm ROTAT telescope operated by the Foundation Interactive Astronomy and Astrophysics, Tübingen. Operated by Carolin Liefke, the ROTAT telescope was one of only a few stations in Europe that observed the close-by Earth passage of asteroid 2014 DA14 (now named 367943 Duende). In school year 2013/14, improving the operational procedures of the telescope is also the focus of three TheoPrax projects conducted by high school student groups in collaboration with the TheoPrax Center at Fraunhofer ICT Pfinztal.

Another opportunity for high-school students to experience astronomical research first-hand and, ideally, work on their own projects, are HdA internships. Some of these are part of regular career orientation (such as the BoGy internship program), or of programs for the benefit of particularly talented/interested students, e.g. in collaboration with the Hector Seminar (Liefke). Since March 2013 Carolin Liefke is additionally scientific mentor of the Astrophysics Group at the Heidelberger Life Science Lab, an initiative of the Deutsches Krebsforschungszentrum. Our largest internship program remains the three-week International Summer Internship, which includes participants from the International Summer Science School Heidelberg. This year, six students, hailing from Australia, France, Germany, Luxemburg, and the United Kingdom took part in this program (Pössel).

Keeping connected: networking

Internationally, our main collaborations are in the framework of the EU-UNAWE network (that is, with our counterparts in Italy, the Netherlands, the United Kingdom, South Africa and Spain) as well as with the WIS-Project in Chile (in cooperation with the Heidelberg University's Center for Astronomy and its Centre of Excellence in Chile). Cecilia Scorza has also been active in Colombia, Venezuela, Ecuador, Peru and Bolivia, helping to set up regional IAU nodes for the Office of Astronomy for Development.

Key strands of our network are tied to specific persons: Cecilia Scorza is member of the Schulkommission (School's committee) of Astronomische Gesellschaft, and she is also the German coordinator for the European Association for Astronomy Education (EAAE) as well as a member of IAU commission 46, "Astronomy Education and Development" and an advisor to the IAU's Office of Astronomy for Development for Latin America. Markus Pössel is a member of the Astronet II Task 5.3 Working Group on outreach matters, which supports the European Commission in the planning of future infrastructure for astronomy, and he was also elected National Outreach Contact for Germany of the IAU's Office for Astronomy Outreach. Natalie Fischer is responsible for the new established Universe Awareness Network Germany, which includes kindergarten and elementary school teachers from all over Germany.

Markus Pössel, Natalie Fischer,
Olaf Fischer, Carolin Liefke,
Alexander Ludwig, Matthias Penselin,
Tobias Schultz, Cecilia Scorza, Jakob Staude
Thomas Henning, Hans-Walter Rix,
Klaus Jäger, Mathias Voss, Frank Witzel

IV.4 Work and family life, dual career, work-life balance

Established since 2006, measures for better compatibility of work and family are continuously developed. A good compatibility of job and family for employees is a very important matter to the MPIA. The institute supports men and women in all cases equally. To attract top scientists and best employees from all over the world, MPIA has set the goal to offer both excellent research conditions as well as an excellent environment for a healthy balance between work and private life.

Instrumente

- Flexible design of working time and location in special life situations (e.g. child care hours, care time, dual career situations)
- Access to a total of 21 places for Max-Planck Institutes in Heidelberg in daycare for children from 8 weeks to 6 years
- Room for Child care
- Baby-Office
- Support at Conferences
- Care offers during holidays via “Bündnis für Familie Heidelberg”
- Dual Career Program
- Contact Support Programs during temporary withdrawal from the profession in special situations
- Special support for parental leave for fathers
- Support for new employees by the International Office at accommodation, search for suitable schools and childcare facilities.
- Mediation service for families via “Besser betreut” in childcare, elder care and household services.

Despite the existing occupancy rights in various childcare facilities and due to childcare problems in 2013, a further cooperation with the daycare "Glückskinder" was decided. In cooperation with the Max Planck Institute for Nuclear Physics (MPIK), the final hurdles for the implementation and opening of the daycare at MPIK in 2014 have been taken

Dual Career Service

The Dual Career (DC) service is an important part in the personal work of the MPIA. The Institute is still active in the working group “Bündnis für Familie”.
Members are the following institutions: DKFZ Heidelberg, EMBL Heidelberg, the MPIs, the College of Education, SRH universities GmbH and SRH Kliniken GmbH.

Aims:

- Support for dual-career
- Promotion of support structures in Heidelberg and the surrounding area

Solutions:

- Timely, cross-institutional support of applications
- Collegial exchange of subject profiles and application possibilities
- Joint offers and information for DC-Couples
- Joint Employment website: www.familie-heidelberg.de/bffh/index-a-515.html

Qualification projects for trainees

“Work and family. My life”: Compatibility of work and family is now regarded as one of the keys to act against a future lack of skilled employees. In cooperation between the MPIA and the “Bündnis für Famillie”, a group of trainees led by Susanne Bock (Heidelberger Dienste) met in July 2013 at MPIA for a three-days-seminar to discuss the main challenges of this field and to sensitize young people at the beginning of their professional life for this topic "work, family, compatibility". Through interviews with colleagues from science and other fields of work as well as through personal discussions at MPIA, the trainees learned what it means to experience "compatibility" in the real working life and how the support should be organized.

Senior Executives in dialog. Family-oriented personnel management as a competitive advantage

For the recruiting of skilled scientists and professionals, a family-friendly personnel management is increasingly becoming a priority for employers. In the working group "Vereinbarkeit von Beruf und Familie" of the “Bündnis für Familie Heidelberg”, MPIA, SAP AG, Stadtwerke Heidelberg, Heidelberg University, in collaboration with the “Kompetenz-Zentrum Beruf und Familie der FamilienForschung Baden-Württemberg”, jointly developed a new offer for senior executives.

In September 2013, the event “Senior Executives in dialog. Family-oriented personnel management as a competitive advantage” took place with active participation of MPIA. The offer was open to selected executives, to give them the opportunity to share their experiences across different areas of business. Some focus questions were, for example: family-oriented personnel management - what does that mean? What different challenges do you see in your younger and your older employees? What are the experiences and the scope of action?

The meeting was very successful and brought new insights and impulses for the MPIA participants.

V. Appendix

V. 1 Staff

Department: Planet and Star Formation

Director: Thomas Henning

Infrared Space Astronomy: Oliver Krause, Zoltan Balog, Jeroen Bouwman, Örs Hunor Detre, Adrian Glauser, Ulrich Grözinger, Ulrich Klaas, Hendrik Linz, Friedrich Müller, Markus Nielbock, Jan Pitann, Silvia Scheithauer, Jürgen Schreiber

Star Formation: Henrik Beuther, Tobias Albertson, Amelia Bayo, Simon Bihr, Arjan Bik, Paul Boley, Markus Feldt, Siyi Feng, Thomas Gerner, Angela Adamo, Joseph Harrington, Katharine Johnston, Jouni Kainulainen, Ralf Launhardt, Rainer Lenzen, Hua-Bai Li, Nils Lippok, Johan Olofsson, Sarah Ragan, Dimitry Semenov, Jin Shen, Bernhard Sturm, Amy Stutz, Jochen Tackenberg, Roy van Boekel, ShiweiWu, Sarolta Zahorec, Sun Zhao, Svitlana Zhukovska

Brown Dwarfs/Exoplanets: Reinhard Mundt, Beth Biller, Micka el Bonnefoy, Wolfgang Brandner, Esther Buenzli, Simona Ciceri, Ian Crossfield, Patricio Cubillos, Niall Deacon, Bertrand Goldmann, Viki Joergens, Luigi Mancini, Elena Manjavacas, Christian Obermeier, Adriana Pohl, Victoria Rodrguez, Maren Mohler-Fischer, Tim Schulze-Hartung, Neil Zimmerman, Taisiya Kopytova

Theory (SP): Hubertus Klahr, Moritz Beutel, Kai-Martin Dittkrist, Karsten Dittrich, Aiara Lobo Gomes, Mykola Malygin, Paul Moliere, Christoph Mordasini, Natalie Raettig, Johannes Reppin, Kai Philipp Salm, Clement Surville, Gabriel-Dominique Marleau Laborastrophysik: Cornelia Jäger, Abel Brieva, Daniele Fulvio, Serge Krasnokutsky, Karsten Potrick, Gael Rouille, Toulou Sabri, Hagen Walter

Frontiers of Interferometry in Germany FRINGE: Thomas Henning, Uwe Graser, Ralf Launhardt

Adaptive Optics: Wolfgang Brandner, Casey Deen, Markus Feldt, Stefan Hippler, Sarah Kendrew, Maria Lenius, Pengqian Yang

MPG Research Group: Thomas Robitaille, Amanda Heidermann, Christine Koepferl, Esteban Morales

Emmy-Noether-Group: "Charakterisierung extrasolarer Planeten": Lisa Kaltenegger, Siddharth Hegde, Yamila Miguel, Yan Betremieux

Department: Galaxies and Cosmology

Director: Hans-Walter Rix

Galaxy Evolution and Milky Way: Hans-Walter Rix, Josef Fried, Yu-Yen Chang, Michelle Collins, Bernhard Dorner, Nina Hernitschek, Jakob Herpich, Marie Martig, Michael Maseda, Melissa Ness, Edward Schlafly, Branimir Sesar, Wilma Trick, Arjen van der Wel, Xiangxiang Xue, Zhitai Zang

Gaia Galactic Survey Mission: Coryn Bailer-Jones, Rene Andrae, Tri Astraatmadja, Fabo Feng, Richard Hanson, Dae-Won Kim, Kester Smith

Interstellarer Matter and Quasars with high Redshift: Fabian Walter, Elisabete Da Cunha, Anahi Caldu Primo, Roberto Decarli, Emanuele Farina, Jorge González, Jacqueline Hodge, Maria Kapala, Nico Krieger, Karin Sandstrom, Eduarodo Banados Torres, Bram Venemans, Laura Zschaechner

High Definition Astronomy: Thomas Herbst, Patrick Fopp, Kalyan K. Radhakrishnan, Joshua Schlieder

Jet Physics of Active Galactic Nuclei: Christian Fendt, Somayyeh Sheikhnezami, Deniss Stepanovs, Qian Qian

Active Galactic Nuclei: Klaus Meisenheimer, Christian Leipski

Extragalactic Star Formation: Eva Schinnerer, Paolo Bianchini, Emer Brady, Dario Colombo, Brent Groves, Annie Hughes, Sharon Meidt, Mark Norris, Miguel Querejeta, Fatemeh Tabatabaei

Coevolution of Galaxies and Black Holes (Emmy-Noether-Gruppe) and EUCLID Mission Group: Knud Jahnke, Stefanie Wachter, Liyualem Ambachew, Felix Hormuth, Katherine Inskip, Matt Mechtley, Gregor Seidel, Robert Singh

Inter- and Circum-galactic Medium: Joe Hennawi, Fabrizio Arrigoni Battaia, Anna Christina Eilers, Cristina Javiera Garcia, Ilya Khrykin, Girish Kulkarni, Khee-Gan Lee, Elisabeta Lusso, Gabriele Maier, Jose Onorbe, Alberto Rorai, Tobias Schmidt, Jonathan Stern, Michael Walther, Gabor Worseck

Structure and Dynamics of Galaxies: Glenn van de Ven, Remco van den Bosch, Alex Büdenbender, Vesselina Kalinova, Mariya Lyubenova, Sladjana Nikolić, Athanasia Tstasi, Akin Yildirim, Ling Zhu

Galaxy Formation in a Dark Universe: Andrea Macciò (Max-Planck-Forschungsgruppe), Salvatore Cielo, Aaron Dutton, Nikolaos Fanidakis, Thales Gutcke, Rahul Kannan, Camilla Penzo, Greg Stinson, Liang Wang, Rainer Weinberger

Instrumentation: Thomas Herbst, Zhaojun Yan, Xianyu Zhang

Instrumentation, Black Holes and Accretion: Jörg-Uwe Pott, Santiago J. Barboza, Michael Boehm, Qiang Fu, Iva Karovicova, Alexander Keck, Rainer Koehler, Kirsten Schnuelle

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Technical and other staff

Public Relations: Pössel (Head), supported by K. Jäger und Quetz

Haus der Astronomie: Pössel (Head), Brümmer-Wissler, N. Fischer, O. Fischer, Liefke, A. Ludwig, Penselin, Schultz, Scorza, Sellentin; *Student Assistants:* Hagstotz, Haude, K. Huber, Khalisi, Kozlikin, Neu, Rohnacher, Tugendhat

Technical Departments: Kürster (Head)
- **Mechanics Design:** Rohloff (Head), Baumeister (Deputy), Ebert, Huber, Münch, Rochau; *Azubis, Praktikanten, Student Assistants:* Grieser
- **Precision Mechanics Workshop:** Böhm (Head), Meister (Deputy), Abel, Brezinski, Heitz, Maurer, Meister, Meixner, Stadler; *Azubis, Praktikanten, Student Assistants:* Abel, Baldauf, Brezinski, Kugler, Mayer, Reichert, Schend, Schwind, Sennhenn, Specht
- **Electronics:** Mohr (Head), Ramos (Deputy), Adler, Alter, H. Ehret, Klein, Lehmitz, Mall, Ridinger, Wrhel; *Azubis, Praktikanten, Student Assistants:* Beust, Dieng, Neumeier, Ramisch, Wydra
- **Instrumentations-Software:** Briegel (Head), Neumann (temponary Deputy), Storz (Deputy), Berwein, Borelli, Kittmann, Kulas, Mathar, Möller-Nilsson, Neumann, Pavlov, Trowitzsch; *Azubis, Praktikanten, Student Assistants:* Barreto
- **Engineering and Project Management:** Bizenberger (Head), Bertram (Deputy), Conrad, De Bonis, Gässler, Graser, Hermann, Hoerbert, Krambs, Laun, Mellein, Meschke, Moreno-Ventas, Naranjo, Panduro, Peter, Schray

Administrative and Technical Service Departments:
- **Library:** Dueck
- **Data Processing:** Piroth (Head), Richter (Deputy), Binroth, Hiller, Hummelbrunner
- **Photographic Lab:** Anders
- **Graphic Artwork:** Quetz (Head), Meißner, Müller-thann
- **Secretariats:** Berner, Cuevas-Alonso, Koltes-Al-Zoubi, Otto, Seifert, Witte-Nguy
- **Technical Services and Cafeteria:** F. Witzel (Head), Nau (Deputy), Behnke, Douffet, Drescher, Jung, Krämer, Lang, B. Witzel, E. Zimmermann
- **Administration:** Voss (Head), purchasing dept.: Wolf, Anders; finances dept.: Hofmann, Kourschil, Anders, Braun, G, Enkler, Lechner, Reifke, Zähringer; staff dept.: Apfel, Baier, Hölscher, Schleich, Schuch, Wagner; reception: Beckmann; trainees: Lechner, Till

Former Staff Members Acting for the Institute: Christoph Leinert, Dietrich Lemke

V.2 Guests

Scientific Guests: Elena D'Ongia, 7. – 9. Jan.; Joerg Fischera, CITA/Univ. Toronto, 9. – 10. Jan.; Katja Poppenhaeger, Harvard Smithsonian, 14. Jan.; Alessandro Gardini, Univ. Oslo, 15. Jan.; Denis Erkal, Univ. Chicago, 18. – 22. Jan.; Marcel Pawlowski, Univ. Bonn, 21. Jan.; Adriano Agnello, Univ. Cambridge, 21. – 24. Jan.; Vid Irsic, Univ. Ljubljani, 22. – 24. Jan.; Julio Rodriguez, IAA, 22. – 23. Jan.; Matilde Fernández, IAA, 22. – 23. Jan.; Michele Compostella, Argelander-Institut für Astronomie Bonn, 23. Jan.; Melissa Ness, ANU, 24. Jan.; Bradley Peterson, OHIO State Univ., 28. – 30. Jan.; Ralph Schoenrich, OSU, 28. – 30. Jan.; K. Radhakrishnan, Univ. Göttingen, 30. Jan. – 1. Feb.; Sacha Hony, 1. Feb. – 30. June; Esther Buenzli, Steward Obs., 3. – 8. Feb.; Florian Rodler, CSIC-IEEC, 4. – 9. Feb.; Raaele D'Abrusco, CfA Harvard, 4. – 6. Feb.; Joan Font, IAC, 4. – 16. Feb.; Kenneth Carrell, NAO, 5. – 7. Feb.; Maria Bergemann, 6. Feb.; Elodie Choquet, 7. – 8. Feb.; Adriane Liermann, MIFR Bonn, 7. – 8. Feb.; Chris Brook, Univ. Madrid, 11. – 14. Feb.; Marco Baldi, Univ. Bologna, 11. – 15. Feb.; Joana Ascenso, ESO, 11. – 13. Feb.; Carl Ferinho, Cornell, 11. – 13. Feb.; Benjamin Leavans, 11. – 14. Feb.; Trent Dupuy, Harvard Univ., 12. – 14. Feb.; Hans Zinnecker, SOFIA Inst., 13. Feb.; Monika Lendl, 14. – 15. Feb.; Sarah Sadovay, Univ. Victoria, 17. – 23. Feb.; Marcel S. Pawlowski, Univ. Bonn, 18. – 22. Feb.; Nicolas Martin, Strasbourg Obs., 18. – 21. Feb.; Daniele Sorini, Univ. Padova, 20. – 22. Feb.; Duncan Forbes, Swinburne Univ., 22. – 23. Feb.; Dan Weisz, Univ. Washington, 23. Feb. – 7. Mar.; Elizabeth Tasker, Hokkaido Univ., 25. – 26. Feb.; Andrew Chung, MPA, 25. Feb. – 1. Mar.; Marianne Vestergaard, DARK Cosm. Center, 3. – 6. Mar.; Kelly Denney, DARK Cosm. Center, 3. – 6. Mar.; Rachael Kratzer, Drexel Univ., 3. – 16. Mar.; Simon Legrand, 3. Mar. – 31. July; Sascha Quanz, ETH, 4. – 5. Mar.; Maria Bergemann, MPA, 5. Mar.; Agnieszka Ryś, IAC, 6. – 17. Mar.; Dario Scovacricchi, INAF, 7. – 9. Mar.; Stepanie Juneau, CEA, 11. – 15. Mar.; Burcu Beygu, Univ. Groningen, 11. – 13. Mar.; Sami Dib, Imper. College, 12. Mar. – 30. Apr.; Sami Dib, Imper. College, 12. Mar. – 31. May; Neale Gibson, ESO, 13. – 15. Mar.; Manoj Puravankara, 14. Mar. – 11. June; Andreas Baumbach, Univ. HD, 18. Mar. – 13. Apr.; Vincent Steinberg, 18. Mar. – 17. July; Maxime Follin, ESAC, 21. – 22. Mar.; Nikolai Voshchinnikov, St. Petersburg Univ., 21. Mar. – 18. Apr.; Liang Wang, Purple M. Obs., 30. Mar. – 26. Apr.; Weishan Zhu, Nanjing Obs., 30. Mar. – 26. Apr.; Angel Berihuete, Univ. Cadiz, 1. Apr. – 16. June; Yaroslav Pavlyuchenkov, INASAN, 2. – 21. Apr.; Camilla Pacici, Yonsei Univ., 8. – 12. Apr.; Andre Müller, ESO Chile, 8. Apr. – 3. May; Florian Schießler, 8. Apr. – 7. July; Elsa Huby, Obs. Paris, 10. Apr.; Tatiana Vasyunina, Univ. Virginia, 10. Apr. – 20. June; J. Moreno-Ventas, CSIC, 11. – 12. Apr.; Fernando Alvarez, 11. Apr.; Livia Vallini, Pisa Univ., 11. Apr. – 30. June; Arik Mitschang, Macquarie Univ., 13. – 15. Apr.; Daniel Zucker, Macquarie Univ., 15. – 19. Apr.; Daniel De Zeeuw, ESO, 15. – 16. Apr.; Bi-Qing For, ICRAR, 15. – 19. Apr.; Christian Obermeier, Univ. München, 17. Apr.; Benjamin Leavens, Strasbourg Obs., 22. – 27. Apr.; Nicolas Martin, Strasbourg Obs., 22. – 24. Apr.; Maria Bergemann, MPA, 22. – 25. Apr.; Tessel van der Laan, 22. – 26. Apr.; Jose Caballero, Univ. Madrid, 23. – 27. Apr.; John Southworth, Keele Univ., 24. Apr.; Enrique Crespo, 25. – 27. Apr.; Coleman Krawczyk, Drexel Univ., 25. Apr. – 8. May; Reinhard Schielicke, Univ. Jena, 27. Apr. – 1. May; Clement Beust, Lyon, 29. Apr. – 15. July; Alvaro Orsi, Univ. Chile, 30. Apr. – 7. May; Maxence Lefevre, Univ. Paris, 3. May – 30. July; Emanuele P. Farina, Univ. Insubria, Como, 4. – 10. May; Roxanne Ligi, Obs. Cote dAzur, 6. May; Devendra Ojha, Mumbai Univ., 6. – 29. May; Fatme Allouche, ESO, 7. May; Patricia Chinchilla, 7. – 8. May; Andreas Schreiber, AEI, 7. – 10. May; Tanja Schroeder, Univ. Frankfurt, 13. May – 30. June; Xi Kang, Purple Mount. Obs., 14. – 15. May; Timothy Davis, ESO, 20. – 24. May; Leslie Bartsch, Carnegie M. Univ., 20. May – 26. July; Jadhav Yashashree, Ohio Univ., 23. May – 10. Aug.; Jack Hughes, Rutgers Univ., 24. – 29. May; Richard M. Crutcher, 24. – 29. May; Imke De Pater, UC Berkeley, 27. – 30. May; Tom Megeath, Univ. Toledo, 1. June – 31. July; Diego Fustes, Univ. La Coruna, 1. June – 31. July; Nicolas Martin, Strasbourg Obs., 2. – 4. June; Randolf Klein, SO FIA Inst., 3. – 8. June; Christian Veillet, Univ. Arizona, 3. – 7. June; Supriya Chakrabarti, Univ. Massachusetts, 3. – 4. June; Gabriele Weiden, MPI Infektionsbiol., 4. June; Fabian Heitsch, Univ. North Carolina, 4. – 28. June; Christina Peters, Drexel Univ., 8. – 24. June; Benjamin Leavens, Univ. Strasbourg, 9. – 11. June; Pascal Oesch, Univ Lick, 10. – 14. June; Sebastiano Cantalupo, UCO/Lick Obs., 10. – 18. June; Felix Boll, Gießen, 10. – 21. June; Max Barretto, 10. June – 31. July; Adam Myers, Univ. Wyoming, 10. June – 9. Aug.; Greg Rudnick, Univ. Kansas, 10. June – 10. Aug.; Yunfan Zhang, Princeton, 10. June – 30. Aug.; Arunima Banerjee, Pune Univ., 12. – 14. June; Eric Pellegrini, Univ. Toledo, 16. – 23. June; J. Xavier Prochaska, UCO/Lick Obs., 16. – 23. June; Kayhan Gultekind, Univ. Michigan, 16. – 21. June; Jonelle Walsh, Univ. Texas, 16. – 21. June; Michael Di Pompeo, Univ. Wyoming, 17. – 24. June; Bradley Peterson, OHIO State Univ., 17. – 21. June; France Allard, ENS Lyon, 17. June – 5. July; Erik Tollerud, Yale, 20. – 21. June; Sara Rugheimer, Harvard Univ., 21. June – 22. July; Mia Bovill, Univ. Chile, 23. – 27. June; Neal Turner, JPL, 24. June – 31. July; Davide Greggio, Padova Obs., 24. June – 24. Aug.; Julianne Dalcanton, Univ. Washington, 25. June – 24. July; Branimir Sesar, Caltech, 30. June – 7. July; Neal Evans, Univ. Texas, 30. June – 13. July; Shih-Ping Lai, Tsing Hua Univ., 30. June – 9. July; Maria Bergemann, Garching, 30. June – 2. July;

Benjamin Weiner, Stew. Obs., 1. July – 23. July; Chris Brook, Univ. Madrid, 1. July – 12. July; Zara Randriamanakoto, South Africa Obs., 1. July – 12. July; William Bethune, Univ. J. Fourier, 1. July – 31. Aug.; Benjamin Laevens, Univ. Strasbourg, 1. July – 31. Aug.; Vincenzo Antonuccio, INAF, 2. July – 1. Aug.; Carmelo Arcidiacono, INAF, 2. July – 26. July; David Hogg, NYU, 2. July – 31. Aug.; Daniel Foreman-Mackey, NYU, 3. July – 30. July; Dan Weisz, Univ. Washington, 4. July – 1. Aug.; Sijing Shen, UC Santa Cruz, 4. – 5. July; Nic Ross, Lawrence Berk. Labs, 7. – 13. July; Ben Oppenheimer, Leiden Obs., 7. – 14. July; Frank van den Bosch, Yale Univ., 7. – 19. July; Björn Benneke, MIT, 7. – 9. July; Stella Oner, Yale, 8. – 12. July; Paul Elliott, ESO/Exeter Univ., 8. – 12. July; Arianna Di Cintio, Univ. Madrid, 8. – 12. July; Iryna Butsky, Caltech, 8. July – 13. Sep.; Mia Bovill, Univ. Chile, 9. – 12. July; We i Wang, Chin. Acad. Sci., 9. – 13. July; Aaron Bryant, Inst. Raumfahrtsys., 10. – 12. July; Herve Beust, Grenoble, 11. – 12. July; Mikhail Klassen, Mc-Master Univ., 11. July – 5. Aug.; Alberto Bolatto, 11. July – 16. Dec.; Fabian Heitsch, Univ. North Carolina, 12. – 21. July; Alexander Karim, AlfA Bonn, 13. – 14. July; Alexander Wolszczan, Penn State Univ., 14. – 26. July; Joe Carson, Charleston College, 14. July – 3. Aug.; Ana Uribe, Chicago, 14. July – 3. Aug.; Vernesa Smolcic, Univ. Zagreb, 15. – 19. July; Mladen Novak, Univ. Zagreb, 15. – 19. July; Felipe Navarrete, AlfA Bonn, 15. – 19. July; Alexander Karim, AlfA Bonn, 16. – 19. July; Mark Sargent, CEA/Saclay, 17. – 19. July; Dominik Riechers, Cornell Univ., 18. July – 2. Aug.; Gregory Green, Harvard, 20. July; Ralph Pudritz, McMaster Univ., 21. – 27. July; Heiko Jakob, GV MPG, 21. – 26. July; Marc White, Mount Stromlo, 22. – 26. July; Herve Beust, Grenoble, 22. – 26. July; Adam Leroy, NRAO, 23. July – 2. Aug.; David Mykytyn, NYU, 23. July – 13. Aug.; Ekta Patel, NYU, 23. July – 13. Aug.; Jonathan Whitmore, Crighton, 29. July – 2. Aug.; Douglas Finkbeiner, Univ. Michigan, 29. July – 9. Aug.; Robyn Sanderson, Kapteyn Astron. Inst., 1. – 2. Aug.; Joseph Shields, Ohio Univ., 1. – 9. Aug.; Joan Font, IAC, 1. Aug. – 31. Aug.; Jorge Barrera Ballestros, IAC, 2. – 9. Aug.; Alexia Lewis, Univ.Washington, 2. – 8. Aug.; C. Cardenas Vazques, IAA-CSIC, 5. – 14. Aug.; Marc Sarzi, Univ. Hertfordshire, 5. – 9. Aug.; Kaspar von Braun, 5. – 8. Aug.; Andras Zsom, MIT, 5. – 9. Aug.; Wladimir Lyra, Caltech, 5. – 7. Aug.; Wyn Evans, IoA Cambridge, 5. – 16. Aug.; C. Cardenas Vasquez, IAA-CSIC, 5. – 14. Aug.; Irene Ferro, IAA-CSIC, 5. – 14. Aug.; Jo Bovy, IAS Princeton, 5. – 18. Aug.; Shude Mao, NAO, 11. – 13. Aug.; Morgan Fouesneau, Univ. Washington, 11. – 17. Aug.; Matilde Fernández, IAA-CSIC, 12. – 14. Aug.; Robyn Sanderson, Kapteyn Astron. Inst., 13. – 16. Aug.; Zolile Mguda, Univ. Cape Town, 19. Aug. – 29. Sep.; Nicolas Martin, Strasbourg Obs., 21. – 22. Aug.; Gergely Csepany, Konkoly Obs., 21. – 23. Aug.; Erika Verebelyi, Konkoly Obs., 21. – 23. Aug.; John Kormendy, Univ. Texas, 21. – 25. Aug.; Morgan Fousneau, Univ. Washington, 21. – 22. Aug.; Shirley Yancy, Steward Obs., 1. – 14. Sep.; Jorge Barrera Ballesteros, 4. Sep. – 31. Oct.; Jacopo Chevallard, IAA Paris, 5. – 6. Sep.; Markus Janson, Univ. Belfast, 7. – 14. Sep.; Mario Flock, CEA, 9. – 16. Sep.; Natalia Dzyurkevich, CNRS, 9. – 16. Sep.; Bhargav Vaidya, Univ. Leeds, 16. – 22. Sep.; Nicolas Martin, Strasbourg Obs., 18. – 19. Sep.; Rosie Chen, MPIfR, 22. – 26. Sep.; Marta Sewilo, Johns Hopkins Univ., 22. – 28. Sep.; Jean- B. Marquette, IAP, 24. – 26. Sep.; Irene Ferro, CSIC, 24. – 27. Sep.; Tatjana Vasyunina, MPIfR, 2. – 11. Oct.; Ryan Leaman, IAC, 7. – 11. Oct.; Nadia Kostogryz, Kiepenheuer Inst., 9. Oct.; Clare Dobbs, Univ. Exeter, 13. – 18. Oct.; Yasuo Fukui, Univ. Nagoya, 14. – 16. Oct.; Bradley Peterson, OHIO State Univ., 14. – 18. Oct.; Mathias Jäger, 15. – 17. Oct.; Jay Gallagher, Univ. Wisconsin, 20. – 25. Oct.; Jenna Ryon, Univ. Wisconsin, 20. – 25. Oct.; Felix Bettonvil, Sterrewacht Leiden, 21. – 25. Oct.; Eddy Elswijk, ASTRON Dwingeloo, 21. – 25. Oct.; Camila Pacici, Yonsei Univ., 21. Oct. – 1. Nov.; Linda Smith, STScI, 23. – 25. Oct.; Nadine Neumayer, ESO, 25. Oct. – 1. Nov.; Ranjan Gupta, UCAA, 27. – 30. Oct.; Ronald Roelfsema, ASTRON Dwingeloo, 29. Oct. – 1. Nov.; Benjamin Hußmann, Univ. Bonn, 30. Oct.; Andre Müller, ESO, 4. – 6. Nov.; Junqiang Ge, NAO Beijing, 4. Nov. – 3. Dec.; Andre Müller, ESO, 4. Nov. – 6. Dec.; Menno de Haan, ASTRON Dwingeloo, 5. – 8. Nov.; Eddy Elswijk, ASTRON Dwingeloo, 5. – 8. Nov.; Peter Ábrahám, Konkoly Obs., 10. – 16. Nov.; Agnes Kóspál, ESA, 10. – 16. Nov.; Attila Moór, Konkoly Obs., 10. – 16. Nov.; Derek Yves, ESO, 11. – 12. Nov.; Gerd Jakob, ESO, 11. – 12. Nov.; Oskar Miettinen, 11. – 15. Nov.; Eric Gendron, Obs. Paris Meudon, 12. – 13. Nov.; Yann Clenet, Obs. Paris Meudon, 12. – 13. Nov.; Malcolm Fridlund, DLR, 12. – 14. Nov.; Pedro R. Capelo, Univ. Michigan, 12. – 14. Nov.; Marc Dietrich, Univ. Giessen, 14. Nov.; Marta Volonteri, IAP Paris, 18. – 20. Nov.; Peter Nugent, Lawrence Berkeley, 20. – 22. Nov.; Rowin Meijerink, Kapteyn Inst., 20. – 22. Nov.; Eugene Vasiliev, Lebedev Inst., 20. – 22. Nov.; Maria De Juan Ovelar, Leiden Obs., 20. Nov.; Irene Ferro, IAA, 21. – 27. Nov.; Marina Prokopyeva, Sobolov Astr. Inst., 27. Nov. – 6. Dec.; Sarah Rugheimer, Harvard Univ., 27. Nov. – 24. Dec.; Sandor Kiraly, Konkoly Obs, 2. – 5. Dec.; Jean-Philippe Bernard, IRAP, 2. – 6. Dec.; Bruno Lopez, OCA Nice, 3. – 5. Dec.; Jarle Brinchmann, Leiden Univ., 3. – 4. Dec.; Laura Watkins, STSI, 5. – 18. Dec.; Erwin de Blok, ASTRON, 7. – 14. Dec.; Antigona Segura, Univ. Mexico, 7. – 22. Dec.; Jonathan Tan, Univ. Florida, 9. – 13. Dec.; Else Starkenburg, Univ. Victoria, 11. – 14. Dec.; Andreas Schreiber, MPI Grav.phy., 11. – 13. Dec.; Volker Weiss, TLS Tautenburg, 18. Dec.; Nicolas Martin, Strasbourg Univ., 18. – 19. Dec.; Tatiana Vasyunina, MPIfR Bonn, 19. – 23. Dec.

Due our regular international meetings and workshops further guests visited the institute, not listed here individually.

V.3 Cooperation with Industrial Companies

3B Scientific GmbH, Hamburg
AAT ASTON GmbH, Nürnberg
abcdruck GmbH, Heidelberg
ADDITIVE GmbH, Friedrichsdorf
Adept Scientific, Frankfurt
Adolf Pfeiffer GmbH, Mannheim
ADR S.A., Thomery
advanced microoptic systems gm, Saarbrücken
Agilent Technologies GmbH & Co. KG, Böblingen
AGIS Industrie Service GmbH & Co. KG, Viersen
AIM Infrarot Module GmbH, Heilbronn
Air Liquide GmbH, Pfungstadt
Aktobis AG, Rodgau
Alexandre Bürkle GmbH & Co. KG, Freiburg
Alfred Kärcher Vertriebs-GmbH, Winnenden
Allectra GmbH, Schönfliess
Allied Vision Technologies GmbH, Stadtroda
ALMA driving elements GmbH, Schollbrunn
ALPHA Übersetzungen, Heidelberg
Alternate Computer Versand, Linden
Alumeco Deutschland GmbH, Augsburg
Aluminium-Service GmbH, Freigericht
Aqua Technik Gudat, Neulußheim
Arena RKD GmbH, Berlin
Argenta Elektronik, Solingen
Ariapura GmbH, Strullendorf
ARM Germany GmbH, Grasbrunn
Arno Barthelmes EK, Zella-Mehlis/Thüringen
Arnulf Betzold GmbH, Ellwangen
AS Scientific Products Ltd., Abingdon, Oxon
asknet AG, Karlsruhe
Astrium GmbH, Friedrichshafen
Astroleuchten.de, Vaihingen/Enz
AstroMedia-Versand, Neustadt in Holstein
Astro-Shop Eric-Sven Vesting e.K., Hamburg
Astro-Theke, Randersacker-Lindenbach
Austerlitz Electronic GmbH, Nürnberg
Autohaus Krauth GmbH & Co. KG, Meckesheim
B+S Express Transport GmbH, Weinheim
Baader Planetarium GmbH, Mammendorf
Baier Digitaldruck, Heidelberg
Baker & Harrison, München
Bechtle ÖA direkt GmbH, Neckarsulm
Beck-Seminare, Heidelberg
Bernhardt Nutzfahrzeuge GmbH, Heidelberg
Berr-Reisen GmbH, Bruckmühl
Binder Elektronik GmbH, Sinsheim
Blitz Button+Wagner Werbung GmbH, Dielheim
Börsig GmbH, Neckarsulm
Bremer und Leguil GmbH, Duisburg
Brick Box, Schönebeck-Sachsen Anhalt
Bruker Optik GmbH, Leipzig
Brunos Copyshop, Heidelberg
buch.de internetstores AG, Münster
Bürklin OHG, Oberhaching
Büro & Technik GmbH, Zwickau
Bürodesign Nejedly GmbH, Darmstadt
Büromarkt Böttcher AG, Jena
Büro-Mix GmbH, Mannheim
Buster Altöl GmbH, Mannheim
C. Otto Gehrckens GmbH & Co. KG, Pinneberg
C. BRUNO BAYHA GmbH, Tuttlingen
CADFEM GmbH, Grafing
CAMTEC POWER Supplies GmbH, Pfinztal
CANCOM NSG GmbH, Jettingen-Scheppach
Carbon Vision GmbH, Unterschleißheim
Carl Roth GmbH & Co. KG, Karlsruhe
Carl Zeiss, Jena
Cassidian Optronics GmbH, Oberkochen
Celexon GmbH & Co. KG, Emsdetten
Christiani Dr.-Ing. P. GmbH, Konstanz
Chroma Systems Solutions, Lake Forest,CA
City PC GmbH, Alsbach
Colordruck Kurt Weber GmbH, Leimen
comgroup GmbH, Konstanz
Compuland GmbH & Co. KG, Wilhelmshaven
COMTRONIC GmbH, Heiligkreuzsteinach
Com-Unic GmbH & Co. KG, Heidelberg
Conatex Didactic Lehrmittel GmbH, Kirkel
Conrad Electronic GmbH, Wernberg-Köblitz
Conrad Electronic SE, Hirschau
Cornelsen Experimenta GmbH & Co., Berlin
Cryomech Inc., Syracruse
Cryophysics GmbH, Darmstadt
Cryovac GmbH, Troisdorf
CrysTec GmbH, Berlin
CTS GmbH, Hechingen
Custom Scientific Inc., Phoenix, Arizona
Cyberport GmbH, Dresden
Datron AG, Mühltal
Dehn + Söhne GmbH + Co. KG, Neumarkt
Dehner GmbH & Co. KG, Rain am Lech
Deininger Schweißtechnik GmbH, Mannheim
Dekra Akademie GmbH, Mannheim
DELL-Computer GmbH, Frankfurt
DELTA-V GmbH, Wuppertal
DeMaCo Holland B.V., Noord-Scharwoude
Der Dekoladen LTD, Mannheim
Deti GmbH, Meckesheim
Deufol Südwest GmbH, Walldorf
Dicronite U.T.E. Pohl GmbH, Iserlohn
Digi-Key Corporation, AB Enschede
Antonio Lenzen, Dipl. Cinematographer, Heidelberg
Dipl.-Ing. Ulf Mikolajczak, Oldenburg
Discipulus Reisebusunternehmen GmbH, Heidelberg
Distrelec Schuricht GmbH, Bremen
Dobmeier-Haushaltswaren GmbH, Wiesau
DPS Vakuum, Großrinderfeld
DPV Elektronik Service GmbH, Eppingen
Dr. Bernhard Humburger, Bad-Wimpfen
Drahtwaren-Driller, Freiburg
DREEBIT GmbH, Dresden

Drucker Druck, Bietigheim
Druckerei & Verlag Steinmeier GmbH, Deiningen
Druckerwerkstatt - Torsten Dobritzsch e.K., Maintal
Dürkes & Obermayer GmbH, Edingen-Neckarhausen
DVS Dekont Vakuum Service GmbH, Erfurt
E. Strauss GmbH & Co., Biebergemünd
E.L.A.S. GmbH, Oberhausen
EC Motion GmbH, Erkelenz-Keyenberg
Edmund Optics GmbH, Karlsruhe
EDP Sciences, Les Ulis Cedex A France
Edwards GmbH, Kirchheim
eibtron.com GmbH, Plauen
EKZ. Bibliotheksservice GmbH, Reutlingen
Elektrometall Schwanenmühle GmbH, Schwanenmühle
Elektro-Steidl, Weinheim
ELMA Electronic GmbH, Pforzheim
Elried Markierungssysteme GmbH, Oberhaching
ELV Elektronik, Leer
Enpar Sonderwerkstoffe GmbH, Gummersbach
EPHY-MESS GmbH, Wiesbaden-Delkenheim
Ergo2Work BV, LD Nijmegen
esd electronic system design GmbH, Hannover
ESO – European Southern Observatory, Garching
Essenpreis Haustechnik GmbH, Östringen
ESSKA GmbH, Hamburg
E-T-A Elektrotechnische Apparate GmbH, Altdorf
Euro Composites S. A., Echternach
EUROstor GmbH, Filderstadt
Exelis Visual Information Solutions GmbH, Gilching
Faber Industrietechnik GmbH, Mannheim
Farnell GmbH, Oberhaching
Fels Fritz GmbH Fachspedition, Heidelberg
Ferrotec GmbH, Unterensingen
Feuer und Eis Touristik GmbH, Weissach am Tegernsee
Fioretto-Straßenmarkierung, Mannheim
Fire-Check GmbH, Wiesenbach
Fischer Elektronik GmbH & Co., Lüdenscheid
FKW Kilgenstein Wiesen GmbH, Wiesen
FlowCAD EDA-Software Vertrieb, Feldkirchen
Foto Walser GmbH & Co KG, Burgheim
fotoversand24.de, Schwerin
Franco-Tech Postbearbeitung GmbH, Oberursel
Fraunhofer Institut, Jena
Freudenberg Filtration, Weinheim
Friedrich Wolf GmbH, Heidelberg
G&G GmbH, Neuss
Gabler Werbeagentur GmbH, München
Gebr. Reinfurt GmbH & Co. KG, Rimpar
Gebrüder Kassel GmbH, Mannheim
Gehlen verpackungen GmbH & Co., Karlsruhe
Geier Metall-u.Stahlhandel GmbH, Mannheim
General Dynamics, Cullman
GEODIS Logistics Deutschland GmbH, Heppenheim
Getränkefachhandel H. Fein, Heidelberg
GIMA GmbH, Bergisch-Gladbach
Gleich Service-Center Nord GmbH, Kaltenkirchen
Glenair Electric GmbH, Oberursel
Glenair Electronic GmbH, Bad Homburg
GMT-Aufzug-Service GmbH, Forst
Go 2 a service GbR, Berlin
Gößl + Pfaff GmbH, Karlskron
Götz-Gebäudemanagement West GmbH, Regensburg
GRAVIS Computervertr. GmbH, Berlin
Grothues Elektrotechnische Geräte, Leimen
Gruppe 3 GmbH, Unterföhring
Gummispezialhaus Körner GmbH, Eppelheim
Güniker + Heck GmbH, Mannheim
Günter Jacobi GmbH, Griesheim
Gutekunst + Co. KG, Metzingen
Gutekunst Stahlverformung KG, Pfalzgrafenweiler
Gutfleisch GmbH, Heidelberg
GVL Cryoengineering GmbH, Stolberg
Haarländer GmbH, Roth
Hach GmbH, Pfungstadt
Häfele GmbH, Schriesheim
Hafner´s Büro, Stuttgart
Hagemeyer Deutschland GmbH & Co. KG, Heidelberg
Hahn & Kolb GmbH, Stuttgart
Halle Bernhard Nachfl. GmbH, Berlin
Hamamatsu GmbH, Herrsching
Harmonic Drive AG, Limburg a.d. Lahn
Hebmüller SRS Technik, Neuss
Heimann Sensor GmbH, Dresden
Heinrich Klar Schilder-u. Etikettenfabrik GmbH, Wuppertal
Heitec AG, Erlangen
Helioworks Inc., Santa Rosa
HELUKABEL GmbH, Hemmingen
Herrmann, Stefan, Barbing
Hifi & Foto Koch GmbH, Düsseldorf
Hilti Deutschland GmbH, Heidelberg
HIWIN GmbH, Offenburg
HM GmbH, Ubstadt Weiher
Hoerner & Sulger GmbH, Schwetzingen
Hoffmann Qualitätswerkzeuge GmbH & Co., Göppingen
Hofmaier GmbH&Co.KG, München
Hohmann Elektronik GmbH, Germering
Hommel Hercules Werkzeughandel GmbH & Co. KG, Viernheim
Hormuth GmbH, Heidelberg
HSD - Part of Computacenter AG & Co. oHG, Berlin
Huber + Suhner GmbH, Taufkirchen
HUG SCHILDER GmbH,
Hummer + Rieß GmbH, Nürnberg
Hupkens Industrial Models, NK Maastricht
HZT Hebe und Zurrtechnik, Menden
IGEFA Handelsgesellschaft mbH & Co. KG, Ahrensfelde/OT Blumberg
Igus GmbH, Köln
Ing. H. Tafelmaier Dünnschicht-Technik GmbH, Rosenheim
Ingenieurbüro M. Steinbach, Jena
Ingenieurbüro Schlossmacher, Unterschleissheim
INGENTI GmbH, Idstein
Initial Textil Service GmbH, Reutlingen
Inmac GmbH, Mainz-Kastel
INNEO Solutions GmbH, Ellwangen
Institut für Luft u. Kältetechn gGmbH, Dresden
Intercon Spacetec, Augsburg
Invent, Braunschweig
IOP Publishing Ltd., Bristol
item Industrietechnik GmbH, Freiburg

IXXAT Automation GmbH, Weingarten
JACOB Elektronik, Karlsruhe
Jacobi Eloxal GmbH, Altlussheim
JANSSEN PRECISION ENGINEERING, AG Maastricht-Airport NL
JECOSYS Redlich-IT GmbH, Jena
Jehier S.A., Chemille
JENOPTIK Optical Systems GmbH, Jena
Jungheinrich Katalog GmbH & Co., Hamburg
Kai Ortlieb Buchbinderei, Eppelheim
KAISER + KRAFT, Stuttgart
Kälte Wärme Klima, Lauffen/N.
KANYA Deutschland GmbH, Marktredwitz
Kartonfritze Carl Evers oHG, Berlin
Kaufmann, Horst W., Crailsheim-Wittau
KA-WE GmbH, Schwetzingen
KAYSER-THREDE GmbH, München
KBS, Sinsheim
Keithley Instruments GmbH, Germering
Kemper GmbH, Vreden
Kerb-Konus-GmbH, Amberg
KFK Verzinkerei GmbH, Sinsheim
KGW - ISOTHERM GmbH, Karlsruhe
Klar Heinrich GmbH, Wuppertal
Kniel GmbH, Karlsruhe
Koch + Schröder GmbH, Neuss
KOCO MOTION GmbH, Dauchingen
Koenen GmbH, Ottobrunn-Riemerling
Kohlhammer W. Druckerei, Stuttgart
Konecranes GmbH, Viernheim
KONEKRANES GmbH, Langenhagen
Konica Minolta, Heusenstamm
KORTH KRISTALLE GmbH, Altenholz
Kroschke GmbH, Braunschweig
Kugler GmbH, Salem
Kurschildgen GmbH, Bergisch Gladbach
L. + H. Hochstein GmbH + Co., Heidelberg
L. Meili & Co. GmbH, Hanau
Labelident GmbH, Schweinfurt
Bez. Schornsteinfegermeister Lainer Andreas, Neckargemünd
Landefeld GmbH, Kassel-Industriepark
Lapp Kabel GmbH, Stuttgart
Lascar Electronics P & V GmbH, Eutingen
Laser-Zentrum-Hannover, Hannover
Laub GmbH + Co., Elztal-Dallau
LB Display, Bad Füssing
Leha-Technik, Remscheid
Lehmanns Fachbuchhandlung GmbH, Heidelberg
Lemo Elektronik GmbH, München
LEONI Fiber Optics GmbH, Neuhaus-Schierschnitz
LIGHT TEC, Hyères
Lista GmbH, Bergneustadt
Lochbühler GmbH, Mannheim
LTN Servotechnik GmbH, Otterfing
LTT Labortechnik Tasler GmbH, Würzburg
Lutz Langer GmbH, Wilhelmshaven
LWS-Technik GmbH & Co., Heilbronn
Maas International GmbH, Bruchsal
Mädler GmbH, Stuttgart
Malteser-Hilfsdienst e.V., Wiesloch
Manja Geier, Werda
Massmann, Hamburg
MBF Filmtechnik GmbH, Frankfurt
mdf-Verpackungen Dietmar Franz e.K., Kürten
Medtronic GmbH, Düsseldorf
Megware Computer GmbH, Chemnitz-Röhrsdorf
Melitta Systemservice GmbH & Co., Minden-Dützen
Melles Griot, Bensheim
MEN Mikro Elektronik GmbH, Nürnberg
MENZEL Metallchemie GmbH, Kuchen
Metallbau GLAWION GmbH, Eberswalde
Metalux Metallveredelungs GmbH, Altlussheim
MFM Hofmaier GmbH & Co. KG, München
MICROSTAXX GmbH, München
Mietfix.de, Heidelberg
Mittelrheinische Treuhand GmbH, Mainz
MKelectronics, Mengen
MKS Instruments Deutschland GmbH, München
MNRAS Journal Team at Blackwel, Edinburgh
Mouser Electronics, München
msscientific Chromatographie GmbH, Berlin
Müller Otto GmbH, Bammental
Mura, Metallbau, Viernheim
Murrplastik-System-Technik, Oppenweiler
Music Store, Köln
MWR/Christian Wirth, Rimbach
Nadella GmbH, Nufringen
NANOTEC - Electronic GmbH, Landsham
National Instruments GmbH, München
Nature Publishing Group Ltd., London
Neolab Laborbedarf, Heidelberg
neoLab Migge Laborbedarf, Heidelberg
Netzsch-Gerätebau GmbH, Selb
Neubert-Glas GbR, Geschwenda
Neumann Rupert Druckerei, Heidelberg
Newport -Electronics GmbH, Deckenpfronn
Newport Spectra-Physics GmbH, Darmstadt
Nibler W. GmbH, Walldorf
Nies Elektronic GmbH, Frankfurt
Nimax GmbH - Astroshop.de, Landsberg
Nollenberger KFZ-Meisterbetrieb, Heidelberg
norelem Normelemente KG, Markgröningen
novotek GmbH, Magstadt
Oculum-Verlag GmbH, Erlangen
Oerlikon LEYBOLD VAKUUM GmbH, Köln
Office discount GmbH, Neufahrn bei München
office24 GmbH, Darmstadt
Office-Profishop, Mönchengladbach
Omega Optical Inc., Brattleboro
OPITEC Handel GmbH, Giebelstadt
ORBITEAM SW-GmbH, Bonn
Otto Ganter GmbH & Co. KG, Furtwangen
OWIS GmbH, Staufen
Oxford University Press, Oxford OX2 6 DP
Palettensystemtechnik GmbH, Bad-Oeynhausen
Peak System Technik GmbH, Darmstadt
PFEIFFER VACUUM GmbH, Asslar
Pfister BÜRO MIT MASS UND SYSTEM, Leimen/St.Ilgen
Phoenix Contact GmbH & Co., Blomberg
Physik Instrumente (PI), Karlsruhe
PI micos, Eschbach
Piezosystem Jena GmbH, Jena
Pilz GmbH & Co. KG, Ostfildern

PLANSEE, Saint Pierre en Faucigny
Plus Online GmbH, Mühlheim, Ruhr
POG - Präzisionsoptik Gera GmbH, Gera
Polytec GmbH, Waldbronn
powerBridge Computer Vertriebs GmbH, Burgwedel
PRO MEDIA CONCEPT GmbH, Konstanz
Pro-Com Datensysteme GmbH, Eislingen
Profimess GmbH, Bremerhaven
ProfiOffice GmbH, Kriftel
Promostore Merchandising, Essen
Qioptiq Photonics GmbH & Co. KG, Göttingen
Radiant Zemax Europe Ltd, Stansted
Raiffeisen Lagerhaus EG Meckes, Bammental
Rainbow Symphony Store, Reseda
Rala GmbH & Co., Ludwigshafen
ratioform Verpackungs GmbH, Groß Gerau
redcoon GmbH, Aschaffenburg
REEG GmbH, Wiesloch
Reichelt Elektronik, Sande
Reichelt-Chemietechnik GmbH, Heidelberg
Reifen Stoll, Wiesenbach
Rhein-Neckar-Verkehr GmbH, Mannheim
Richard Wirth e.K. Gebäudereinigung, Heidelberg
Ringfeder Power Transmission GmbH, Krefeld
Rittal GmbH + Co. KG, Herborn
RMG Metallfachhandel GmbH, Ladenburg
Robemetall GmbH, Rockenberg
Roger Senden-RSP Technology, BV Delfzijl
Roth Carl GmbH & Co. KG, Karlsruhe
RS Components GmbH, Mörfelden-Walldorf
Rufflar Brandschutz + Lagertechnik, Laudenbach
SAMTEC Germany, Germering
Sanitär Raess GmbH, Heidelberg
SAUTER-Cumulus GmbH, Freiburg
Schäfer Fritz GmbH, Neunkirchen
Schäfer-Shop GmbH, Betzdorf
Schairer Ophthal-Technik GmbH, Stuttgart
Schenker Deutschland AG, Mannheim-Rheinau
Scherer Kabel GmbH, Walzbachtal
Schlosserei Gaub H., Eppelheim
Schmidt Mess- und Regeltechnik, Spiesheim/Rhh.
Schneider Günther GmbH, Sandhausen
Schrauben-Jäger AG, Karlsruhe
Schroff GmbH, Straubenhardt
Schulz H.u.G. Ingenieure, Heidelberg
SCHUPA Schumacher GmbH, Walldorf
Schweickert Elektrotechnik GmbH, Nußloch
SDMS technologies, Saint-Romans/France
SE Spezial-Electronic AG, Bückeburg
Security@work GmbH, Schorndorf-Schlichten
Service+Planungsbüro GbR cuttershop.com, Wolfratshausen
Shirtinator AG, München
Siemens AG, Mannheim
Sigma-Aldrich Chemie GmbH, Taufkirchen bei München
Soemtec-Werbeträger, Kölleda
Solarcontrol, Heidelberg
SparxSystems Software GmbH, Wien
Spectron Gas Control Systems G, Frankfurt
Spektrum der Wissenschaft GmbH, Heidelberg
SPIE Journals Department, Washington 98225-0010 USA
Spiess Elektro Markt GmbH, Rauenberg
Springer-Feinwerktechnik, Jena
Stäubli Tec Systems GmbH, Bayreuth
Stegmeier,Heinz GmbH, Fridingen/Do.
StoCretec, Kriftel
Strähle Raum-Systeme GmbH, Waiblingen
Streicher Maschinenbau GmbH & Co, Deggendorf
Studiohintergrund.de, Krostitz
Subal GmbH, Wien
SVB-Spezialversand, Bremen
Swagelok Karlsruhe, Forst
synoTECH GmbH, Hückelhoven
Systerra Computer GmbH, Jena
Tautz Druckluft + Sandstrahltechnik, Mannheim
TBA Hibinger, Worms
TC Direct GmbH, Mönchengladbach
Technik Direkt, Würzburg
Telemeter Electronic GmbH, Donauwörth
Teleskop-Service Ransburg GmbH, Putzbrunn-Solalinden
Testo GmbH & Co., Lenzkirch
THALES CRYOGENICS, Eindhoven
The MathWorks GmbH, Ismaning
The University of Chicago Press, Chicago, Illinois
Theile Büro-Systeme, Speyer
ThermaSOL Systems GmbH, Denzlingen
Thomann Profi Equipment, Burgebrach
Thorlabs GmbH, Dachau
ThyssenKrupp Plastics GmbH, Mannheim
Till Schrauben GmbH, Riedstadt-Goddelau
Tischer Gastro, Heidelberg
Ton in Ton, Wischhafen
Topcart International GmbH, Erzhausen
Torsten Dobritzsch e.K., Maintal
Total Walther GmbH, Ratingen
TransMIT Prof. Dr. Thummes, Gießen
transtec AG, Tübingen
Trinos Vakuum-Systeme GmbH, Göttingen
Trioptics GmbH, Wedel
Tucson Optical Research Corp., Tucson
TÜV Süd Industrie Service GmbH, Mannheim
TÜV-Rheinland-Industrieservice, Stuttgart
Tydex J. S. Co., St. Petersburg
U-Form-Verlag, Solingen
UHT Umschlag- und Hafentechnik, Eberswalde
UKP GmbH, Mainz
Ultra Präzision Messzeuge GmbH, Aschaffenburg
VAT Deutschland GmbH, Grasbrunn
VCU GmbH, Mettlach
Verlag für Lehrmittel Pößneck, Pößneck
Verlag Vopelius Jena e.V., Jena
Verlagsgruppe Weltbild GmbH, Augsburg
vhf camfacture AG, Ammerbuch
Volker Röhrs Versandbuchhandlung, Stelle
Völkner GmbH, Nürnberg
W. Sell Computer-Dienst, Wiesbaden
Wagner Vertriebs GmbH, Haltern am See
Walter Bautz GmbH, Griesheim
Watterott electronic GmbH, Leinefelde
Webcraft GmbH, Gottmadingen
Wegertseder GmbH, Ortenburg
Werbeartikel Wagner, Dielheim
Westfalen AG, Münster

Wiesemann u. Theis GmbH, Wuppertal
Wilhelm & Missal OHG, Leimen
Willi Stober GmbH & Co. KG, Karlsruhe
Winkler GmbH & Co. KG, Viernheim
Witzenmann Rhein-Ruhr GmbH, Xanten
Wollschläger GmbH & Co. KG, Mannheim
Würth Elektronik, Waldenburg
Zeidler OHG, Heidelberg
Zimmermann Elektronik Vertriebs-GmbH, Darmstadt
Zöllig GmbH, Hirschberg

V.4 Conferences and Talks

Conferences Organized at the institute / HdA

Fachbeirat/Vergleichende Evaluation des MPIA, MPIA Heidelberg, 27. Feb. – 1. Mar. (K. Jäger, Rix, Henning, Cuevas, Witte-Nguy u.a.)
ESPRI Science Team meeting, MPIA Heidelberg, 18. Mar. (Launhardt, Zimmerman)
Pan-STARRS1 Key Project 5 Workshop, MPIA Heidelberg, 22.–24. Apr. (N. Martin)
PACS/ICC Meeting #42, Haus der Astronomie Heidelberg, 22.–25. Apr. (Nielbock)
Magnetic Fields from Cloud Cores to Protostellar Disks, Workshop, MPIA Heidelberg, 21.–24. May (Beuther, Henning, Klahr)
NIRSPEC Meeting, 17. Apr., MPIA Heidelberg; LBT Board Meeting, 12. June, MPIA Heidelberg (Rix)
Wissenschaftliches Colloquium mit Gästen zur Verabschiedung von Josef Fried und Rainer Lenzen, MPIA Heidelberg, 3. July (K. Jäger)
PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July (Beuther, Henning, Steinacker)
DG13, Dust Growth in Star- & Planet-Forming Environments, MPIA Heidelberg, 22.–25. July (Steinacker)
HOPS team meeting, Haus der Astronomie, Heidelberg, 22.–25. July (Stutz)
Phases of the ISM, MPIA Sommerkonferenz, MPIA Heidelberg, 29. July – 1. Aug. (Decarli, Groves, Sandstrom)
MW Dynamical Modeling Workshop, MPIA Heidelberg, 5.–7. Aug. (Rix)
MegaSAGE Meeting 2013, Haus der Astronomie, Heidelberg, 23.–27. Sept. (Hughes, Robitaille, Zhukovska)
Galaxy and Cosmology Group Retreat, Lobbach, 22.–24. Oct. (Tabatabaei)
LINC-NIRVANA Consortium Meeting, MPIA Heidelberg, 28.–29. Oct. (Kürster)
Ground-based Spectroscopy of Exoplanets Atmospheres, Workshop, MPIA Heidelberg, 4.–6. Nov. (Crossfield, Henning, van Boekel)
MPIA-Kuratorium, MPIA Heidelberg, 2. Dec. (K. Jäger, Rix, Henning, Cuevas, Berner)
MATISSE Progress Meeting, Workshop, MPIA Heidelberg, 4.–5. Dec. (Olofsson)

Other Conferences Organized or Supported

Durham PS1SC Extragalactic Workshop, Durham University, Durham, UK, 7.–9. Jan. (N. Martin)
6th HGSFP Winterschool 2013, University Center Obergurgl, Austria, 19. – 23. Jan. (Hegde)
Polarimetry for rocky exoplanet characterization, EGU General Assembly 2013, Vienna, Austria, 7.–12. Apr. (Kaltenegger)
»Astrophysical Parameters« Gaia DPAC CU8 plenary meeting, Brüssel, Belgien, 15.–16. Apr. (Bailer-Jones)
Far-infrared emission as window to study the formation of galaxies, Black Holes and dust in the young Universe, Ringberg Meeting, Ringberg, 13.–17. May (Decarli, Leipski, Meisenheimer, Walter)
MPIA Student Workshop, Enkhuizen, The Netherlands, 13.–17. May (Maseda)
The Diuse Interstellar Bands, IAUS 297, Haarlem, The Netherlands, 20.–24. May (C. Jäger)
RSF13, Regulation of Star Formation in molecular gas: From galactic to sub-cloud scales,
Workshop, Ringberg Castle, 23.–29 June (Meidt, Robitaille, Schinnerer)
Crossing the Boundaries in Planetary Atmospheres: From Earth to Exoplanets, Chapman
Conference, Annapolis, Maryland, USA, 24.–28. June (Kaltenegger)
3rd Workshop on Binaries in the Solar System, Kohala Coast, Hawaii, USA, 30. June – 2. July (Conrad)
1st Pan-STARRS1 Strasbourg/MPIA workshop, Strasbourg astronomical Observatory, France, 9.–11. July (N. Martin)
Origins of Life – At the crossroads between Biochemistry and Astrophysics, Symposium, MPIKS Dresden, 10.–12. July (Henning)
PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July (Bihr, Hegde, Henning, Johnston, Koepferl, Linz, Ragan, Semenov)
DG13, Dust Growth in Star- & Planet-Forming Environments, MPIA Heidelberg, 22.–25. July (C. Jäger)
The 6th meeting on Cosmic Dust, Center for Planetary Science, Kobe, Japan, 5.–9. Aug. (C. Jäger)
High Energy Astrophysics, IMPRS, 8th Heidelberger Sommerschule, Heidelberg, 9.–13. Sept. (Fendt)

dotastronomy 5, New England Research & Development Center, Cambridge, MA, USA, 16.–18. Sept. (Kendrew)

Improving the performances of current optical interferometers and future designs, International colloquium at Haute-Provence Observatory, France, 23.–27. Sept. (Pott)

Waves and Particles: Multi-Messengers from the Universe, Jahrestagung der Astronomischen Gesellschaft 2013, Tübingen, 24.–27. Sept. (K. Jäger)

»Public Outreach in der Astronomie« Meeting auf der Jahrestagung der Astronomischen Gesellschaft 2013, Tübingen, 24. Sept. (K. Jäger, Pössel)

»The Legacy of the Herschel Space Observatory« Splintersession der Jahrestagung der Astronomischen Gesellschaft 2013, Tübingen, 24. und 26. Sept. (Nielbock)

»Evolution of Star Clusters: From Star Formation to Cosmic Ages« Splintersession der Jahrestagung der Astronomischen Gesellschaft 2013, Tübingen, 24.–27. Sept. (Olczak)

IWSSL 2013, International Workshop on Spectral Stellar Libraries, University of Lyon, France, 14.–17. Oct. (Bailer-Jones, Bayo)

Galaxy and Cosmology Group Retreat, Lobbach, 22.–24. Oct. (Hughes, Rix)

9th Planet and Star Formation-Retreat, Neunkirchen, 16.–18. Nov. (Betremieux, Olofsson, van Boekel)

The Life Cycle of Dust in the Universe: Observations, Theory, and Laboratory Experiments, Taipei, Taiwan, 18.–22. Nov. (Henning)

Galaxy and Cosmology Sta Retreat, Sägmühle, Pfalz, 25.–26. Nov. (Rix)

2nd Pan-STARRS1 Strasbourg / MPIA workshop, Strasbourg astronomical Observatory, France, 27.–28. Nov. (N. Martin)

Exoplanets and Disks – their Formation and Diversity II, 5th Subaru International Conference, Keauhou Kona, Hawaii, 8.–12. Dec. (Henning, Kaltenegger)

Conferences and Meetings Attended, Scientific Talks and Poster Contributions

Angela Adamo: PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July (Poster); Massive Young Star Clusters Near and Far: From the Milky Way to Reionization, Guillermo Haro Conference 2013, Centro de Convenciones Puebla, Mexico, 2.–6. Dec. (Poster & Talk);

Fabrizio Arrigoni Battaia: Early Galaxy Formation in LCDM, 30th Jerusalem Winter School in Theoretical Physics, The Hebrew University of Jerusalem, Israel, 30. Dec. 2012 – 10. Jan. 2013 (Poster); ENIGMA group workshop, MPIA Heidelberg, 17.–20. June (Poster); The Physical Link between Galaxies and their Halos, MPIA/MPE/ESO/Excellence Cluster Universe Conference, Garching, 24.–28. June (Talk); Multiwavelength AGN Surveys and Studies, IAU S304, Yerevan, Armenien, 7.–11. Oct. (Poster and Talk)

Coryn Bailer-Jones: IWSSL 2013, International Workshop on Spectral Stellar Libraries, University of Lyon, France, 14.–17. Oct. (Talk)

Eduardo Banados: Multiwavelength AGN Surveys and Studies, IAU S304, Yerevan, Armenien, 7.–11. Oct. (Poster and Talk); PanSTARRS-1 Science Consortium Meeting, Graduate Institute of Astronomy, NCU, Taiwan, 3.–8. Nov. (Talk)

Amelia Bayo: PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July (Poster); IWSSL 2013, International Workshop on Spectral Stellar Libraries, University of Lyon, France, 14.–17. Oct. (Talk)

Yan Betremieux: 1st ELSI International Symposium, ELSI Earth-Life Science Institute, Tokio, Japan, 27.–29. Mar.; PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July (Poster); EPSC, European Planetary Science Congress, University College London, UK, 8.–13. Sept. (Poster); 9th MPIA Planet and Star Formation – Retreat, Neunkirchen, 16.–19. Sept.

Henrik Beuther: High-Mass Star Formation, From Large to Small Scales in the Era of Herschel & ALMA, Workshop, Lorentz Center Leiden, The Netherlands, 21.–25. Jan. (Talk); Phases of the ISM, MPIA Sommerkonferenz, MPIA Heidelberg, 29. July – 1. Aug. (Talk); Physical Processes in the ISM, MPE Garching, Munich, 21.–25. Oct. (Talk);

Simon Bihr: PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July (Poster); Physical Processes in the ISM, MPE Garching, Munich, 21.–25. Oct. (Poster)

Arjan Bik: The Origins of Stellar Clustering, Aspen summer Workshop, Aspen, Colorado, USA, 26. May – 16. June; PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July

Alex Büdenbender: Gaia Challenge Workshop, University of Surrey, UK, 19.–23. Aug. (Talk)

Esther Buenzli: PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July (Poster, Gewinnvortrag für das beste Poster); Exoplanets and Brown Dwarfs, Mind the Gap, Hateld, UK, 2.–5. Sept. (Talk); Polarimetry of planetary systems, Villa Il Gioiello, Florence, Italy, 23.–26. Sept. (Talk)

Yu-Yen Chang: Galaxy and Cosmology Group Retreat, Lobbach, 22.–24. Oct. (Talk)

Salvatore Cielo: Exoplanets and Brown Dwarfs, Mind the Gap, Hateld, UK, 2.–5. Sept. (Poster)

Michelle Collins: 221st Meeting of the American Astronomical Society, Long Beach, California, USA, 6.–10. Jan. (Votrag); Small Stellar Systems in Tuscany, Konferenz, Prato, Italy, 10.–14. June (Poster); A Universe of dwarf galaxies – Observations,

Theories, Simulations, Lyon, France, 14.–18. June (Talk); EWASS 2013, European Week of Astronomy and Space Science, Turku, Finnland, 8.–12. July (Talk)

Albert Conrad: 44th Lunar and Planetary Science Conference, Houston, Texas, USA, 18.– 22. Mar. (Talk); 3rd Workshop on Binaries in the Solar System, Kohala Coast, Hawaii, USA, 30. June – 2. July (Talk)

Ian Crossfield: 221st Meeting of the American Astronomical Society, Long Beach, California, USA, 6.–10. Jan. (Talk); Shaping E-ELT Science and Instrumentation, Workshop, ESO Garching, 25. Feb. – 1. Mar. (Poster); PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July (Poster)

Elisabete da Cunha: KNAWAcademy Colloquium FIRSED 2013, University of Groningen, The Netherlands, 3.–5. Apr. (Talk); Farinfrared emission as window to study the formation of galaxies, Black Holes and dust in the young Universe, Ringberg Meeting, Ringberg, 13.–17. May (Talk); The Origins of Stellar Clustering, Aspen summer Workshop, Aspen, Colorado, USA, 26. May – 16. June (Talk and discussion session chair); EWASS 2013, European Week of Astronomy and Space Science, Turku, Finnland, 8.–12. July (Talk)

Niall Deacon: Euclid Consortium Meeting, Leiden Observatory, Leiden, The Netherlands, 13. – 15. May; PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July (Poster); Exoplanets and Brown Dwarfs, Mind the Gap, Hateld, UK, 2.–5. Sept. (Talk); dotastronomy 5, New England Research & Development Center, Cambridge, MA, USA, 16.–18. Sept.

Roberto Decarli: »Beauty and the beast: Massive black holes and their role in galaxy formation« 6th HGSFP Winterschool 2013, University Center Obergurgl, Austria, 1. – 23. Jan. (Talk); EWASS 2013, European Week of Astronomy and Space Science, Turku, Finnland, 8.–12. July (Talk); Galaxy evolution over ve decades, Konferenz, Cavendish Astrophysics, Cambridge, UK, 3.–6. Sept. (Talk)

Karsten Dittrich: Waves and Instabilities in Geophysical and Astrophysical Flows, Winterschool, Les Houches, France, 3.–8. Feb. (Poster); Ice and Planet Formation, Workshop, Lund Observatory, Lund, Sweden, 15.–17. May (Talk); PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July (Poster); DG13, Dust Growth in Star- & Planet-Forming Environments, MPIA Heidelberg, 22.–25. July (Talk) Aaron Dutton: 2013 Santa Cruz Galaxy Formation Workshop, Oakes College, California, USA, 12.–16. Aug. (Talk)

Emanuele Paolo Farina: MAGIC Collaboration Meeting, Universidad Complutense, Madrid, Spain, 18.–22. Nov.

Christian Fendt: PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July (Poster); HEPRO IV, 4th High Energy Phenomena in Relativistic Out ows, 23.–26. July (Talk); Waves and Particles: Multi-Messengers from the Universe, Jahrestagung der Astronomischen Gesellschaft 2013, Tübingen, 24.–27. Sept. (Talk)

Daniele Fulvio: Laboratory Astrophysics 2013, Workshop, Universität Kassel, 30. Sept. – 2. Oct. 2013 (Poster)

Wolfgang Gässler: ARGOS consortium meeting, Florence, Italy, 6.–8. May; ARGOS consortium meeting, Fraueninsel Kloster Chiemsee, 15.–16. Oct.

Thomas Gerner: PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July (Poster); Waves and Particles: Multi-Messengers from the Universe, Annual Meeting of the Astronomische Gesellschaft 2013, Tübingen, 24.–27. Sept. (Talk); Physical Processes in the ISM, MPE Garching, Munich, 21.–25. Oct. (Poster)

Bertrand Goldman: Brown Dwarfs come of Age, Konferenz, Fuerteventura, Kanaren, 20. – 24. May (Talk); PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July (Poster); Exoplanets and Brown Dwarfs, Mind the Gap, Hateld, UK, 2.–5. Sept. (Talk); 9th MPIA Planet and Star Formation – Retreat, Neunkirchen, 16.–19. Sept.

Brent Groves: KNAW Academy Colloquium FIRSED 2013, University of Groningen, The Netherlands, 3.–5. Apr.; RSF13, Regulation of Star Formation in molecular gas: From galactic to sub-cloud scales, Workshop, Ringberg Castle, 23.–29 June (Talk); KINGFISH Leiden Workshop, Sterrewacht Leiden, The Netherlands, 11.–15. Oct. (Talk); Physical Processes in the ISM, MPE Garching, Munich, 21.–25. Oct. (Talk)

Richard Hanson: The Modern Radio Universe 2013, Konferenz, Bonn, 22.–26. Apr.; Setting the Scene for Gaia and Lamost, IAUS 298, Lijiang, Yunnan, China, 20.–24. May (Poster); Galaxy and Cosmology Group Retreat, Lobbach, 22.–24. Oct. (Talk); Galactic Dynamics in the Times of Gaia and other Great Surveys, International Advanced School, UNAM, Mexico City, Mexico, 3.–12. Nov. 2013 (Talk)

Siddarth Hegde: 6th HGSFP Winterschool 2013, University Center Obergurgl, Austria, 19.–23. Jan. (Poster); 1st ELSI International Symposium, ELSI Earth-Life Science Institute, Tokio, Japan, 27.–29. Mar.; AbGradCon 13, Konferenz, Montreal, Quebec, Canada, 10.–14. June (Talk); Origins of Life – At the crossroads between Biochemistry and Astrophysics, Symposium, MPIKS Dresden, 10.–12. July (Poster); PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July (Poster); Kepler Science Conference II, NASA Ames Research Center, Moett Field, USA, 4.–8. Nov. (Poster)

Stefan Hippler: GRAVITY Consortium Meeting, MPE, Garching, 19.–20. Feb.; METIS Consortium Meeting, ETH, Zürich, Schweiz, 18.–19. Mar.; GRAVITY Progress Meeting, MPE/ESO, Garching, 31. July; METIS Adaptive Optics Meeting, Sterrewacht Leiden, The Netherlands, 18. Sept.; GRAVITY Pulse Tube Cryocooler Progress Meeting, Universität Giessen, 17. Oct.; GRAVITY Interface Meeting, MPE/ESO, Garching, 28.–29. Oct.; METIS Consortium Meeting, UK ATC, Edinburgh, Schottland, 25.–26. Nov.

Jaqueline Hodge: Phases of the ISM, MPIA Sommerkonferenz, MPIA Heidelberg, 29. July – 1. Aug. (Poster)

Annie Hughes: Planck Cold Cores Meeting, Toulouse, France, 17.–19. Apr. (Talk); Phases of the ISM, MPIA Sommerkonferenz, MPIA Heidelberg, 29. July – 1. Aug. (Talk); MegaSAGE Meeting 2013, Haus der Astronomie, Heidelberg, 23.–27. Sept.; PILOT Team Meeting, Paris, France, 30. Sept. – 2. Oct.; Galaxy and Cosmology Group Retreat, Lobbach, 22.–24. Oct. (Talk); Structure and Chemistry of the Interstellar Medium, Meeting, Observatoire de Paris, France, 11.–13. Dec. (Talk)

Katherina Inskip: The Triggering Mechanisms for Active Galactic Nuclei, Lorentz Center, Leiden, The Netherlands, 22.–26. July (2 Poster)

Cornelia Jäger: The Diuse Interstellar Bands, IAUS 297, Haarlem, The Netherlands, 20.–24. May (Talk); The Life Cycle of Dust in the Universe: Observations, Theory, and Laboratory Experiments, Taipei, Taiwan, 18.–22. Nov. (Talk)

Klaus Jäger: Meeting der Planungsgruppe »Astronomie in Germany« Frankfurt a. M., 29. Jan. und 11. July; Kamingespräch des Heidelberger OB, Rathaus Heidelberg, 7. Mar.; Meeting des Rat Deutscher Sternwarten (RDS), Bonn, 13. Mar., und Tübingen, 23. Sept.; Meeting des wissenschaftlichen Beirates der »International Summer Science School Heidelberg« 16. May und 19. Nov.; Meeting der LBT-Beteiligungsgesellschaft (LBTB), Heidelberg, 12. June; Astronet Workshop, Heidelberg, 17.–18. June; Meeting des AK Wissenschaftsmarketing der Stadt Heidelberg, 9. July, 9. Sept. und 19. Nov.; Waves and Particles: Multi-Messengers from the Universe, Jahrestagung der Astronomischen Gesellschaft 2013, Tübingen, 24.–27. Sept. (4 Kurzvorträge, Moderation der Festveranstaltung) mit Vorstandssitzung der AG (23. Sept.) und AG-MGV (24.09.); PR-Netzwerktreen der MPG, MPIK Heidelberg, 4.–5. Nov.

Viki Joergens: Brown Dwarfs come of Age, Konferenz, Fuerteventura, Kanaren, 20.–24. May (Talk); 63rd Lindau Nobel Laureate Meeting, Lindau, 30. June – 5. July; PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July (Poster); 9th MPIA Planet and Star Formation – Retreat, Neunkirchen, 16.–19. Sept.; Waves and Particles: Multi-Messengers from the Universe, Annual Meeting of the Astronomische Gesellschaft 2013, Tübingen, 24.–27. Sept. (Talk)

Katharine Johnston: NAM 2013, National Astronomy Meeting, University of St. Andrews, UK, 1.–5. July (Talk); The Galactic Center: Feeding and Feedback in a Normal Galactic Nucleus, IAU 303, Santa Fe, USA, 30. Sept. – 4. Oct. (Poster); Physical Processes in the ISM, MPE Garching, Munich, 21.–25. Oct. (Talk)

Jouni Kainulainen: RSF13, Regulation of Star Formation in molecular gas: From galactic to sub-cloud scales, Workshop, Ringberg Castle, 23.–29 June (Talk); PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July (Poster); Phases of the ISM, MPIA Sommerkonferenz, MPIA Heidelberg, 29. July – 1. Aug. (Talk); Physical Processes in the ISM, MPE Garching, Munich, 21.–25. Oct. (Talk)

Iva Karicova: New advances in stellar physics: from microscopic to macroscopic processes, Meeting, Rosco, France, 27.–30. May (Talk); DG13, Dust Growth in Star- & Planet-Forming Environments, MPIA Heidelberg, 22.–25. July (Talk);

Sarah Kendrew: AO4ELT3, Adaptive Optics for Extremely Large Telescopes, Florence, Italy, 26.–31. May (Talk)

Ulrich Klaas: Only the best data products for the Legacy Archive, Herschel Calibration Workshop, ESO/ESAC, Madrid, Spain, 25.–27. Mar.; Far-infrared emission as window to study the formation of galaxies, Black Holes and dust in the young Universe, Ringberg Meeting, Ringberg, 13.–17. May (2 Vorträge); Herschel Lessons Learned Meeting, ESAC, Villafranca Madrid, Spain, 28.–30. May; PACS/ICC Meeting #43, MPE Garching, 12.–14. Nov.

Hubert Klahr: Lead Net, Meeting, Mainz, 6.–7. May; Ice and Planet Formation, Workshop, Lund Observatory, Lund, Sweden, 15.–17. May (Talk); DG13, Dust Growth in Star- & Planet-Forming Environments, MPIA Heidelberg, 22.–25. July (Talk)

Rainer Köhler: PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July (Poster)

Christine Koepferl: PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July (Poster)

Derek Kopon: AO4ELT3, Adaptive Optics for Extremely Large Telescopes, Florence, Italy, 26.–31. May (Talk); Adaptive Optics: Methods, Analysis and Applications, Meeting, Renaissance Arlington Capital View Hotel, Arlington, Virginia, USA, 23. – 27. June (Talk); PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15. – 19. July (Poster); L2 and L3 Science Themes, Presentation Meeting 2013, Institut Oceanographique de Paris, France, 3.–4. Sept.

Serge Krasnokutski: QFC2013, International Conference on Quantum Fluid Clusters, Thon-Dittmer-Palais, Regensburg, 16.–19. June (Talk); The 6th meeting on Cosmic Dust, Center for Planetary Science, Kobe, Japan, 5.–9. Aug.; The Life Cycle of Dust in the Universe: Observations, Theory, and Laboratory Experiments, Taipei, Taiwan, 18.–22. Nov.

Oliver Krause: EChO Mission Consolidation Review, Noordwijk, The Netherlands, Jan.; Space Cryogenics Workshop, Anchorage, USA, 23.–25. June (Talk); EChO Open Science Workshop, ESA/ESTEC, Noordwijk, The Netherlands, 1.–3. July; The Universe Explored by Herschel, International Symposium, ESA/ESTEC, Noordwijk, The Netherlands, 15.–18. Oct.; Kepler Science Conference II, NASA Ames Research Center, Moett Field, USA, 4.–8. Nov.

Kathryn Kreckel: Phases of the ISM, MPIA summer conference, Heidelberg, 29. July – 1. Aug.; Waves and Particles: Multi-Messengers from the Universe, Annual Meeting of the Astronomische Gesellschaft 2013, Tübingen, 24.–27. Sept. (Talk); Physical Processes in the ISM, MPE Garching, Munich, 21.–25. Oct. (Poster)

Rolf Kuiper: »Radiation Pressure in Massive Star Formation« ENS Journal Club, Ecole Normale Superieure, Paris, France, 7. Jan.; »Radiation Pressure in Massive Star Formation« SAP Seminar, Institute of Research into the Fundamental Laws of the Universe, Saclay, France, 10. Jan.; »Radiation Pressure Feedback in Massive Star Formation« Astrophysics Colloquium, Astronomy and High Energy Astrophysics Institute (IAAT), Universität Tübingen, 4. Feb.; »The Radiation Pressure Problem and the Flashlight Eect in Massive Star Formation« Star Formation Luncheon Seminar, Jet Propulsion Laboratory (JPL), California Institute of Technology, Pasadena, CA, USA, 12. Mar.; »The Formation of the Most Massive Stars« Origins Institute Colloquium Origins Institute, McMaster University Hamilton, Ontario, Canada, 25. Mar.; »Feedback in Massive Star Formation« Astrophysics Lunch Talk, Origins Institute, McMaster UniversityHamilton, Ontario, Canada, 28. Mar.; »A Solution to the Radiation Pressure Problem in Massive Star Formation« NAOC Lunch Talk, National Astronomical Observatories (NAOC), Chinese Academy of Sciences (CAS) Peking, China, 24. Apr.; »A Solution to the Radiation Pressure Problem in Massive Star Formation« IHEP Seminar, Institute for High Energy Physics (IHEP), Chinese Academy of Sciences (CAS), Peking, China, 9. May; »On the reliability of approximate radiation transport methods for irradiated circumstellar disk studies« NAOC & KITPC Tea Seminar, National Astronomical Observatories (NAOC) & Kavli Institute for Theoretical Physics China (KITPC), Chinese Academy of Sciences (CAS) Peking, China, 10. May; The Formation of Planets: The Critical First Growth Phase, DFG Forschergruppe FOR 759, Institute for Astronomy and Astrophysics (IAAT), University of Tübingen, 10. June (Talk); 9th MPIA Planet and Star Formation – Retreat, Neunkirchen, 16.–19. Sept. (Talk); Dust Radiative Transfer 2013 – Codes & Benchmarks, Institut de Planetologie et d'Astrophysique de Grenoble, France, 9.–11. Oct. (Talk)

Girish Kulkarni: MPIA Theory Seminar, MPIA Heidelberg, 7. Feb.; ICC Seminar; University of Barcelona, Spain, 14. Feb.; Visitor seminar, MPA Garching, 8. May 2013; Reionization in the Red Centre: New windows on the high redshift Universe, 2013 CAASTRO Annual Science Conference, Ayers Rock Resort, Australien, 15.–19. July (Talk); ENIGMA group workshop, MPIA Heidelberg, 17.–20. June; Lunch seminar, Universität Leiden, The Netherlands, 18. Oct.; ITC seminar, Harvard-Smithsonian Center for Astrophysics, Cambridge, Massachusetts, USA, 29. Oct.; Visitor seminar, Columbia University, New York City, USA, 31. Oct.; Visitor seminar, Institute for Advanced Studies, Princeton, New Jersey, USA, 4. Nov.; Visitor seminar, Steward Observatory, University of Arizona, Tucson, USA, 5. Nov.; Extragalactic seminar, The University of Texas, Austin, USA, 7. Nov.; IMPS seminar; University of California Santa Cruz, USA, 12. Nov.; Galread seminar, Princeton University, New Jersey, USA, 18. Nov.; Visitor seminar, University of California Los Angeles, USA, 25. Nov.

Ralf Launhardt: PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July (Poster); The Universe Explored by Herschel, International Symposium, ESA/ESTEC, Noordwijk, 15.–18. Oct. (Talk)

Christian Leipski: KNAW Academy Colloquium FIRSED 2013, University of Groningen, The Netherlands, 3.–5. Apr. (Talk); Far-infrared emission as window to study the formation of galaxies, Black Holes and dust in the young Universe, Ringberg Meeting, Ringberg, 13.–17. May (Talk) Hendrik Linz: PACS/ICC Meeting #42, Haus der Astronomie Heidelberg, 22.–25. Apr.; Herschel Calibration Workshop, ESA Villafranca, Spain, 24.–27. May; PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July (Poster); The Universe Explored by Herschel, International Symposium, ESA/ESTEC, Noordwijk, 15.–18. Oct. (Poster); PACS/ ICC Meeting #43, MPE Garching, 12.–14. Nov.

Nils Lippok: PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July (Poster)

Mariya Lyubenova: Black Hole Fingerprints: Dynamics, Disruptions and Demographics, SnowPAC, University of Utah, USA 17.–22. Mar.; 5th CALIFA Busy Week, Potsdam, 15.–19. Apr.; 6th CALIFA Busy Week, Porto, Portugal, 14.–18. Oct.

Andrea Macciò: The Physical Link between Galaxies and their Halos, MPIA/MPE/ESO/ Excellence Cluster Universe Conference, Garching, 24.–28. June (Talk); The origin of the Hubble sequence, 75th Anniversary Conference: IAP, IAP amphitheatre, Paris, France, 24 – 28. June (Talk)

Luigi Mancini: Gravitational Microlensing – 101 years from theory to practice, 1st Doha International Astronomy Conference, Qatar National Convention Centre, Doha, Qatar, 10.–13. Feb. (Talk); PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July (Poster); EPSC, European Planetary Science Congress 2013, University College London, UK, 8.–13. Sept. (Talk)

Gabriel-Dominique Marleau: PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July (Poster); 9th Planet and Star Formation-Retreat, Neunkirchen, 16.–18. Nov. (Talk)

Nicolas Martin: Durham PS1SC Extragalactic Workshop, Durham University, Durham, UK, 7.–9. Jan. (Talk); Pan-STARRS1 Science Consortium Meeting, Honolulu, USA, 18.–22. Mar. (Talk); ngCFHT, The Next Generation of the CFHT: A wide field spectroscopic facility for the coming decade, Workshop, Hilo, USA, 27.–29. Mar. (Talk); Pan-STARRS1 Key Project 5 Workshop, MPIA Heidelberg, 22.–24. Apr. (Talk); Setting the Scene for Gaia and Lamost, IAUS 298, Lijiang, Yunnan, China, 20.–24. May (Poster); Small Stellar Systems in Tuscany, Konferenz, Prato, Italy, 10.–14. June (Talk); The Physical Link between Galaxies and their Halos, MPIA/MPE/ESO/Excellence Cluster Universe Conference, Garching, 24.–28. June (Talk); From Dwarfs to Giants: Mike Irwins travels in the Local Group and beyond, Workshop, Sexten Primary School, Sesto Pusteria, Italy, 29. July – 3. Aug. (Talk); Workshop on the Future of Dark Matter Astro-Particle Physics: Insights and Perspectives, Trieste, Italy, 8.–11. Oct. (Talk); PanSTARRS-1 Science Consortium Meeting, Graduate Institute of Astronomy, NCU, Taiwan, 3.–8. Nov. (Talk)

Michael Maseda: Early Galaxy Formation in LCDM, 30th Jerusalem Winter School in Theoretical Physics, The Hebrew University of Jerusalem, Israel, 30. Dec. 2012 – 10. Jan. 2013 (Poster); 3D-HST Collaboration Meeting, Lorentz Center, Leiden, The Netherlands, 6.–10. May (Talk); The Physical Link between Galaxies and their Halos, MPIA/MPE/ESO/Excellence Cluster Universe Conference, Garching, 24.–28. June (Poster); 3D-HST Collaboration Meeting, San Juan, Puerto Rico, USA, 21.–25. Oct. (Talk)

Sharon E. Meidt: The Future of SPH, Workshop, MPA Garching, 18.–19. Feb.; Phases of the ISM, MPIA Sommerkonferenz, MPIA Heidelberg, 29. July – 1. Aug. (Talk); KINGFISH Leiden Workshop, Sterrewacht Leiden, The Netherlands, 11.–15. Oct. (Talk); Galaxy and Cosmology Group Retreat, Lobbach, 22.–24. Oct. (Talk)

Klaus Meisenheimer: KNAW Academy Colloquium FIRSED 2013, University of Groningen, The Netherlands, 3.–5. Apr. (SOC); Far-infrared emission as window to study the formation of galaxies, Black Holes and dust in the young Universe, Ringberg Meeting, Ringberg, 13.–17. May

Esteban Morales: PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July; The Galactic Center: Feeding and Feedback in a Normal Galactic Nucleus, IAU 303, Santa Fe, USA, 30. Sept. – 4. Oct.; 9th Planet and Star Formation-Retreat, Neunkirchen, 16.–18. Nov. (Talk)

Christoph Mordasini: 1st CHEOPS science meeting, Center for Space and Habitability, Bern, Schweiz, 15.–16. May (Talk)

Reinhard Mundt: PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July (vier Poster)

Markus Nielbock: Only the best data products for the Legacy Archive, Herschel Calibration Workshop, ESO/ESAC, Madrid, Spain, 25.–27. Mar. (Talk); PACS/ICC Meeting #42, Haus der Astronomie Heidelberg, 22.–25. Apr. (Talk); Herschel Calibration Steering Group Meeting #33, ESAC, Spain, 4. June (Talk); PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July (Poster); The Universe Explored by Herschel, International Symposium, ESA/ESTEC, Noordwijk, The Netherlands, 15.–18. Oct. (Poster); PACS/ICC Meeting #43, MPE Garching, 12.–14. Nov. (Talk); Herschel Calibration Steering Group Meeting #34, ESAC, Spain, 27. Nov. (Talk)

Sladjana Nikolić: Supernova environmental impacts, IAUS 296, Raichak, India, 7.–11. Jan. (Talk); High Energy Astrophysics, IMPRS, 8th Heidelberger Sommerschule, Heidelberg, 9.–13. Sept.; Waves and Particles: Multi-Messengers from the Universe, Annual Meeting of the Astronomische Gesellschaft 2013, Tübingen, 24.–27. Sept. (Talk)

Mark Norris: Small Stellar Systems in Tuscany, Konferenz, Prato, Italy, 10.–14. June

Christoph Olczak: MODEST-13, Meeting, Fesenkov Astrophysical Institute, Kasachstan, 19.–23. Sept. (Talk)

Johan Olofsson: PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July (Poster); Waves and Particles: Multi-Messengers from the Universe, Jahrestagung der Astronomischen Gesellschaft 2013, Tübingen, 24.–27. Sept. (Talk); SPHERE Disk Science Group meeting, Zürich, Schweiz, Dec. (Talk)

Camilla Penzo: 2013 Santa Cruz Galaxy Formation Workshop, Oakes College, California, USA, 12.–16. Aug. (Talk)

Karsten Potrick: QFC2013, International Conference on Quantum Fluid Clusters, Thon-Dittmer-Palais, Regensburg, 16.–19. June; The 6th meeting on Cosmic Dust, Center for Planetary Science, Kobe, Japan, 5.–9. Aug.

Jörg-Uwe Pott: AO4ELT3, Adaptive Optics for Extremely Large Telescopes, Florence, Italy, 26.–31. May (Poster)

Sarah Ragan: High-Mass Star Formation, From Large to Small Scales in the Era of Herschel & ALMA, Workshop, Lorentz Center Leiden, The Netherlands, 21.–25. Jan.; RSF13, Regulation of Star Formation in molecular gas: From galactic to sub-cloud scales, Workshop, Ringberg Castle, 23.–29 June (Talk); PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July (Poster); The Universe Explored by Herschel, International Symposium, ESA/ESTEC, Noordwijk, The Netherlands, 15.–18. Oct. (Talk); Physical Processes in the ISM, MPE Garching, Munich, 21.–25. Oct. (Talk)

Hans-Walter Rix: LBT Board Meeting, Ohio, USA, 23.–24. Mar.; GES 2013: Gaia-ESO Survey First Science, Workshop, Nice, France, 8.–11. Apr.; NIRSPEC Science Meeting, Amsterdam, The Netherlands, 17. Apr.; Euclid Consortium Meeting, Leiden Observatory, Leiden, The Netherlands, 13.–15. May; Setting the Scene for Gaia and Lamost, IAUS 298, Lijiang, Yunnan, China, 20.–24. May; 1st Pan-STARRS1 Strasbourg/MPIA workshop, Strasbourg astronomical Observatory, France, 9.–11. July; NIRSPEC Meeting, Cambridge, UK, 7.–8. Oct.; LBTC Board Meeting, Rom, Italy 9. – 11 Oct.; PS1 Science Consortium Meeting, Taipei, Taiwan, 4.–7 Nov.; 2nd Pan-STARRS1 Strasbourg /

MPIA workshop, Strasbourg astronomical Observatory, France, 27.–28. Nov.; ESO Council, Chile, 8.–15 Dec.

Thomas Robitaille: RSF13, Regulation of Star Formation in molecular gas: From galactic to sub-cloud scales, Workshop, Ringberg Castle, 23.–29 June; PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July (Poster); MegaSAGE Meeting 2013, Haus der Astronomie, Heidelberg, 23.–27. Sept.

Gael Rouille: QFC2013, International Conference on Quantum Fluid Clusters, Thon-Dittmer-Palais, Regensburg, 16.–19. June (Talk); The 6th meeting on Cosmic Dust, Center for Planetary Science, Kobe, Japan, 5.–9. Aug. (Talk); Laboratory Astrophysics 2013, Workshop, Universität Kassel, 30. Sept. – 2. Oct. 2013 (Talk); The Life Cycle of Dust in the Universe: Observations, Theory, and Laboratory Experiments, Taipei, Taiwan, 18.–22. Nov. (Talk)

Tolou Sabri: »State-of-the-art Astrochemistry Summer School« LASSIE 2013, Sommerschule, Paris Observatory, France, 4.–6. Sept.; The Life Cycle of Dust in the Universe: Observations, Theory, and Laboratory Experiments, Taipei, Taiwan, 18.–22. Nov.

Karin Sandstrom: C+ as an Astronomical Tool,Workshop, Lorentz Center, Leiden, The Netherlands, 4.–8. Feb. (Talk); Infrared and Submillimeter Probes of Gas in Galaxies: From the Milky Way to the Distant Universe, Sheraton Pasadena, California, USA, 17.–20. Mar. (Talk); RSF13, Regulation of Star Formation in molecular gas: From galactic to sub-cloud scales, Workshop, Ringberg Castle, 23.–29 June (Talk)

Silvia Scheithauer: MIRI European Consortium Meeting, Gothenburg, Sweden, 28.–31. May 2013; PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July; 9th MPIA Planet and Star Formation – Retreat, Neunkirchen, 16.–19. Sept.

Eva Schinnerer: 221st Meeting of the American Astronomical Society, Long Beach, Kalifornia, USA, 6.–10. Jan. (Poster); DAGAL ITN Meeting, 1st Annual Network Meeting, Oulu, Finnland, 4.–7. Mar. (Talk); COSMOS Team Meeting, Kyoto University, Kyoto, Japan, 20.–24. May; Phases of the ISM, MPIA Sommerkonferenz, MPIA Heidelberg, 29. July – 1. Aug. (Talk)

Eddie Schlafly: Setting the Scene for Gaia and Lamost, IAUS 298, Lijiang, Yunnan, China, 20.–24. May (Talk); PanSTARRS-1 Science Consortium Meeting, Graduate Institute of Astronomy, NCU, Taiwan, 3.–8. Nov. (Talk) Joshua Schlieder: PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July (Poster)

Kirsten Schnuelle: The restless nature of AGNs: variability as a probe of the central engine, Naples, Italy, 20.–23. May (Poster)

Juergen Schreiber: HERSCHEL-PACS Spectrometer Pipeline Meeting, MPE Garching, 5. – 6. Feb. (Presentation of the Pointing Correction Software); HERSCHEL-PACS Spectrometer Pipeline Meeting, MPE Garching, 25.–26. July (Praesentation der Pointing Korrektur Software); PACS/ICC Meeting #43, MPE Garching, 12.–14. Nov.; HERSCHEL-PACS Spectrometer Pipeline Meeting, MPE Garching, 15. Nov. (Präsentation der Pointing Korrektur Software)

Dmitry Semenov: Atomic Processes in Interstellar Ices, Workshop, Universität Leiden, The Netherlands, 13.–13. Mar.; The first 10 million years of the solar system (DFG SPP 1385), Paneth Colloquium, Nördlingen, 21.–23. Oct. (Poster);

Branimir Sesar: 221st Meeting of the American Astronomical Society, Long Beach, California, USA, 6.–10. Jan. (Talk); LSST@Europe: The Path to Science, Meeting, Cambridge, UK, 9.–12. Sept. (Talk)

Robert Singh: 5th CALIFA Busy Week, Potsdam, 15.–19. Apr. (Talk); Phases of the ISM, MPIA Sommerkonferenz, MPIA Heidelberg, 29. July – 1. Aug. (Poster); Multiwavelength AGN Surveys and Studies, IAU S304, Yerevan, Armenien, 7.–11. Oct. (Poster); 6th CALIFA BusyWeek, Porto, Portugal, 14.–18. Oct. (Talk); Galaxy and Cosmology Group Retreat, Lobbach, 22.–24. Oct. (Talk)

Juergen Steinacker: DG13, Dust Growth in Star- & Planet-Forming Environments, MPIA Heidelberg, 22.–25. July (Talk); Dust Radiative Transfer 2013 – Codes & Benchmarks, Institut de Planetologie et d'Astrophysique de Grenoble, France, 9.–11. Oct. (Talk); The Life Cycle of Dust in the Universe: Observations, Theory, and Laboratory Experiments, Taipei, Taiwan, 18.–22. Nov. (Poster)

Greg Stinson: The Future of SPH, Workshop, MPA Garching, 18.–19. Feb. (Talk); What Regulates Galaxy Evolution?, Workshop, Lorentz Center, Leiden, The Netherlands, 22.–26. Apr. (Talk); The Physical Link between Galaxies and their Halos, MPIA/MPE/ESO/Excellence Cluster Universe Conference, Garching, 24.–28. June (Talk); The Milky Way as a Laboratory for Galaxy Formation, Workshop, Aspen Center for Astrophysics, USA, 21. July – 1. Aug. (Talk)

Amelia Stutz: HOPS Spring Meeting, Instituto de Astrofsica de Andaluca, Granada, Spain, 22.–26. Apr. (Talk); PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July (Poster); 9th MPIA Planet and Star Formation – Retreat, Neunkirchen, 16.–19. Sept.; The Universe Explored by Herschel, International Symposium, ESA/ESTEC, Noordwijk, The Netherlands, 15.–18. Oct. (Poster); Physical Processes in the ISM, MPE Garching, Munich, 21.–25. Oct. (Talk)

Fatemeh Tabatabaei: GeSKA14, German SKA Science Meeting, Universität Bielefeld, 12.–13. Feb. (Talk); The Modern Radio Universe 2013, Konferenz, Bonn, 22. – 26. Apr. (Talk); The Universe Explored by Herschel, International Symposium, ESA/ESTEC, Noordwijk, The Netherlands, 15.–18. Oct. (Talk); Waves and Particles: Multi-Messengers from the Universe, Jahrestagung der Astronomischen Gesellschaft 2013, Tübingen, 24.–27.

Sept. (2 Vorträge); Physical Processes in the ISM, MPE Garching, Munich, 21.–25. Oct. (Poster)

Athanasia Tsatsi: DAGAL ITN Meeting, 1st Annual Network Meeting, Oulu, Finnland, 4.–7. Mar. (Talk); ERIS 2013, Fifth European Radio Interferomerty School, Dwingeloo, The Netherlands, 9.–13. Sept.; DAGAL ITN Integral Field Unit Workshop, Groningen, The Netherlands, 14. Sept.; Workshop on Creative Scientic Writing, MPIA Heidelberg, 25. Nov.

Roy van Boekel: PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July

Glenn van de Ven: 5th CALIFA BusyWeek, Potsdam, 15.–19. Apr. (Talk); 6th CALIFA Busy Week, Porto, Portugal, 14.–18. Oct. (Talk)

Bram Venemans: Pan-STARRS1 Science Consortium Meeting, Honolulu, USA, 18.–22. Mar. (Talk); Far-infrared emission as window to study the formation of galaxies, Black Holes and dust in the young Universe, Ringberg Meeting, Ringberg, 13.–17. May (Talk); Galaxy evolution over ve decades, Konferenz, Cavendish Astrophysics, Cambridge, UK, 3.–6. Sept. (Talk); LSST@Europe: The Path to Science, Meeting, Cambridge, UK, 9.–12. Sept. (Talk)

Kaspar von Braun: EWASS 2013, EuropeanWeek of Astronomy and Space Science, Turku, Finnland, 8.–12. July (Talk); PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July (3 Poster); Setting a new standard in the analysis of binary stars, Meeting, KU Leuven, Belgien, 16.–19. Sept. (Poster)

Stefanie Wachter: Euclid Consortium Meeting, Leiden Observatory, Leiden, The Netherlands, 13. – 15. May (Talk); PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July; Scientic Detector Workshop, Florence, Italy, 7.–11. Oct.

Michael Walther: ENIGMA group workshop, MPIA Heidelberg, 17.–20. June (Talk); Intergalactic Interactions: A Higgs Centre Workshop on the Intergalactic Medium, University of Edinburgh, UK, 24.–28. June (Poster)

Laura Watkins: 221st Meeting of the American Astronomical Society, Long Beach, California, USA, 6.–10. Jan. (Poster); Small Stellar Systems in Tuscany, Konferenz, Prato, Italy, 10.–14. June (Talk); Gaia Challenge Workshop, University of Surrey, UK, 19.–23. Aug.

Gabor Worseck: Reionization in the Red Centre, Ayers Rock Resort (Australien), 15. – 19. June (Talk); Intergalactic Interactions: A Higgs Centre Workshop on the Intergalactic Medium, University of Edinburgh, UK, 24.–28. June (Talk)

Xiangxiang Xue: MW Dynamical Modeling Workshop, MPIA Heidelberg, 5.–7. Aug. (Talk)

Svitlana Zhukovska: Phases of the ISM, MPIA Sommerkonferenz, MPIA Heidelberg, 29. July – 1. Aug. (Poster); MegaSAGE Meeting 2013, Haus der Astronomie, Heidelberg, 23. – 27. Sept. (Talk); Physical Processes in the ISM, MPE Garching, Munich, 21.–25. Oct. (Talk)

Invited Talks, Colloquia

Angela Adamo: »Star clusters as tracers of star formation across space and time« Space Telescope science Institute, Baltimore, USA, 4. Apr. (Talk); »Star clusters as tracers of star formation across space and time talks« Department of Physics, Durham University, UK, 11. July (Talk); »Star clusters as tracers of star formation across space and time« Astrophysics research institute, Liverpool John Moóres University, UK, 8. Oct. (Talk); »Cluster formation as function of the environment« ITA Heidelberg, 11. Nov. (Talk)

Fabrizio Arrigoni Battaia: Ponticia Universidad Catolica de Chile, Santiago, Chile, 30. Aug. (Talk); Gemini Observatory Southern Operations Center, La Serena, Chile, 9 Sept. (Colloquium)

Tri L. Astraatmadja: »Starlight beneath the waves: Neutrino telescopes as gamma-ray telescopes« Department of Astronomy, Institut Teknologi Bandung, Indonesien, 19./23. Aug. (Colloquium); »The Gaia astrometric satellite and the search for hypervelocity star candidates« Department of Astronomy, Institut Teknologi Bandung, Indonesien, 20. Aug. (Colloquium)

Amelia Bayo: »Disk evolution in low mass-stars and brown dwarfs« Observatoire de Besancon, France. Combined colloquium with a mini-lecture on »Virtual Observatory: what, how and why« »VOSA: Virtual Observatory SED analyzer. New capabilities« ESAC, Madrid; ESA faculty organized colloquium »Activity, rotation and preservation of disks. Further tests to understand the formation of brown dwarfs« Institut für Astronomie, Universität Vienna, Austria, Apr. (Seminar); »Building robust censuses to understand the mechanism of formation of Brown Dwarfs« Max-Plank-Institut für Radioastronomie, Bonn, Apr. (Colloquium); »Science with the Virtual Observatory« IMAV 2013, First International Meeting of Astrostatistics in Valparaso, Chile, 6.–10. May (Workshop); La Serena School for Data Science (organized at the CTIO recinto), La Serena, Chile, Aug. (Talk); IMAV 2013, First International Meeting of Astrostatistics in Valparaso, Chile, 6-10. May (Vorstrag)

Henrik Beuther: University of Arizona in Tucson, Mar. (Colloquium); University of Leiden, Apr. (Colloquium)

Arjan Bik: MPIA Fachbeirat, 1. Mar. (Talk); Space telescope Science institute, Baltimore, 5. Apr. (Colloquium); Liverpool John Moóres University, 10. Oct. (Colloquium)

Michelle Collins: Strasbourg astronomical Observatory, France, Feb., (Colloquium); NRC Herzberg Institute of Astrophysics, Sept. (Talk); University of Victoria, Canada, Sept. (Talk); University of California, Santa Cruz, USA, Sept. (Talk); University of California, Los Angeles, USA, Sept. (Talk)

Ian Crossfield: Univerität Freuburg May (Colloquium); IPAG, Grenoble, France, Oct. (Colloquium); Universität von Arizona/Lunar & Planetary Lab, Tucson, USA, Nov. (Colloquium)

Elisabete da Cunha: Black Board Colloquium, ITA Heidelberg, Mar. (Talk); University of Zagreb, Kroatien, Sept. (Colloquium)

Niall Deacon: Mullard Space Science Laboratory, Surrey, UK, 30, Apr. (Besuchervortrag); University of Portsmouth, UK, 1. May (Besuchervortrag); University of Hertfordshire, UK, 2. May (Besuchervortrag); University of St Andrews, UK, 5. Aug. (Besuchervortrag); American Museum of Natural History, 13. Sept. (Besuchervortrag); Harvard/Smithsonian CfA, 19. Sept. (Besuchervortrag)

Roberto Decarli: »An observational outlook on massive black holes and galaxies« EWASS 2013, European Week of Astronomy and Space Science, Turku, Finnland, 8.–12. July (Talk); Phases of the ISM, MPIA Sommerkonferenz, MPIA Heidelberg, 29. July – 1. Aug. (Talk)

Casey Deen: Universidad de Chile at Calan, Santiago de Chile, Chile (Talk)

Aaron Dutton: Carnegie Mellon University, Pittsburgh, USA, Feb. (Colloquium); University of Massachussetts, Amherst, USA, Feb. (Colloquium); The Physical Link between Galaxies and their Halos, MPIA/MPE/ESO/Excellence Cluster Universe Conference, Garching, 24.–28. June (Talk)

Nikolaos Fanidakis: »The clustering of AGN: predictions from semi-analytics« Ponticia Universidad Catolica de Chile, Santiago, 21. Mar. (Colloquium); »The large scale environment of AGN« Institute of theoretical Astrophysics, Heidelberg, 8. Apr. (Colloquium); »The halo environment of AGN: predictions from semi-analytics« Astrophysical Institute of Potsdam, Potsdam, 10. July (Colloquium)

Markus Feldt: Exoplanets and Disks – their Formation and Diversity II, 5th Subaru International Conference, Keauhou Kona, Hawaii, 8.–12. Dec. (Talk)

Bertrand Goldman: Observatoire de Strasbourg, France, 26. Apr. (Colloquium); ecole Normale Superieure, Paris, France, 17. June (Talk)

Roland Gredel: »Das Large Binocular Telescope – Auf dem Weg in ein neues Zeitalter der Astronomie« Hochschule Mannheim, Physikalisches Colloquium, 6. June

Brent Groves: »Dust Luminosity, Gas, and star formation in nearby galaxies« Monash University, Melbourne, Australien, 25. Feb. (Talk); Far-infrared emission as window to study the formation of galaxies, Black Holes and dust in the young Universe, Ringberg Meeting, Ringberg, 13.–17. May (Talk); »Dust Luminosity, Gas, and star formation in nearby galaxies« University of Zagreb, Kroatien, 1. Oct. (Colloquium); Sommersemester 2013: »Physics of the ISM: Dust« Universität Heidelberg (guest presentation); Wintersemester 2013/2014: »Multiwavelength analysis of galaxies: Dierent eyes on the universe« Heidelberg Graduate School of Physics Winterschool (guest presentation)

Richard Hanson: ITA Blackboard Colloquium, Heidelberg, 1. July (Colloquium)

Siddarth Hegde: Tokyo Institute of Technology, Tokyo, Japan, 25. Mar. (Colloquium); Planet and Star Formation Seminar, MPIA Heidelberg, 7. Aug. (Colloquium).

Thomas Henning: »Water Worlds in Protoplanetary Disks« JPL Pasadena, USA, Jan. (Colloquium); »Extrasolar Planets, Blue Dots, and the Origin of Life« MPI für Entwicklungsbiologie, Tübingen, Feb. (Colloquium); »Gas in Protoplanetary Disks« Ice and Planet Formation, Workshop, Lund Observatory, Lund, Sweden, 15.–17. May (Talk); »Formation of carbonaceous matter« The Diuse Interstellar Bands, IAUS 297, Haarlem, The Netherlands, 20.–24. May (Talk); »Physics of Cosmic Dust« MegaSAGE Meeting 2013, Haus der Astronomie, Heidelberg, 23.–27. Sept. (Talk); »From Gas Disks to Exoplanet Atmospheres« ESTEC, Noordwijk, The Netherlands, Sept. (Colloquium); »Infrared Spectroscopy of Cosmic Dust« Laboratory Astrophysics 2013, Workshop, Universität Kassel, 30. Sept. – 2. Oct. 2013 (Talk); »Star Formation in the Milky Way« Academy of Sciences of the Czech Republic, Prague, Tschechische Republik, Oct. (Colloquium); »Star & Planetary System Formation & Evolution« The Universe Explored by Herschel, International Symposium, ESA/ESTEC, Noordwijk, The Netherlands, 15.–18. Oct. (Talk); »Chemical Processes in the ISM: Dust« Physical Processes in the ISM, MPE Garching, Munich, 21.–25. Oct. (Talk); The Life Cycle of Dust in the Universe: Observations, Theory, and Laboratory Experiments, Taipei, Taiwan, 18.–22. Nov. (Talk); »Physics of Star Formation« University of Hongkong, Hongkong, Nov. (Colloquium)

Stefan Hippler: Shanghai Astronomical Observatory, Chinese Academy of Sciences, Shanghai, China, 28. May (Talk); Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences, Shanghai, China, 30. May (Talk)

Jaqueline Hodge: The University of California, Davis, USA, 17. Jan. (Colloquium); EWASS 2013, European Week of Astronomy and Space Science, Turku, Finnland, 8.–12. July (Talk); Galaxy evolution over ve decades, Konferenz, Cavendish Astrophysics, Cambridge, UK, 3.–6. Sept. (Talk)

Annie Hughes: LInstitut de Recherche en Astrophysique et Planetologie (IRAP), Toulouse, France, 16. Apr. (Colloquium); Swinburne University of Technology, Melbourne, Australien, 22. May (Colloquium); RSF13, Regulation of Star Formation in molecular gas: From galactic to sub-cloud scales, Workshop, Ringberg Castle, 23.–29 June (Talk); Laboratoire dAstrophysique de Bordeaux, France, 31. Oct. (Colloquium); Ernst-Patzer-Preisverleihung, MPIA Heidelberg, 29. Nov. (Colloquium)

Friedrich Huisken: »Laboratory studies on the role of PAHs as DIB carriers« The Diuse Interstellar Bands, IAUS 297, Haarlem, The Netherlands, 20.–24. May (Talk); »Reactions of metal atoms and clusters with oxygen and hydrocarbons in helium droplets« QFC2013, International Conference on Quantum Fluid Clusters, Thon-Dittmer-Palais, Regensburg, 16.–19. June (Talk); »Laboratory experiments for the interpretation of astrophysical phenomena« Laboratory Astrophysics 2013, Workshop, Universität Kassel, 30. Sept. – 2. Oct. 2013 (Talk);

Cornelia Jäger: »Laboratory experiments on cosmic dust condensation« und »Laboratory experiments on cosmic dust processing« State-of-the-art Astrochemistry Summer School, LASSIE 2013, Sommerschule, Paris Observatory, France, 4.–6. Sept. (zwei Vorträge); »Condensation and Processing of Dust in Astrophysical Environments« Physical Processes in the ISM, MPE Garching, Munich, 21.–25. Oct. (Talk)

Knud Jahnke: Seeking the Leading Actor on Cosmic Stage: Galaxies vs Black Holes, Castellammare del Golfo, Sicily, Italy, 24.–28. June (Talk); EWASS 2013, European Week of Astronomy and Space Science, Turku, Finnland, 8.–12. July (Talk); The Triggering Mechanisms for Active Galactic Nuclei, Lorentz Center, Leiden, The Netherlands, 22.–26. July (Talk); Symposium on Gravity and Light, Kavli IPMU, University of Tokio, Japan, 30. Sept. – 3. Oct. (Colloquium)

Viki Joergens: Scientic Advisory Board 2013, Heidelberg, 28. Feb. (Talk); »Brown dwarf disks, out ows, and binaries« Center for Astronomy Heidelberg, Institute of Theoretical Astrophysics, University of Heidelberg, Germany, 13. June (Talk); »Brown dwarf disks and out ows« University Observatory Munich, Germany, 24. July (Talk); Board of Trusties Meeting, MPIA Heidelberg, 2. Dec. (Talk)

Lisa Kaltenegger: Cornell University, New York, USA, Jan.; Durban University of Technology, Durban, South Africa, Mar.; HITS, Heidelberg, Apr.; Universität Leiden, Apr.; Institute for Space Research, Graz, June; University Wyoming, USA, Oct.; Universität Tübingen, Nov., Physikalisches Colloquium, MPIA Heidelberg, 22. Nov.; 221st Meeting of the American Astronomical Society, Long Beach, California, USA, 6.–10. Jan. (Talk); 1st ELSI International Symposium, ELSI Earth-Life Science Institute, Tokio, Japan, 27.–29. Mar. (Talk); Origins of Life – At the crossroads between Biochemistry and Astrophysics, Symposium, MPIKS Dresden, 10.–12. July (Talk); Gemeinsame Jahrestagung von ÖPG, SPG, ÖGAA und SGAA, JKU Linz, Schweiz, 3.–6. Sept. (Talk); EXOPAG 8, NASAs Exoplanet Exploration Program Analysis Group, 8th Meeting, Denver, USA, 5.–6. Oct. (Talk); Denver Public Schools, Denver, USA, Oct. (Talk); AGU Fall 2013 Meeting, American Geophysical Union, San Francisco, USA, 9.–12. Dec. (Talk)

Hubert Klahr: »Disk Weather« Waves and Instabilities in Geophysical and Astrophysical Flows, Winterschool, Les Houches, France, 3.–8. Feb. (Talk); »Zonal Flows and Vortices in Circumstellar Disks: The Formation of Planetesimals in Starving Mode« CIPS: UC Berkeley, 25. Sept. (Colloquium); »Stability of Rotating Fluids« Russell Severance Springer Seminar Series, Department of Mechanical Engineering UC Berkeley, 25. Sept. (Colloquium); »Convective Overstability in Circumstellar disks and Planetesimal Formation in Starving Mode« TAT Tübingen, 16. Dec.

Rainer Köhler: Observing techniques, instrumentation and science for metre-class telescopes, Workshop, Tatranska Lomnica, Slowakai, 23.–26. Sept. (Talk)

Oliver Krause: EWASS 2013, European Week of Astronomy and Space Science, Turku, Finnland, 8.–12. July (Talk)

Rolf Kuiper: »Formation of Massive Stars« Massive Stars: From Alpha to Omega, Konferenz, Rhodes, Griechenland, 10.–14. June (Talk)

Girish Kulkarni: ITA Colloquium, Universität Heidelberg, 4. Mar.

Ralf Launhardt: MPIfR Bonn, 6. Sept. (Colloquium)

Dietrich Lemke: »Von der Kurpfalz in den Kosmos: Eine astronomische Entdeckungsreise durch fünf Jahrhunderte« Kurpfälzisches Museum Heidelberg, Vortragsreihe Macht des Glaubens, 17. July (Talk); »Das Weltraum-Observatorium HERSCHEL – Entdeckungen im kalten Kosmos« Planetarium Nürnberg, 23. July (Talk); »Das Weltraum-Teleskop HERSCHEL – Entdeckungen im kalten Kosmos« Planetarium Münster, 3. Sept. (Talk); »Max Wolf – Stammvater der Heidelberger Astronomie« Gedenk-Colloquium zum 150. Geburtstag, Landessternwarte Heidelberg, 5. July (Festvortrag); »Astronomy in Heidelberg – The past ve centuries« Haereus-Sommerschule Cosmology« Heidelberg, 18. Aug. (Talk and astronomical history guided tour); »Die Astronomische Gesellschaft 1863 – 2013, Geschichten und Bilder aus 150 Jahren« Tagung der Astronomischen Gesellschaft, Tübingen, 25. Sept. (book presentation and talk)

Elisabetta Lusso: KNAW Academy Colloquium FIRSED 2013, University of Groningen, The Netherlands, 3.–5. Apr. (Talk); Far-infrared emission as window to study the formation of galaxies, Black Holes and dust in the young Universe, Ringberg Meeting, Ringberg, 13. – 17. May (Talk)

Mariya Lyubenova: 5th CALIFA Busy Week, Potsdam, 15.–19. Apr. (Colloquium); IVOA Interop, Interoperability meeting, German Astrophysical Virtual Observatory, Heidelberg, 12.–17. May (Talk)

Luigi Mancini: »Simultaneous Multi-band Photometry« Ground-based Spectroscopy of Exoplanets Atmospheres, Transit Meeting, Haus der Astronomie, Heidelberg, 4.–6. Nov. (Talk); »High-precision ground-based photometry« Observing techniques, instrumentation and science for metre-class telescopes, Workshop, Tatranska Lomnica, Slowakai, 23.–26. Sept. (Talk); Ground-based Spectroscopy of Exoplanets Atmospheres, Workshop, MPIA Heidelberg, 4.–6. Nov. (Talk)

Nicolas Martin: ngCFHT, The Next Generation of the CFHT: A wide eld spectroscopic facility for the coming decade, Workshop, Hilo, USA, 27.–29. Mar. (Talk); The Physical Link between Galaxies and their Halos, MPIA/MPE/ESO/Excellence Cluster Universe Conference, Garching, 24.–28. June (Talk); From Dwarfs to Giants: Mike Irwins travels in the Local Group and beyond, Workshop, Sexten Primary School, Sesto Pusteria, Italy, 29. July – 3. Aug. (Talk); Workshop on the Future of Dark Matter Astro-Particle Physics: Insights and Perspectives, Trieste, Italy, 8.–11. Oct. (Talk) Sharon E. Meidt: RSF13, Regulation of Star Formation in molecular gas: From galactic to sub-cloud scales, Workshop, Ringberg Castle, 23.–29 June (Talk); NAM 2013, National Astronomy Meeting, University of St. Andrews, UK, 1.–5. July (Talk)

Esteban Morales: Black Board Colloquium, ITA Heidelberg, 4. Nov. (Talk)

Christoph Mordasini: Gravitational Microlensing – 101 years from theory to practice, 1st Doha International Astronomy Conference, Qatar National Convention Centre, Doha, Qatar, 10.–13. Feb. (Talk); Osservatorio di Padova, Padova, Italy. 24, Apr. (Colloquium); Planet Validation, Workshop, University of Marseille, France, 13.–15. May (Talk); Heidelberg Joint Astronomical Colloquium, Heidelberg, 21. May (Colloquium); PLATO 2.0 Science Workshop, ESTEC, Noordwijk, The Netherlands, 29.–31. July (Talk); 10 Years of Science with HARPS, Konferenz, Geneva, Schweiz, 16.–17. Sept. (Talk); Kepler Science Conference II, NASA Ames Research Center, Moett Field, USA, 4.–8. Nov. (Talk); Jodrell Bank Centre for Astrophysics, Manchester, UK, 11. Dec.

Sladjana Nikolić: National Institute for Astrophysics (INAF), Arcetri, Florence, Italy, 16.–21. June (Colloquium)

Mark Norris: »RESOLVE Team Meeting« UNC – Chapel Hill, USA, 18. Jan. (Talk); »Small Stellar Systems in Tuscany« Prato, Italy, 14. June (Talk); University of Nottingham, UK, 16. Oct. (Colloquium)

Christoph Olczak: Nicolaus Copernicus Astronomical Centre, Warschau, Polen, 4. Dec. (Colloquium)

Camilla Penzo: Department of Physics and Astronomy, Universität von Bologna, Italy 29. Oct. (Talk)

Sarah Ragan: »APEX Observations of Protostars in IRDCs\ HOPS team meeting, Haus der Astronomie, Heidelberg, 22. July (Colloquium)

Hans-Walter Rix: Caltech, Pasadena, 2. Apr. (Colloquium); Setting the Scene for Gaia and Lamost, IAUS 298, Lijiang, Yunnan, China, 20.–24. May (Talk)

Thomas Robitaille: Magellanic Cloud Star Formation: From the Milky Way to Distant Galaxies, Workshop, Lorentz Center, Leiden, The Netherlands, 18.–22. Feb. (Talk); Dust Radiative Transfer 2013 – Codes & Benchmarks, Institut de Planetologie et d'Astrophysique de Grenoble, France, 9.–11. Oct. (Talk); University of Hertfordshire, 20. Nov. (Colloquium)

Thomas Robitaille: Magellanic Cloud Star Formation: From the Milky Way to Distant Galaxies, Workshop, Lorentz Center, Leiden, The Netherlands, 18.–22. Feb. (Talk); Monte-Carlo Radiative transfer Summer school St Andrews, 1.–22. Aug. (Talk); Dust Radiative Transfer 2013 – Codes & Benchmarks, Institut de Planetologie et d'Astrophysique de Grenoble, France, 9.–11. Oct. (Talk)

Sarah Sadavoy: Universite de Montreal in Montreal, Quebec, Canada, 17. Dec. (Colloquium)

Karin Sandstrom: University of North Carolina, Chapel Hill, USA, 7. Mar. (Colloquium); San Francisco State University, San Francisco, CA USA, 13. Mar. (Colloquium); ITA Heidelberg, Heidelberg, 28. Oct. (Colloquium); University of Toledo, USA; 14. Nov. (Colloquium)

Eva Schinnerer: Helsinki University, Helsinki, 8. Mar. (Colloquium)

Dmitry Semenov: Atomic Processes in Interstellar Ices, Workshop, Universität Leiden, The Netherlands, 13. Mar. (Talk); PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July (Talk); PSF Seminar, MPIA Heidelberg, 24. Sept. (Colloquium)

Juergen Steinacker: IPAG Business School, Grenoble, France, 29. Nov. (Colloquium)

Greg Stinson: University of Michigan, Ann Arbor, USA, 16. Dec. (Colloquium)

Amelia Stutz: MPI für Radioastronomie, Bonn, 19. Feb. (Colloquium); PPVI, Protostars & Planets 6, Kongresshaus Heidelberg, 15.–19. July (Talk)

Fatemeh Tabatabaei: ASTRON Dwingeloo, The Netherlands, 30. May (Colloquium); HITS Heidelberg, 11. Dec. (Colloquium)

Roy van Boekel: »The link between planet formation history and planetary atmospheric spectra« NOVA Network 2 meeting, Amsterdam, The Netherlands, 12. Nov. (Talk)

Glenn van de Ven: DAGAL ITN Meeting, 1st Annual Network Meeting, Oulu, Finnland, 4.–7. Mar.; 9th Patras Workshop on Axions, WIMPs and WISPs, Schloss Waldthausen, Mainz 24.–28. June (Talk); MW Dynamical Modeling Workshop, MPIA Heidelberg, 5. – 7. Aug. (Talk); Gaia Challenge Workshop, University of Surrey, UK, 19.–23. Aug. (Talk)

Arjen van der Wel: NAM 2013, National Astronomy Meeting, University of St. Andrews, UK, 1.–5. July

Bram Venemans: Radio Sources and Society, The Wonderful Century, Symposium, Universität Leiden, The Netherlands, 10.–13. June (Talk); Gemini Observatorium, Hilo, USA, 12. Feb. (Colloquium)

Kaspar von Braun: VDI Munich, 3. Nov. (Colloquium)

Fabian Walter: Planetarium Mannheim Mar.; Freundeskreis Planetarium Mannheim, Dec.; ALMA Talk, Haus der Astronomie, Heidelberg, Dec.

Laura Watkins: MPIA Heidelberg (Colloquium); Strasbourg Observatory, Strasbourg, France (Colloquium)

Gabor Worseck: Swinburne University of Technology, Melbourne, Australien, 8. Aug. (Colloquium)

Svitlana Zhukovska: Far-infrared emission as window to study the formation of galaxies, Black Holes and dust in the young Universe, Ringberg Meeting, Ringberg, 13.–17. May (Talk); The Life Cycle of Dust in the Universe: Observations, Theory, and Laboratory Experiments, Taipei, Taiwan, 18.–22. Nov. (Talk)

Lecture Series

Coryn Bailer-Jones: GREAT Summer School in Astrostatistics, Alicante, June 2013

Hendrik Linz: Radio and Millimetre Astronomy, ZAH/ARI, Oct. 2012 – Jan. 2013

Greg Stinson: TransRegio Cosmology Winter School, Tonale, Italy, 1-6. Dec.

Popular Talks

Amelia Bayo: »50 years searching for brown dwarfs« »Cita con las estrellas 2013« Sociedad Malagueña de Astronomía, University of Malaga, Spain, 10. Mar. (Invited Talk)

Niall Deacon: »One-armed Estonians and astronomy, a retrospective« American Museum of Natural History, Astronomy on Tap, The Ding-Dong Lounge, New York, NY, 12. Sept.

Markus Feldt: »Suche nach extrasolaren Planeten – Methoden und Ergebnisse« Haus der Astronomie, Heidelberg, 11. Apr.; »Suche nach extrasolaren Planeten – Methoden und Ergebnisse« Kopernikusschule Freigericht, 6. Nov.

Thomas Henning: »Vom Sternenstaub zu extrasolaren Planeten« Planetarium Mannheim, 24. Jan.

Stefan Hippler: »Der scharfe Blick ins Universum – Laser und Adaptive Optik ermöglichen glasklare Sicht ins All« Haus der Astronomie, Heidelberg, 14. Nov.

Annie Hughes: »Women in Astronomy« Zonta Club of Adelaide, Australien, 6. Mar.; »The Magellanic System: A History of Discovery« Burnside Lions Club, Adelaide, Australien, 28. May

Cornelia Jäger: »Vom Molekül zur Festkörper-Astrophysik im Labor« »Lange Nacht der Wissenschaften« Jena, 29. Nov.

Klaus Jäger: »Das Unsichtbare sichtbar machen – Mit welchen Tricks Astronomen das Weltall erforschen« Planetarium Mannheim, 24. Apr.; »Der Himmel im Computer – Virtuelle Planetarien« as part of Girls' Day 2013, MPIA Heidelberg, 25. Apr.; »Vom Zentrum der Welt zum winzigen Staubkorn – die Stellung der Erde im Wandel der Zeit« Kurpfälzisches Museum Heidelberg, 15. May; »Das Unsichtbare sichtbar machen – Mit welchen Tricks Astronomen das Weltall erforschen« Pfalzmuseum für Naturkunde, Bad Dürkheim, 4. July; »Making the invisible visible – some fancy tricks in modern astronomy« International Summer Science School Heidelberg, ISG-Hotel Heidelberg, 30. July; »Das Unsichtbare sichtbar machen – Mit welchen Tricks Astronomen das Weltall erforschen« Planetarium Mannheim, 17. Oct.

Viki Joergens: »Braune Zwerge: Gescheiterte Sterne oder Superplaneten?« Haus der Astronomie, Heidelberg, 13. June

Lisa Kaltenegger: »Search for a Second Earth« Yuri's night Vienna, Austria, Apr.; Urania, Berlin, May; Alpbach Technologie Tage, Alpbach, Austria, Aug.; »Search for exoplanets and Life in the universe« Planetarium Klagenfurt, Austria, Nov.

Hubert Klahr: »Aus Staub geboren: Das 1 × 1 der Planetenentstehung« Planetarium Münster, 29. Oct.

Oliver Krause: »Das James-Webb-Weltraumteleskop: Ein neues Fenster ins infrarote Weltall« Planetarium Berlin 6. Feb.; »Entdeckungen im kalten Kosmos mit dem Weltraumobservatorium Herschel« Hochschule Mannheim, 5. Dec.; »Neues vom größten Weltraumteleskop Herschel« Hochschule Rüsselsheim, 13. Dec.

Ralf Launhardt: Der Lebensweg der Sterne, Planetarium Mannheim, 2. Oct.

Dietrich Lemke: Max Wolf – Stammvater der Heidelberger Astronomie, talk at the "Arbeitskreis Astronomie-Geschichte" of the German Astronomical Society, Tübingen, 23. Sept.

Christoph Mordasini: Interview SWR Landesschau ZOOM, 15. July; »Entstehung von Planeten innerhalb und außerhalb des Sonnensystems« Engadiner Sternenfreunde, Academia Engadina, Samedan, Schweiz, 3. Aug.

Markus Nielbock: »Dunkelwolken: Frostige Kinderstuben der Sterne« Engadiner Astronomiefreunde, Academia Engiadina, Samedan, Schweiz, 8. June (public talk); »Kalte und dunkle Kinderstuben im All« Astronomiestiftung Trebur, 21. June (public talk); »Das Herschel-Weltraumteleskop – Weltraumforschung im Klassenzimmer« Haus der Astronomie, Heidelberg, 9. Nov. (advanced teacher training of the HE Heraeus foundation); »Das Herschel-Weltraumteleskop – Ein Resümee zum Projektende« Engadiner Astronomiefreunde, Academia Engiadina, Samedan, Schweiz, 30. Nov. (public talk)

Silvia Scheithauer: »Auf der Suche nach Exoplaneten« Sommer-Kinderuniversität, Bretten, Rathaus Bretten, 5. Aug.; »Auf der Suche nach Exoplaneten« Sommer-Kinder-Akademie, Gymnasium Schönborn, Bruchsal, 8. Aug.

Roy van Boekel: »Astrophysik« Institute of Physiological Chemistry, Universität Hannover, 5. Sept.

Glenn van de Ven: »Exposing the intimate life of galaxies« Planetarium Porto, Portugal, 17. Oct.

Kaspar von Braun: Sternwarte Cologne, 25. Sept; Sternwarte Heilbronn, 27. Sept.

V. 5 Teaching and Service

Teaching Activities

Winter Term 2012/2013:

Coryn Bailer-Jones: Exercises for Experimentalphysics I (tutorial)
Henrik Beuther, Hendrik Linz: Radio and Millimetre Astronomy (Lecture)
Henrik Beuther: Exercises for PEP1
Christian Fendt: IMPRS Seminar, University of Heidelberg (with Glover, Kaltenegger, Meisenheimer) (Seminar)
Christian Fendt: Exercises for Experimentalphysics III (tutorial)
Harald Mutschke, Cornelia Jäger: Laboratory Astrophysics, Friedrich Schiller Universität, Institut für Festkörperphysik (Lecture); Seminar Laboratory Astrophysics, Friedrich Schiller University, Jena (Seminar)
Knud Jahnke: Exercises for Experimentalphysics I (tutorial)
Viki Joergens: Extrasolar Planets and Brown Dwarfs (Lecture)
Lisa Kaltenegger: Astrobiology and Astrophysics II, Seminar for Bachelor and Master students, University of Heidelberg; Astronomical Colloquium (with C. Dullemond) (Colloquium)
Andrea Maccio: Cosmology Seminar, University of Heidelberg (Exercises)
Christoph Mordasini: Universelle Kompetenz Numerik, University of Heidelberg (Block course)
Wilma Trick: Theoretische Physik I: Punktmechanik and Mathematische Methoden (Exercise for Bachelor students)
Glenn van de Ven: Seminar on current research topics (IMPRS 1, mit Christian Fendt (MPIA), Andreas Koch (LSW), and Simon Glover (ITA); Galaxien, University of Heidelberg (Block course) (with Fabian Walter) (Lecture and Exercises)
Fabian Walter: Galaxien, University of Heidelberg (Block course) (with Glenn van de Ven) (Lecture and Exercises)

Summer Term 2013

Coryn Bailer-Jones: Undergraduate computer/lecture course Statistical Methods, elective module Physics Bachelor/Master der University of Heidelberg (Lecture with Exercises)
Henrik Beuther: Star formation (with Thomas Henning) (Lecture)
Alex Büdenbender: Einführung in die Astronomie II (Exercises)
Christian Fendt: IMPRS Seminar, University of Heidelberg (with Clark, Glover, van de Ven); Astronomie für Nicht-Physiker, University of Heidelberg (with Just); Astronomie III Seminar, University of Heidelberg (with Mundt, Gail, Koch)
Richard Hanson: Experiment F36 Wellenfrontanalyse im Fortgeschrittenpraktikum für Physiker (with Stefan Hippler) (Practicals)
Jakob Herpich: Exercise for Introduction to Computational Physics, MPIA Heidelberg (Exercise)
Stefan Hippler: Experiment F36Wellenfrontanalyse im Fortgeschrittenpraktikum für Physiker (with Richard Hanson) (Practicals)
Harald Mutschke, Cornelia Jäger: Seminar Laboratory Astrophysics, Friedrich Schiller University, Jena (Seminar)
Knud Jahnke, Hans-Walter Rix: Einführung in die Astronomie and Astrophysik II (Lecture)
Lisa Kaltenegger: Astronomical Colloquium (with C. Dullemond)(Colloquium)
Klaus Meisenheimer: workshop PEP2 (Experimentalphysik 2) (Exercises)
Reinhard Mundt: Introduction to Astronomy and Astrophysics III, University of Heidelberg (Lecture)
Camilla Penzo: Exercises for General Relativity (Exercises)
Thomas Robitaille: Python: programming for scientists (Course)
Dmitry Semenov: 6th HGSFP Winterschool 2013, Chemistry in the Universe, University Center Obergurgl, Osterreich (Block course)
Glenn van de Ven: Seminar on current research topics (IMPRS 1, with Christian Fendt (MPIA), Andreas Koch (LSW), and Simon Glover (ITA)) (Seminar)

Winter Term 2013/2014

Fabrizio Arrigoni Battaia: Praktical experiment F30 Stellare CCD-Photometrie (Practicals)
Coryn Bailer-Jones: Experimentalphysik 3, elective module im physics Bachelor/Masters course der University of Heidelberg (Exercises)
Amelia Bayo: "Virtual Observatory", Max Planck Institute for Radio Astronomy, Bonn (Workshop)
Henrik Beuther: Einführung in die Astronomie and Astrophysik 1 (with Christian Fendt) (Lecture and Exercises)
Christian Fendt: IMPRS Seminar, University of Heidelberg (with Glover, Meisenheimer, van de Ven) (Seminar)
Siddarth Hegde: Experiment F36 Wellenfrontanalyse im Fortgeschrittenpraktikum für Physiker (Exercises)
Harald Mutschke, Cornelia Jäger: Seminar Laboratory Astrophysics, Friedrich Schiller University, Jena (Seminar)
Viki Joergens: Exercises for Experimentalphysics1 (PEP1): Klassische Mechanik (Mechanik and Thermodynamik) (Exercises)

Knud Jahnke: Planeten- and Sternentstehung (Bachelor-compulsory seminar)
Lisa Kaltenegger: Astrobiology and Astrophysics II Seminar and Lecture für Bachelor and Master-Studenten, University of Heidelberg; Astronomy, University of Heidelberg (Colloquium)
Rainer Köhler: Introduction to IDL for Scientic Research (Block course)
Rolf Kuiper: Star Formation, University of Tübingen (Lecture)
Andrea Macciò: Cosmology Seminar, University of Heidelberg, Galaxy Formation, University of Heidelberg (Block course)
Michael Maseda: Laboratory Astrophysics Exercises (Block course)
Christoph Mordasini: Universelle Kompetenz Numerik, University of Heidelberg (Block course); Exercises for Experimentalphysics 1 PEP1, University of Heidelberg (Exercises)
Qian Qian: Einführung in die Astronomie and Astrophysik 1 (Exercises)
Thomas Robitaille: Python: programming for scientists (Course); IMPRS-Workshop
über High Energy Astrophysics, 8th Heidelberg Summer School, Heidelberg, 9. – 13. September
Dmitry Semenov: Molecular Astrophysics: from Theory to Lab to Observations (with Dr. Holger Kreckel, MPIK, Heidelberg) (Lecture and Exercises)
Glenn van de Ven: Seminar on current research topics (IMPRS 1, with Christian Fendt (MPIA), Andreas Koch (LSW), and Simon Glover (ITA)); Galaxies, Block course (with Andrea Maccio)(Lecture and Exercises)
Michael Walther: Cosmology Seminar, University of Heidelberg (Exercises)

Service in Committees

Referees for Scientific Journals

Angela Adamo: ApJ, A&A, MNRAS
Tri L. Astraatmadja: MNRAS
Coryn Bailer-Jones: ApJ, MNRAS, Nature
Amelia Bayo: A&A
Yan Betremieux: ApJ
Henrik Beuther: ApJ, A&A, MNRAS
Arjan Bik: MNRAS
Esther Buenzli: ApJ
Yu-Yen Chang: ApJ
Ian Crosseld: ApJ, A&A, MNRAS
Elisabete da Cunha: ApJ, MNRAS
Roberto Decarli: ApJ, ApJ Letters, MNRAS
Aaron Dutton: ApJ, MNRAS, Nature
Emanuele Paolo Farina: A&A
Christian Fendt: ApJ, A&A, MNRAS, Geophysical & Astrophysical Fluid Dynamics
Bertrand Goldman: ApJ
Roland Gredel: ApJ, A&A, MNRAS
Brent Groves: ApJ, A&A, MNRAS
Stefan Hippler: Italian Ministry of Education, University and Research
Jaqueline Hodge: ApJ
Felix Hormuth: Astrobiology
Friedrich Huisken: Advanced Materials, Nanotechnology, Science, NanoLetters, Applied Physics Letters, Journal of Applied Physics, Chemical Physics Letters, Chemical Reviews, Journal of Chemical Physics, Journal of Physical Chemistry, Journal of Nanoparticle Research, Computational Materials Science
Cornelia Jäger: ApJ, MNRAS, Carbon
Viki Joergens: A&A
Katharine Johnston: MNRAS
Jouni Kainulainen: A&A
Lisa Kaltenegger: ApJ, ApJL, A&A, MNRS, ICARUS, Astrobiology
Iva Karicova: A&A
Sarah Kendrew: ApJ, MNRAS
Ulrich Klaas: Experimental Astronomy
Hubert Klahr: ApJ, Journal of Fluid Mechanics
Oliver Krause: ApJ, Nature
Rolf Kuiper: Science, MNRAS
Ralf Launhardt: A&A, ApJ
Christoph Leinert: Icarus, Kapitel des Buches »Polarization of stars and planetary systems« Dietrich Lemke: Referee für JAI
Hendrik Linz: ApJ, A&A, MNRAS
Elisabetta Lusso: MNRAS
Mariya Lyubenova: MNRAS
Andrea Maccio: ApJ, A&A, MNRAS, Nature
Marie Martig: MNRAS
Nicolas Martin: ApJ, MNRAS
Sharon E. Meidt: ApJ, A&A
Esteban Morales: A&A
Christoph Mordasini: ApJ, MNRAS
Reinhard Mundt: ApJ, A&A
Markus Nielbock: A&A
Johan Olofsson: A&A
Jörg-Uwe Pott: A&A
Sarah Ragan: ApJ Letters, A&A
Hans-Walter Rix: ApJ, A&A, MNRAS
Thomas Robitaille: A&A
Sarah Sadavoy: ApJ
Karin Sandstrom: ApJ, A&A, MNRAS
Eva Schinnerer: RevMexAA, ApJ
Eddie Schlafly: ApJ, PASP
Joshua Schlieder: MNRAS
Dmitry Semenov: ApJ, A&A, Planetary & Space Science, Chemical Reviews

Juergen Steinacker: ApJ, Planetary and Space Science
Greg Stinson: ApJ, A&A, MNRAS
Fatemeh Tabatabaei: AJ
Roy van Boekel: ApJ, A&A
Glenn van de Ven: The ApJ, A&A, MNRAS, Science
Arjen van der Wel: ApJ, A&A, MNRAS, Publications of the Astronomical Society of Australia
Kaspar von Braun: AJ
Stefanie Wachter: AJ
Fabian Walter: ApJ, Nature
Gabor Worseck: MNRAS
Xiangxiang Xue: A&A
Svitlana Zhukovska: MNRAS

Referees for Research Grants

Amelia Bayo: PhDProgramm der Universität von Wien
Henrik Beuther: ERC; DFG; ANR
Elisabete da Cunha: NASA Astrophysics Data Program 2013
Christian Fendt: DAAD; French National Research Agency, Frankreich; Pazi Foundation, Israel; DAAD-Auswahlverfahren, Programm zur Förderung ausländischer Doktoranden
Roland Gredel: CONICYT (Chile), MINECO (Spanien), NWO (Niederländisch)
Annie Hughes: Macquarie University (Australien)
Friedrich Huisken: DFG; Marie-Curie, EU; Fonds zur Förderung der wissenschaftlichen Forschung in Österreich; Fonds de la Recherche Scientic (FNRS) Belgium; Agence Nationale de la Recherche (ANR) France; Dutch Research Council (NWO), The Netherlands; National Research Foundation (NFR), South Africa
Cornelia Jäger: DFG
Lisa Kaltenegger: NASA, NSF
Hubert Klahr: Danish Council for Independent Research, Fund for Scientic Research – FNRS, Brüssel, Belgien
Ralf Launhardt: ERC starting grants evaluation panel
Luigi Mancini: French Polar Institute
Nicolas Martin: Canadian Time Allocation Committee
Sharon E. Meidt: Natural Sciences and Engineering Research Council of Canada
Klaus Meisenheimer: Netherlands Organisation for Scientic Research
Reinhard Mundt: DFG
Hans-Walter Rix: DFG, EU, NOVA, AvH, MPG, Israeli Science Foundation
Eva Schinnerer: Natural Sciences and Engineering Research Council of Canada
Dmitry Semenov: »Origins of the Solar System«, National Science Foundation, USA
Branimir Sesar: NASA Fermi Cycle 6
Arjen van der Wel: Royal Astronomical Society

HdA

Olaf Fischer supervised the development of 14 new sets of WIS classroom materials for the upper and middle school within the project "Wissenschaft in die Schulen!" (a cooperation with Spektrum der Wissenschaft publishers).
Olaf Fischer supervised four Staatsexamen theses: Christopher Brinkmann: »Wirkungen von kosmischem Staub auf das Licht von Hintergrundsternen« (9/2012–3/2013); Anne-Carin Moessinger: »Einfache Messanordnungen zur Untersuchung der Sonne« (9/2012–3/2013); Benedikt Sommerauer: »Kosmischer Staub – Von Kleinstpartikeln zu Planeten« (3/2013–9/2013); Thorben Dijkstra: »Arbeitsweise des Interferometers ALMA« (6/2013–12/2013).
Markus Pössel co-supervised the Staatsexamen thesis: Franziska Storz: »Planetenbahnen vermessen mit All-Sky-Kamerabildern« (4/2013 – 10/2013).
Cecilia Scorza co-supervised a Staatsexamen thesis: Anna Rögner: »Offene Sternhaufen – Bausteine der Milchstraße« (10/2012 – 5/2013).
Olaf Fischer supervised two BOGY interns (24./25.1.).
Carolin Liefke supervised three BOGY internship programs with in total nine pupils (4. – 8.2., 18. – 22.3. and 8. – 12.4.).
Markus Pössel supervised six interns for the "Internationales Sommerpraktikum des HdA" (simultaneously part of the practical of the International Summer Science School of the city of Heidelberg) (22.7. – 9.8.).

Summer Term 2013:

Olaf Fischer, Carolin Liefke: "Vom Urknall zur Dunklen Energie" (Seminar), University of Heidelberg
Markus Pössel (with Björn Malte Schäfer): "Cosmology" (Block course), University of Heidelberg.
Markus Pössel, Olaf Fischer (with Björn Malte Schäfer): "Kosmologie-Sommerschule für Lehrer und Lehramtskandidaten" (Block course), University of Heidelberg.

Winter Term 2013/2014:

Natalie Fischer: "Grundlagen der Astronomie für die Schule" (Vorlesung), University of Education Heidelberg.
Olaf Fischer, Carolin Liefke, Cecilia Scorza and Markus Pössel: "Einführung in die Astronomie für Lehramt an Gymnasien Physik" (lecture, practicals), University of Heidelberg
Carolin Liefke, Olaf Fischer: "Astronomie in verschiedenen Spektralbereichen" (Seminar), University of Heidelberg.

V.6 Publications

In Journals with Referee System:

Adamo, A., G. Östlin, N. Bastian, E. Zackrisson, R. C. Livermore and L. Guaita: Highresolution study of the cluster complexes in a lensed spiral at redshift 1.5: constraints on the bulge formation and disk evolution. The Astrophysical Journal 766, id. 105 (2013).

Adams, J. J., J. D. Simon, A. D. Bolatto, G. C. Sloan, K. M. Sandstrom, A. Schmiedeke, J. T. van Loon, J. M. Oliveira and L. D. Keller: Dusty OB stars in the Small Magellanic Cloud. II. Extragalactic disks or examples of the Pleiades phenomenon? The Astrophysical Journal 771, id. 112 (23 pp) (2013).

Adibekyan, V. Z., P. Figueira, N. C. Santos, A. Mortier, C. Mordasini, E. Delgado Mena, S. G. Sousa, A. C. M. Correia, G. Israelian and M. Oshagh: Orbital and physical properties of planets and their hosts: new insights on planet formation and evolution. Astronomy and Astrophysics 560, id. A51 (8 pp) (2013).

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