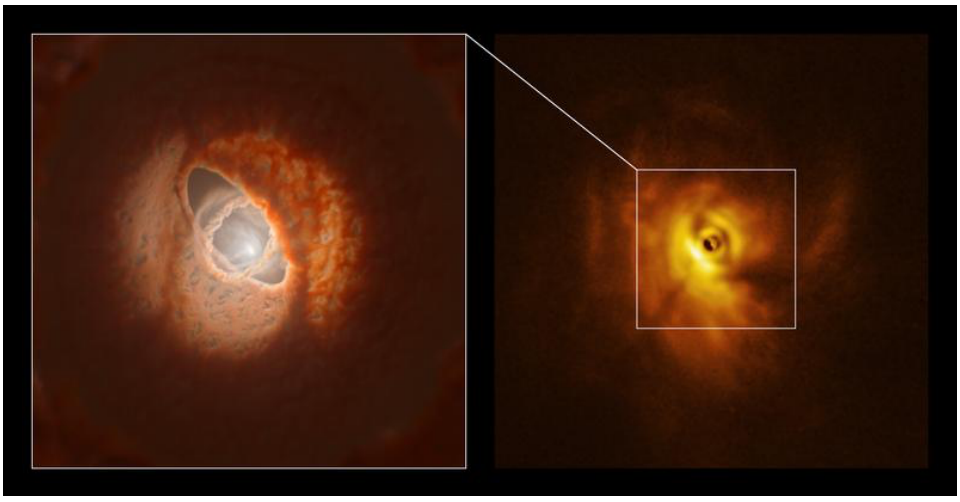
Physics and Astronomy 04.09.2020

New observations show planet-forming disc torn apart by its three central stars



Neueste Berichte

A team of astronomers have identified the first direct evidence that groups of stars can tear

apart their planet-forming disc, leaving it warped and with tilted rings. This new research suggests exotic planets, not unlike Tatooine in Star Wars, may form in inclined rings in bent discs around multiple stars. The results were made possible thanks to observations with the European Southern Observatory's Very Large Telescope (ESO's VLT) and the Atacama Large Millimeter/submillimeter Array (ALMA).

Our Solar System is remarkably flat, with the planets all orbiting in the same plane. But this is not always the case, especially for planet-forming discs around multiple stars, like the object of the new study: GW Orionis. This system, located just over 1300 light-years away in the constellation of Orion, has three stars and a deformed, broken-apart disc surrounding them.

"Our images reveal an extreme case where the disc is not flat at all, but is warped and has a misaligned ring that has broken away from the disc," says Stefan Kraus, a professor of astrophysics at the University of Exeter in the UK who led the research published today in the journal Science. The misaligned ring is located in the inner part of the disc, close to the three stars.

The new research also reveals that this inner ring contains 30 Earth-masses of dust, which could be enough to form planets. "Any planets formed within the misaligned ring will orbit the star on highly oblique orbits and we predict that many planets on oblique, wide-separation orbits will be discovered in future planet imaging campaigns, for instance with the ELT," says team member Alexander Kreplin of the University of Exeter, referring to ESO's Extremely Large Telescope, which is planned to start operating later this decade. Since more than half the stars in the sky are born with one or more companions, this raises an exciting prospect: there could be an unknown population of exoplanets that orbit their stars on very inclined and distant orbits.

To reach these conclusions, the team observed GW Orionis for over 11 years. Starting in 2008, they used the AMBER and later the GRAVITY instruments on ESO's VLT Interferometer in Chile, which combines the light from different VLT telescopes, to study the gravitational dance of the three stars in the system and map their orbits. "We found that the three stars do not orbit in the same plane, but their orbits are misaligned with respect to each other and with respect to the disc," says Alison Young of the Universities of Exeter and Leicester and a member of the team.

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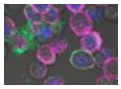

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They also observed the system with the SPHERE instrument on ESO's VLT and with ALMA, in which ESO is a partner, and were able to image the inner ring and confirm its misalignment. ESO's SPHERE also allowed them to see, for the first time, the shadow that this ring casts on the rest of the disc. This helped them figure out the 3D shape of the ring and the overall disc.

The international team, which includes researchers from the UK, Belgium, Chile, France and the US, then combined their exhaustive observations with computer simulations to understand what had happened to the system. For the first time, they were able to clearly link the observed misalignments to the theoretical "disc-tearing effect", which suggests that the conflicting gravitational pull of stars in different planes can warp and break their discs.

Their simulations showed that the misalignment in the orbits of the three stars could cause the disc around them to break into distinct rings, which is exactly what they see in their observations. The observed shape of the inner ring also matches predictions from numerical simulations on how the disc would tear.

Interestingly, another team who studied the same system using ALMA believe another ingredient is needed to understand the system. "We think that the presence of a planet between these rings is needed to explain why the disc tore apart," says Jiaqing Bi of the University of Victoria in Canada who led a study of GW Orionis published in the *Astrophysical Journal Letters* in May this year. His team identified three dust rings in the ALMA observations, with the outermost ring being the largest ever observed in planet-forming discs.

Future observations with ESO's ELT and other telescopes may help astronomers fully unravel the nature of GW Orionis and reveal young planets forming around its three stars.

More information

This research was presented in the paper "A triple star system with a misaligned and warped circumstellar disk shaped by disk tearing – https://science.sciencemag.org/cgi/doi/10.1126/science.aba4633 " to appear in *Science* (doi: 10.1126/science.aba4633).

The team is composed of Stefan Kraus (University of Exeter, School of Physics & Astronomy, UK [Exeter]) Alexander Kreplin (Exeter), Alison K. Young (Exeter and School of Physics and Astronomy, University of Leicester, UK), Matthew R. Bate (Exeter), John D. Monnier (University of Michigan, USA [Michigan]), Tim J. Harries (Exeter), Henning Avenhaus (Max Planck Institute for Astronomy, Heidelberg, Germany), Jacques Kluska (Exeter and Instituut voor Sterrenkunde, KU Leuven, Belgium [KU Leuven]), Anna S. E. Laws (Exeter), Evan A. Rich (Michigan), Matthew Willson (Exeter and Georgia State University, USA), Alicia N. Aarnio (University of North Carolina Greensboro, USA), Fred C. Adams (Michigan), Sean M. Andrews (Center for Astrophysics | Harvard & Smithsonian, USA [CfA]), Narsireddy Anugu (Exeter, Michigan and Steward Observatory, University of Arizona, USA), Jaehan Bae (Michigan and Carnegie Institution for Science, Washington, USA), Theo ten Brummelaar (The CHARA Array of Georgia State University, California, USA), Nuria Calvet (Michigan), Michel Cure (Instituto de Fisica y Astronomia, Universidad de Valparaiso, Chile), Claire L. Davies (Exeter), Jacob Ennis (Michigan), Catherine Espaillat (Michigan and Boston University, USA), Tyler Gardner (Michigan), Lee Hartmann (Michigan), Sasha Hinkley (Exeter), Aaron Labdon (Exeter), Cyprien Lanthermann (KU Leuven), Jean-Baptiste LeBouquin (Michigan and Universite Grenoble Alpes, CNRS, IPAG, France), Gail H. Schaefer (CHARA), Benjamin R. Setterholm (Michigan), David Wilner (CfA), and Zhaohuan Zhu (University of Nevada, USA).

ESO is the foremost intergovernmental astronomy organisation in Europe and the world's most productive ground-based astronomical observatory by far. It has 16 Member States: Austria, Belgium, the Czech Republic, Denmark, France, Finland, Germany, Ireland, Italy, the Netherlands, Poland, Portugal, Spain, Sweden, Switzerland and the United Kingdom, along with the host state of Chile and with Australia as a Strategic Partner. ESO carries out an ambitious programme

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focused on the design, construction and operation of powerful ground-based observing facilities enabling astronomers to make important scientific discoveries. ESO also plays a leading role in promoting and organising cooperation in astronomical research. ESO operates three unique world-class observing sites in Chile: La Silla, Paranal and Chajnantor. At Paranal, ESO operates the Very Large Telescope and its world-leading Very Large Telescope Interferometer as well as two survey telescopes, VISTA working in the infrared and the visible-light VLT Survey Telescope. Also at Paranal ESO will host and operate the Cherenkov Telescope Array South, the world's largest and most sensitive gamma-ray observatory. ESO is also a major partner in two facilities on Chajnantor, APEX and ALMA, the largest astronomical project in existence. And on Cerro Armazones, close to Paranal, ESO is building the 39-metre Extremely Large Telescope, the ELT, which will become "the world's biggest eye on the sky".

The Atacama Large Millimeter/submillimeter Array (ALMA), an international astronomy facility, is a partnership of ESO, the U.S. National Science Foundation (NSF) and the National Institutes of Natural Sciences (NINS) of Japan in cooperation with the Republic of Chile. ALMA is funded by ESO on behalf of its Member States, by NSF in cooperation with the National Research Council of Canada (NRC) and the National Science Council of Taiwan (NSC) and by NINS in cooperation with the Academia Sinica (AS) in Taiwan and the Korea Astronomy and Space Science Institute (KASI). ALMA construction and operations are led by ESO on behalf of its Member States; by the National Radio Astronomy Observatory (NRAO), managed by Associated Universities, Inc. (AUI), on behalf of North America; and by the National Astronomical Observatory of Japan (NAOJ) on behalf of East Asia. The Joint ALMA Observatory (JAO) provides the unified leadership and management of the construction, commissioning and operation of ALMA.

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Links

* Research paper – https://www.eso.org/public/archives/releases/sciencepapers/eso2014/eso2014a.pdf

* Interactive 3D model of the disc structure and stellar orbit of the GW Orionis triple system, as derived from the observations (Open with Acrobat Reader to display interactive elements properly) – https://www.eso.org/public/archives/releases/pdf/eso2014a.pdf

* Augmented reality representation of the GW Orionis triple system (via the National Radio Astronomy Observatory) – https://public.nrao.edu/news/alma-discovers-misaligned-rings-in-planet-forming-disk-around-triple-stars/

* Photos of the VLT – http://www.eso.org/public/images/archive/category/paranal/

* Photos of ALMA – https://www.eso.org/public/images/archive/category/alma/

* For scientists: got a story? Pitch your research – http://eso.org/sci/publications/announcements/sciann17277.html

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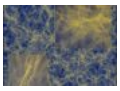

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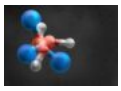

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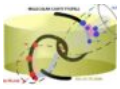

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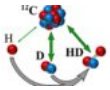

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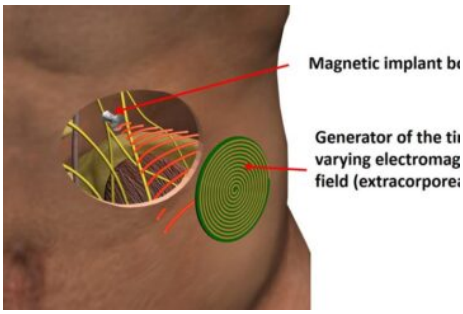

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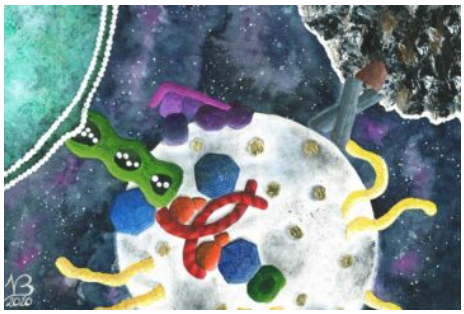

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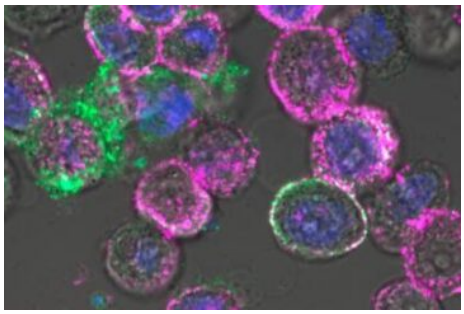

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