

Modeling Star and Planet Formation

Rolf Kuiper
(University of Duisburg-Essen) 

Perspectives of Planet and Star Formation
Heidelberg
June 22, 2026

University of Duisburg-Essen (UDE)

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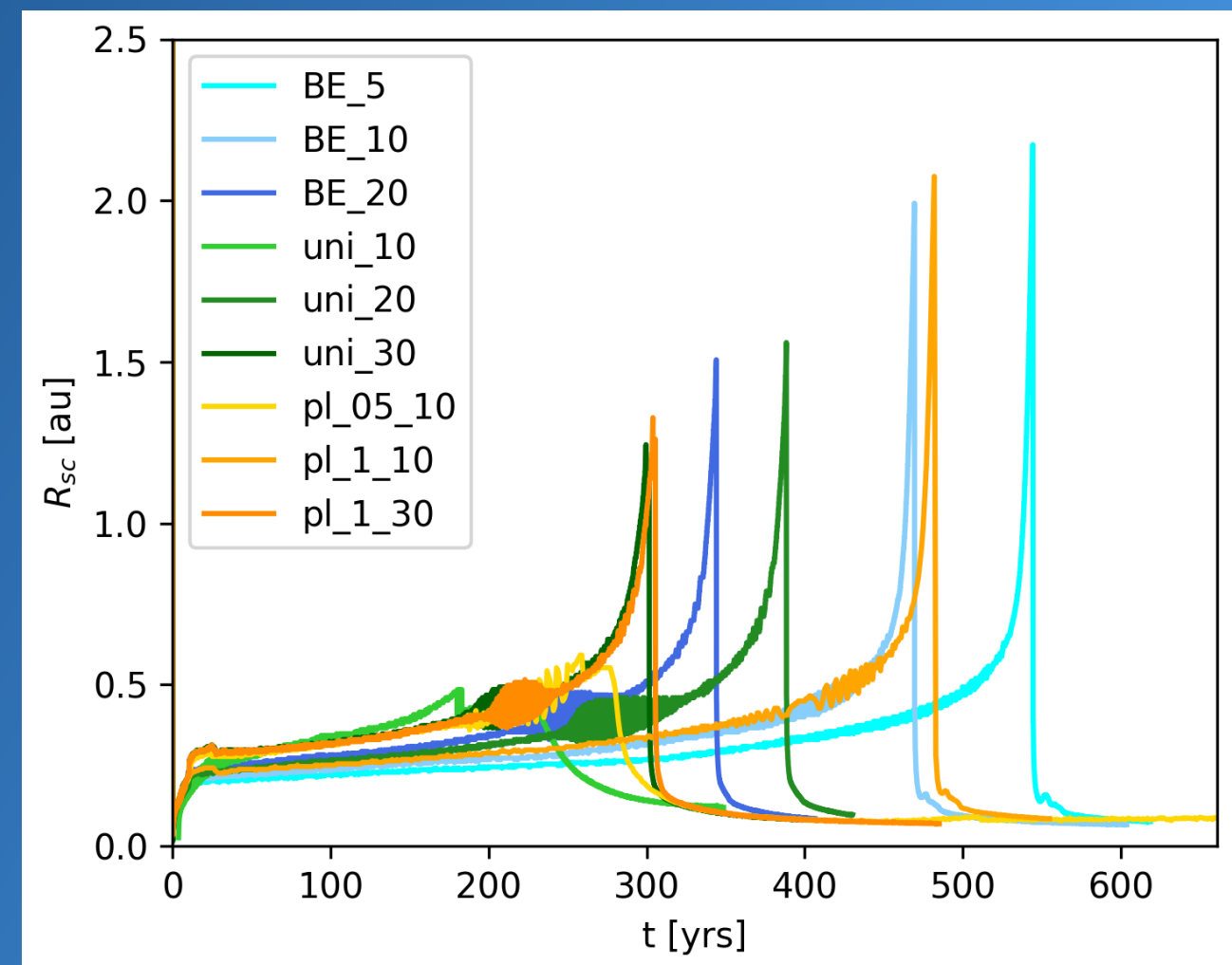
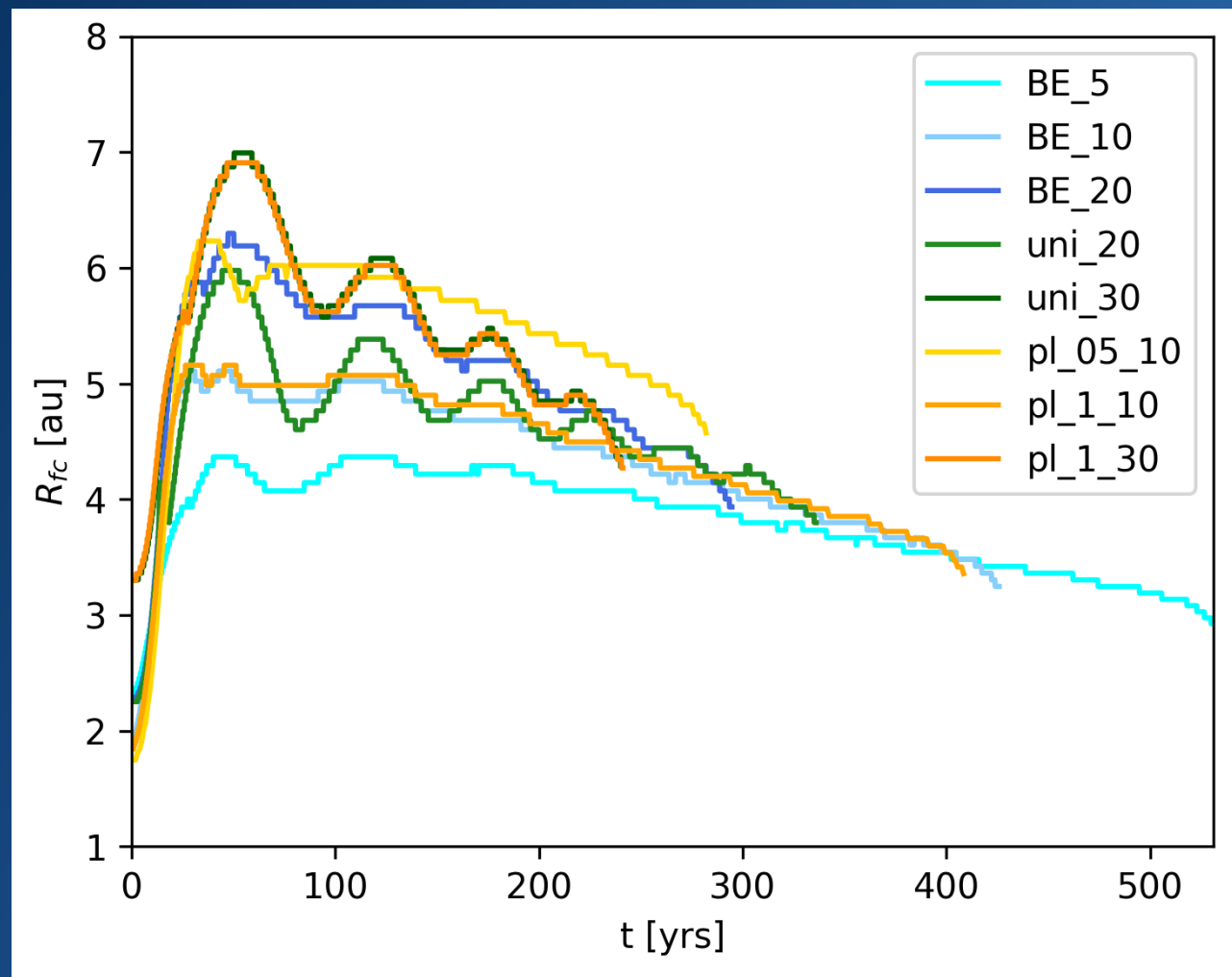
Open-Minded



Earliest Phases of Star, Disk, and Jet Formation

Larson Core Formation

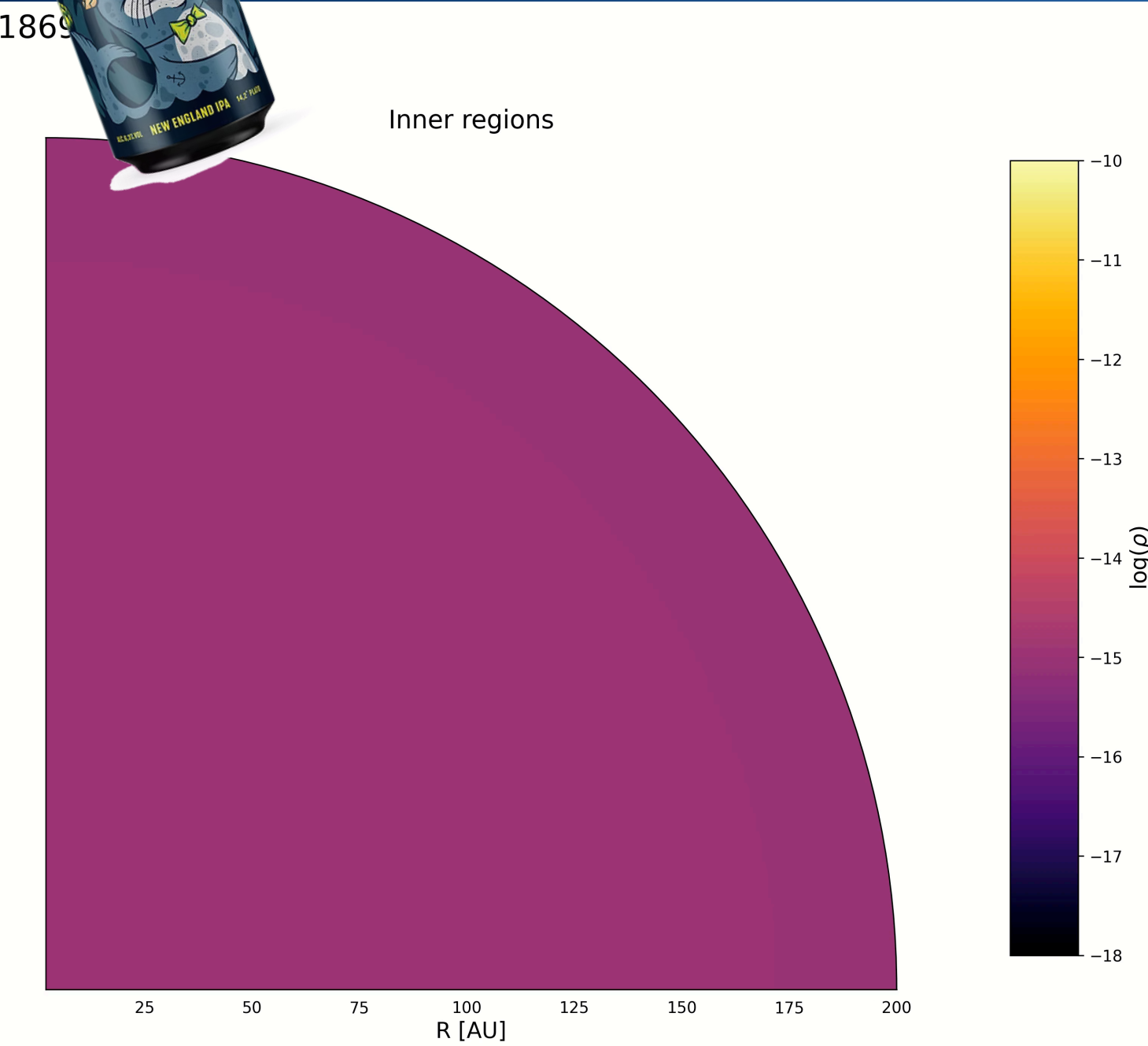
- First and Second Larson Core Properties (see also Bhandare et al. 2018, 2020)
- All classical initial conditions: Bonnor-Ebert, uniform density, power-law profiles
- Derivation of Formation Conditions based on initial properties of the *star-forming* gas (not the whole mass reservoir)



Marx, Bhandare, & Kuiper (in prep.)

Early Jet Evolution

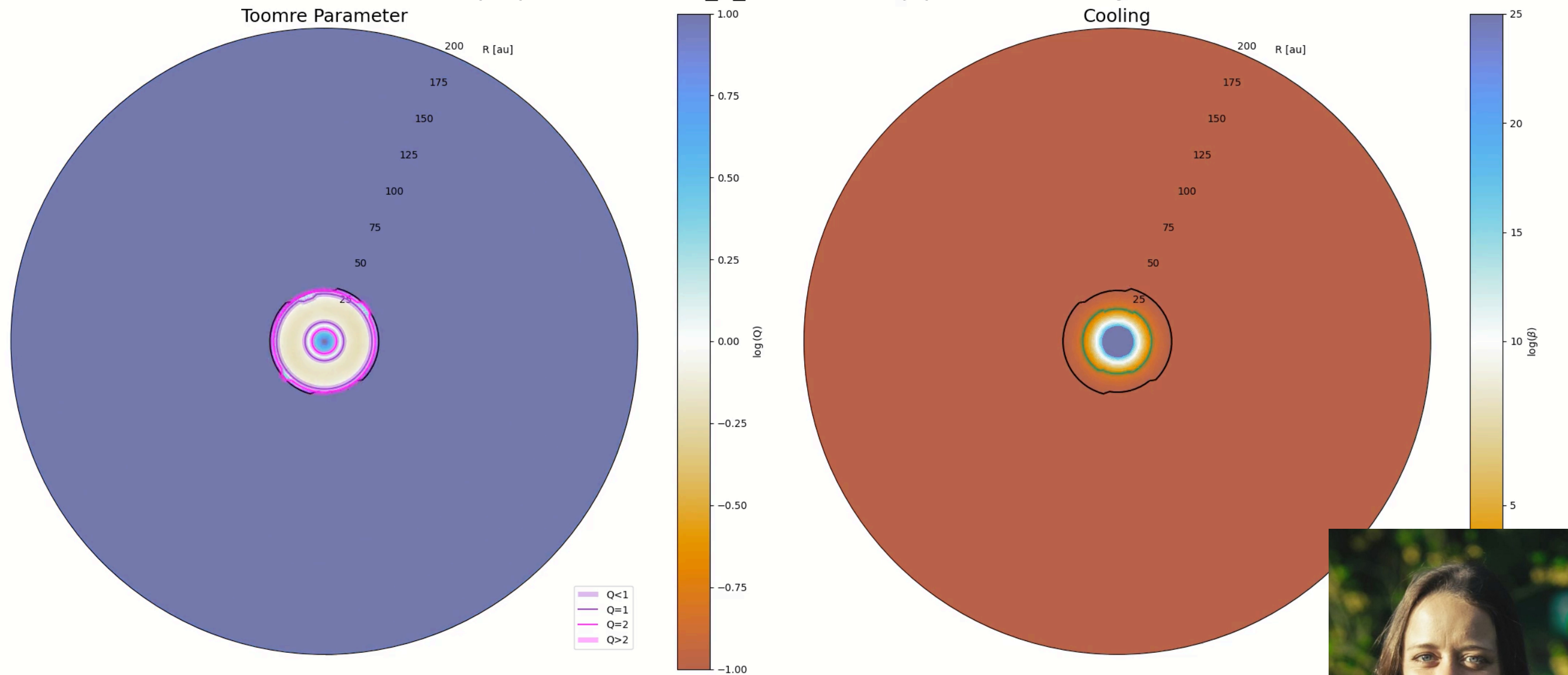
NEIPA: Numerical Equivalent to „Investigating Protostellar Accretion“
(see talk by Tom Megeath today)



Frederike Marx
(PhD)

Early Disk Evolution

Disk properties of BE3D_2_rot1 in the r - ϕ -plane at 14800 years

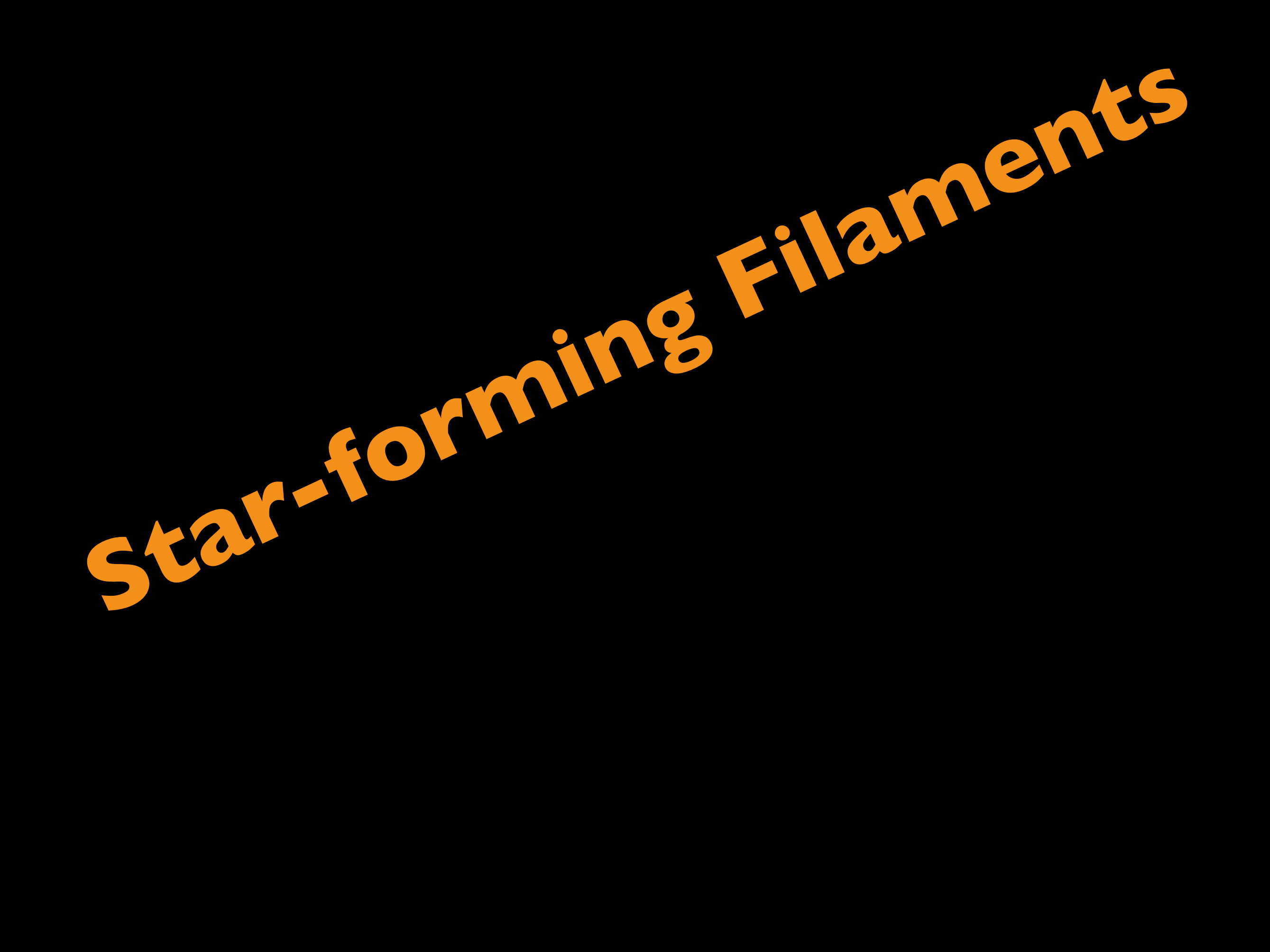


Marx et al. (in prep.); see also Tomida et al. (2017)

All processes (cores, disks, jets) studied as function of stellar mass!



Frederike Marx
(PhD)

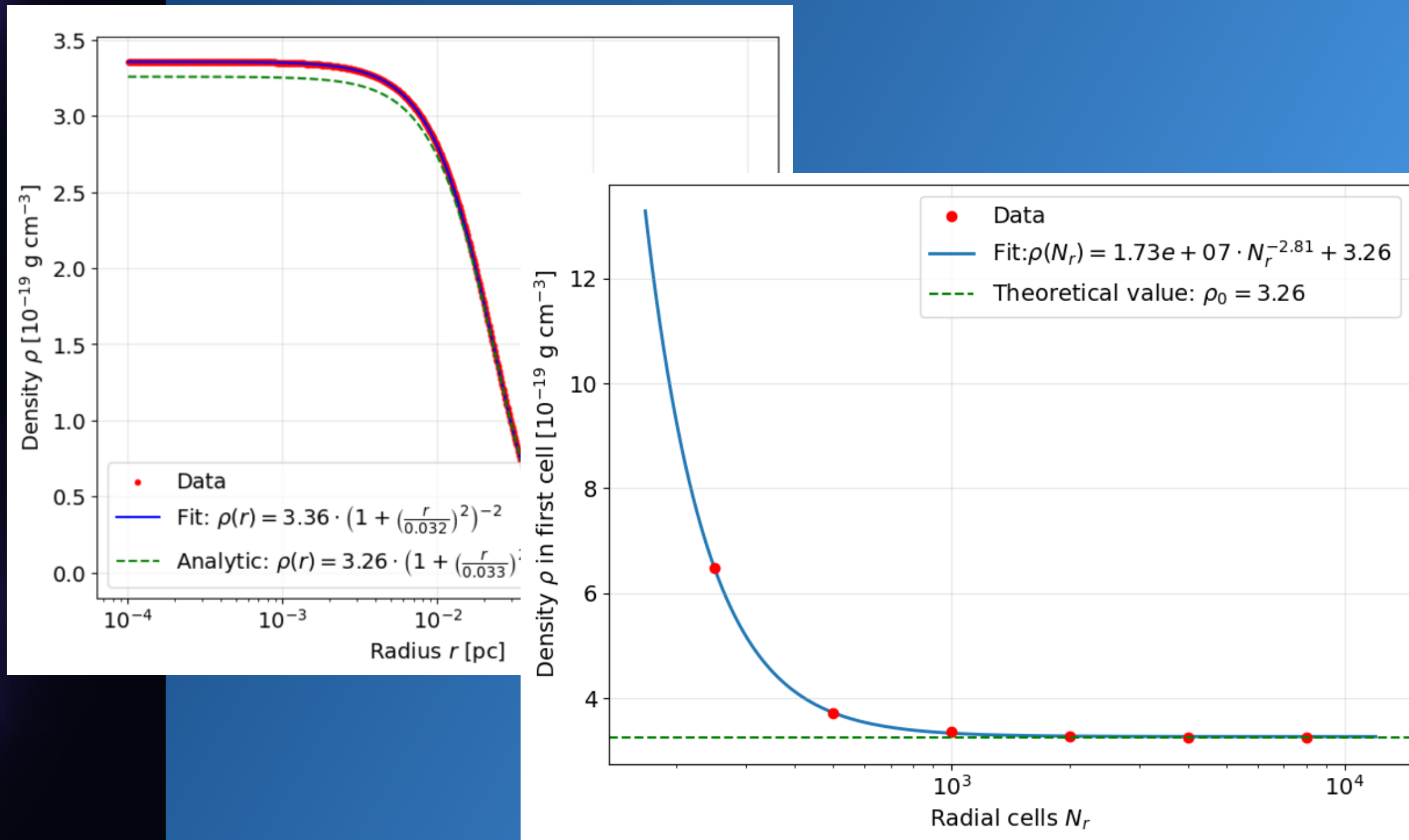


Star-forming Filaments

Star-forming Filaments

Rigorous Testing of Numerical Framework

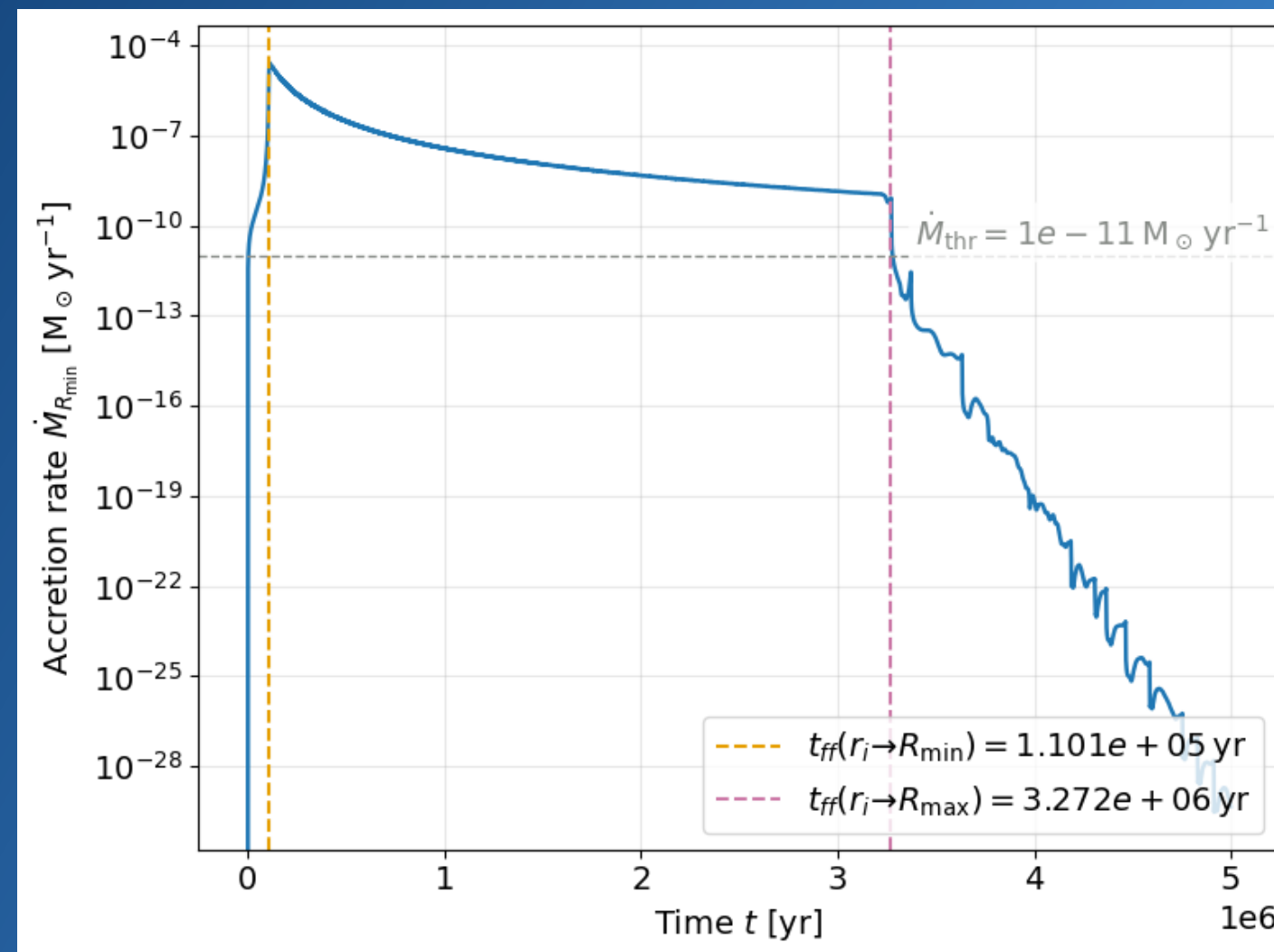
- Radial Equilibrium



Star-forming Filaments

Rigorous Testing of Numerical Framework

- Radial Equilibrium
- Radial Dynamics: Onset + Collapse



Onset timescale $\sim 0.5\%$ within theoretical value.
Collapse timescale $\sim 2.5\%$ within theoretical value.

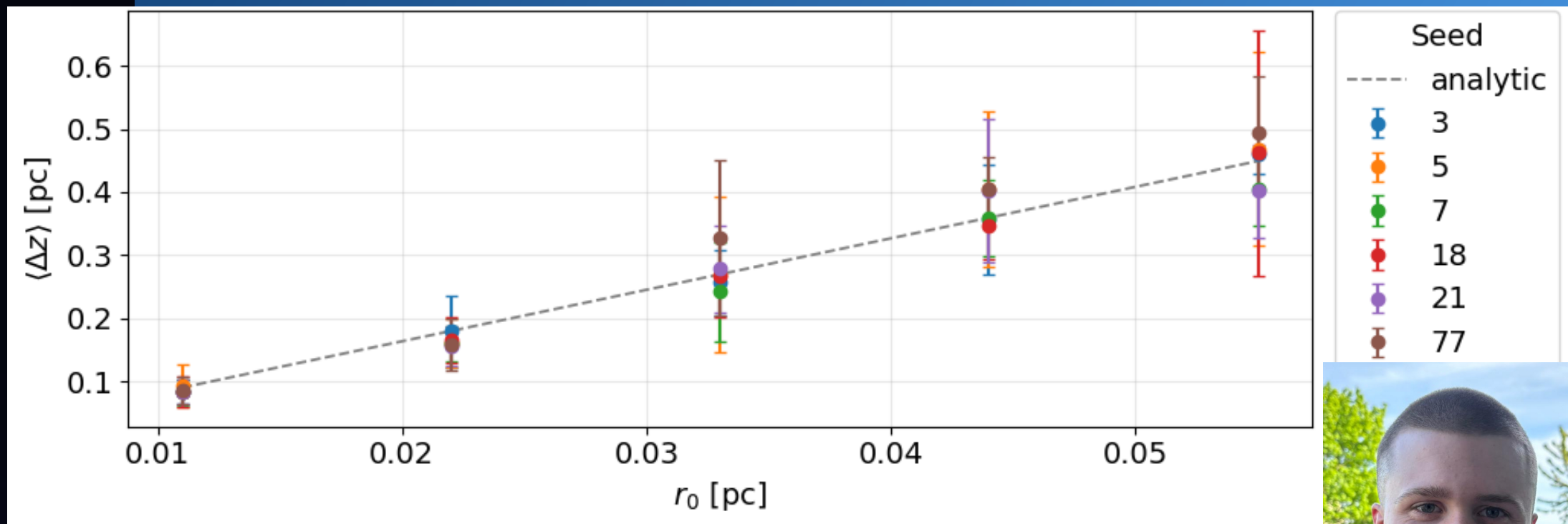


Emilio Schmidt
(Master)

Star-forming Filaments

Rigorous Testing of Numerical Framework

- Radial Equilibrium
- Radial Dynamics: Onset + Collapse
- Vertical Dynamics: Fragmentation

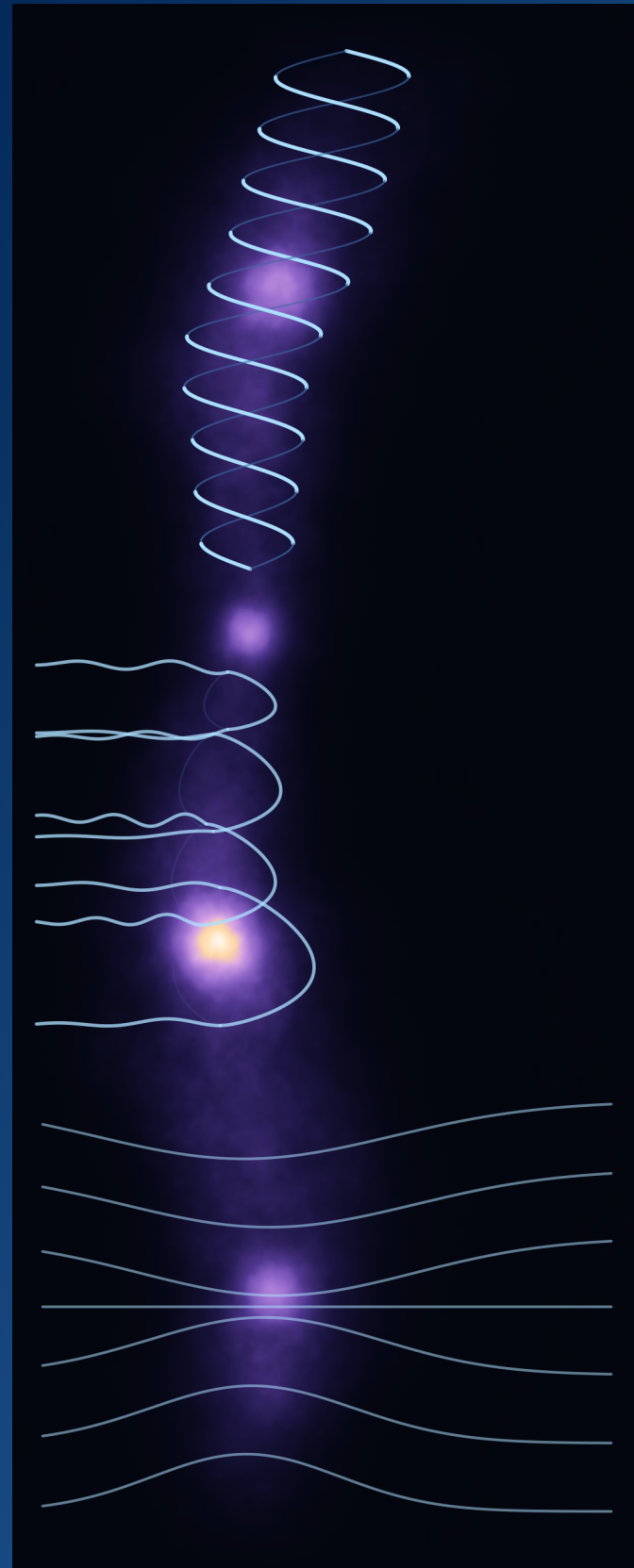


Emilio Schmidt
(Master)

Star-forming Filaments

Rigorous Testing of Numerical Framework

- Radial Equilibrium
- Radial Dynamics: Onset + Collapse
- Vertical Dynamics: Fragmentation
- MHD Equilibrium of Fiege & Pudritz (2000) ... in progress

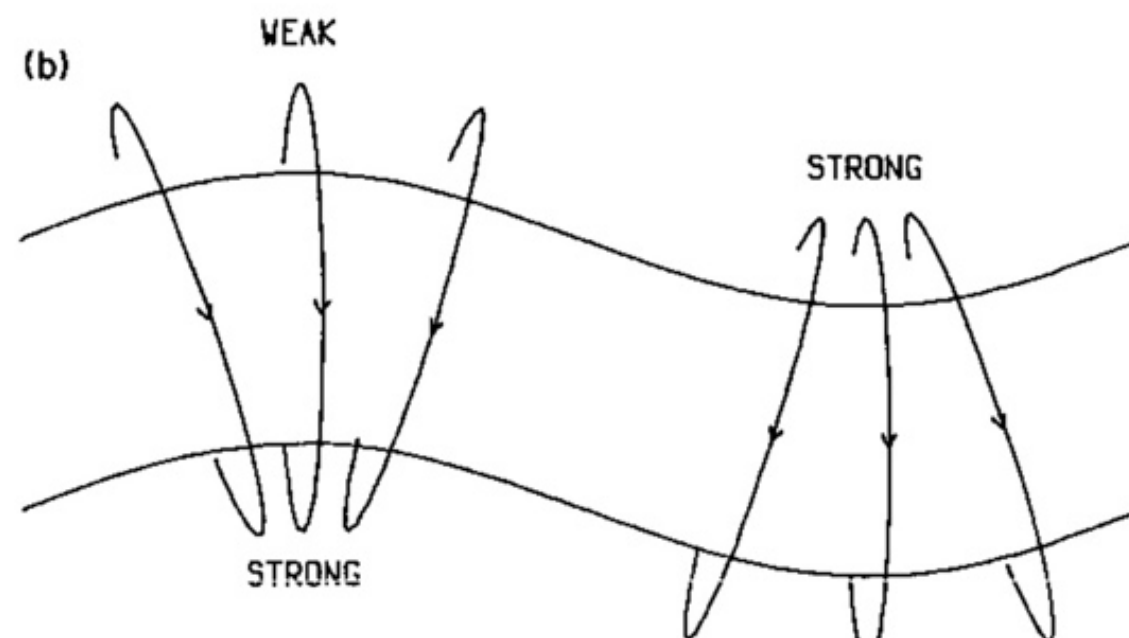
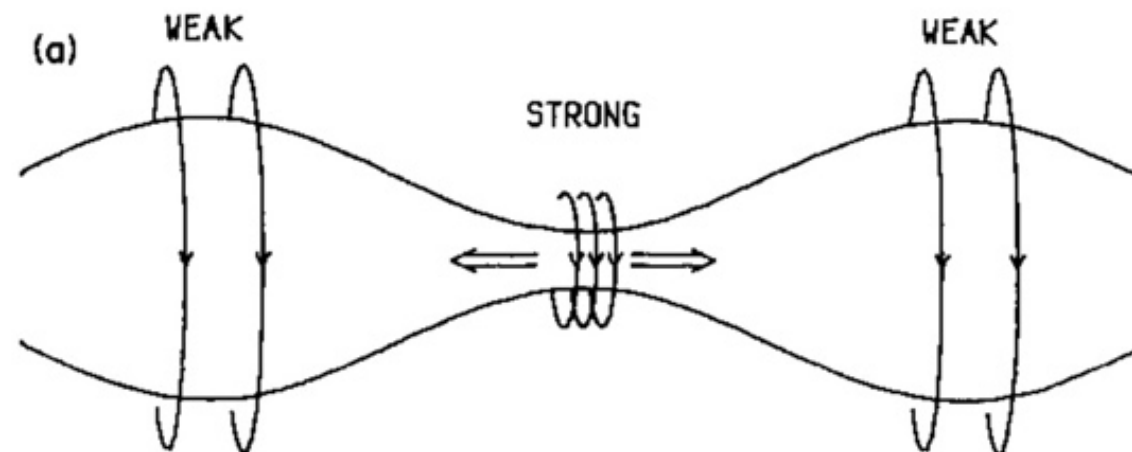


Emilio Schmidt
(Master)

Star-forming Filaments

Outlook (in collaboration with Eric Keto):

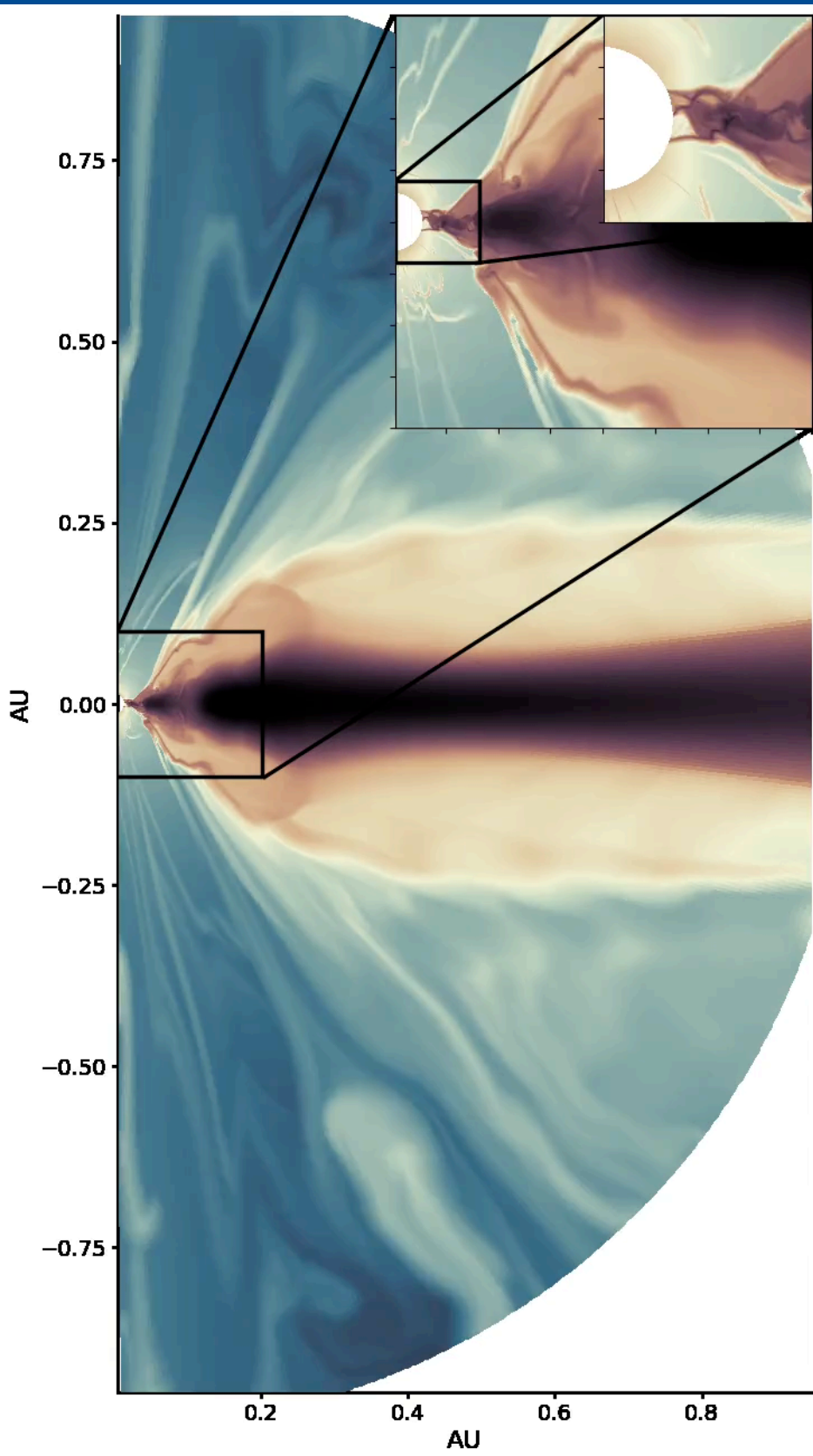
- ▶ Timescales for Core Formation and Filament Twisting
- ▶ [Feedback from Environment]
- ▶ ...



Emilio Schmidt
(Master)

Accreting Stars

HADES Project on Accreting Protostars



- MHD
- Axial symmetry
- Stellar B-Field + Disk Field
- Low-Mass Star Formation



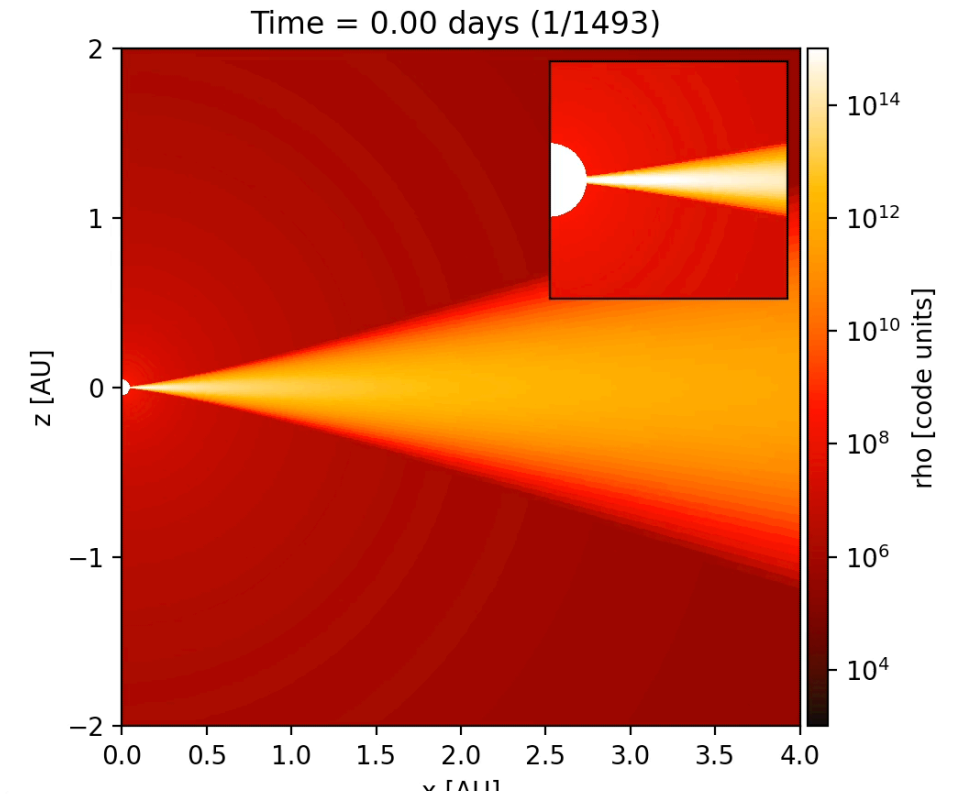
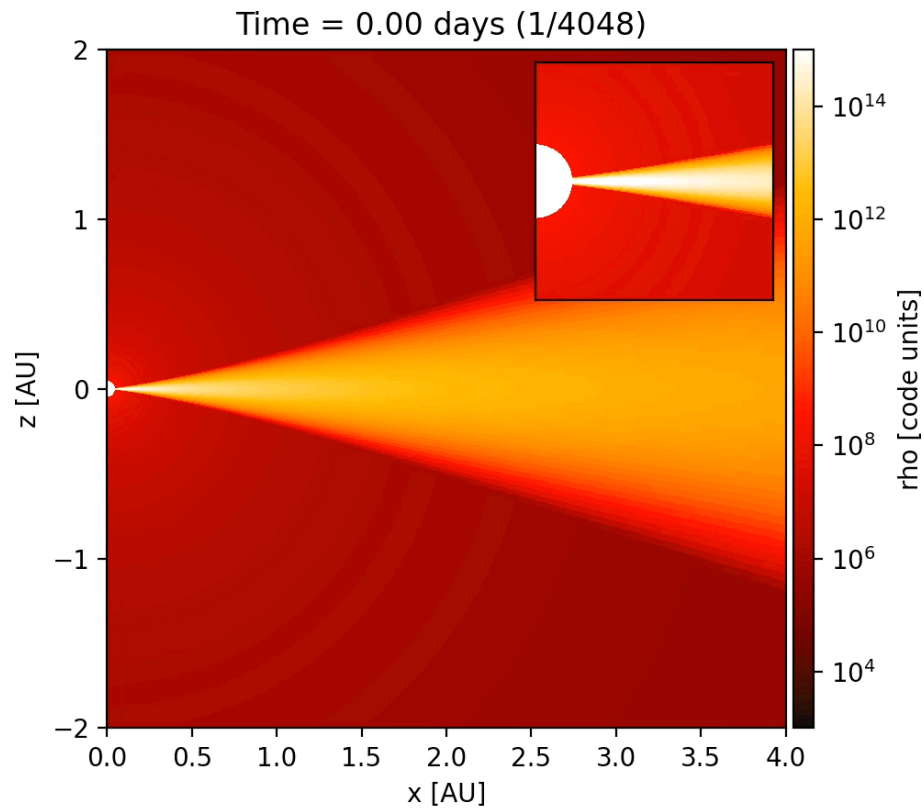
Brandt Gaches
(Emmy Noether
Research Group Leader)

Gaches, Tan, Rosen, & Kuiper (2024): on Accretion

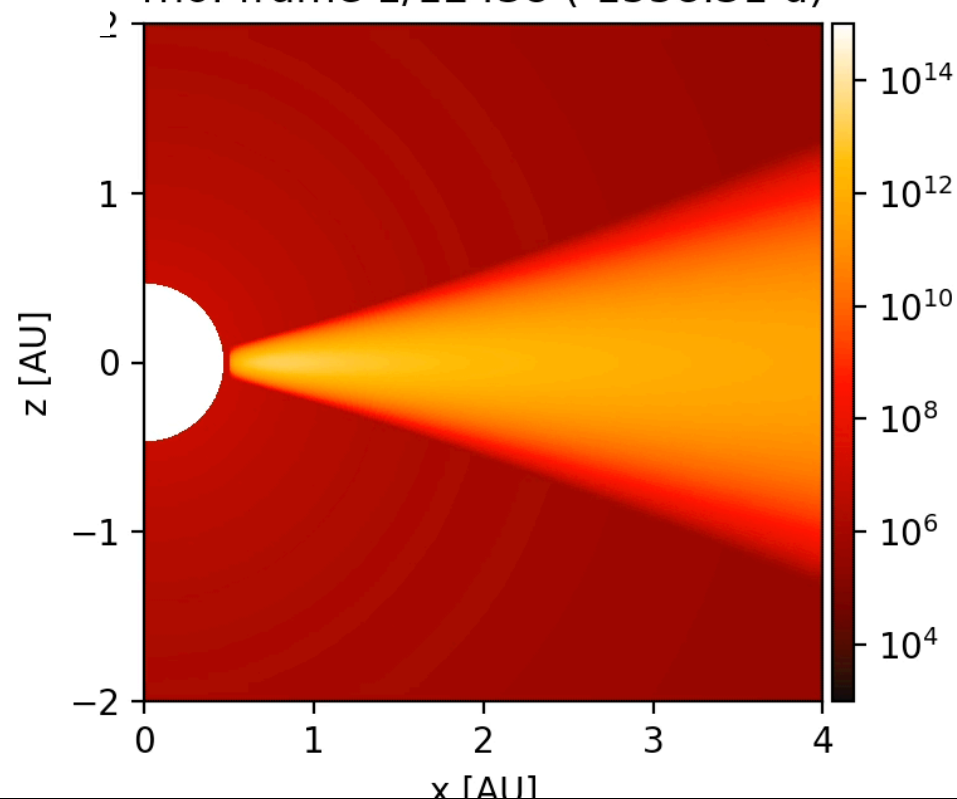
Gaches et al. (in prep.): on Outflows

HADES Project on Accreting Protostars

→ stronger stellar magnetic field



02_high_res_1024nr_test
rho: frame 1/12438 (-1558.31 d)



→ bloated star

Here: High-Mass SF

- * Irradiation
- * Photoionization
- * [Radiation Forces]

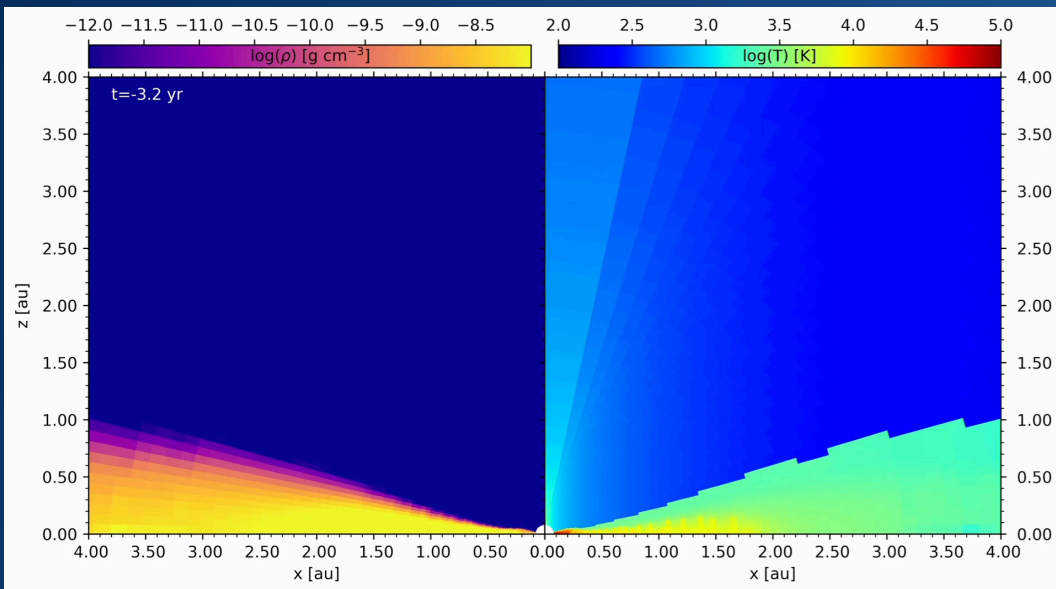


Fynn Wawrzyniak
(Master)

What else?

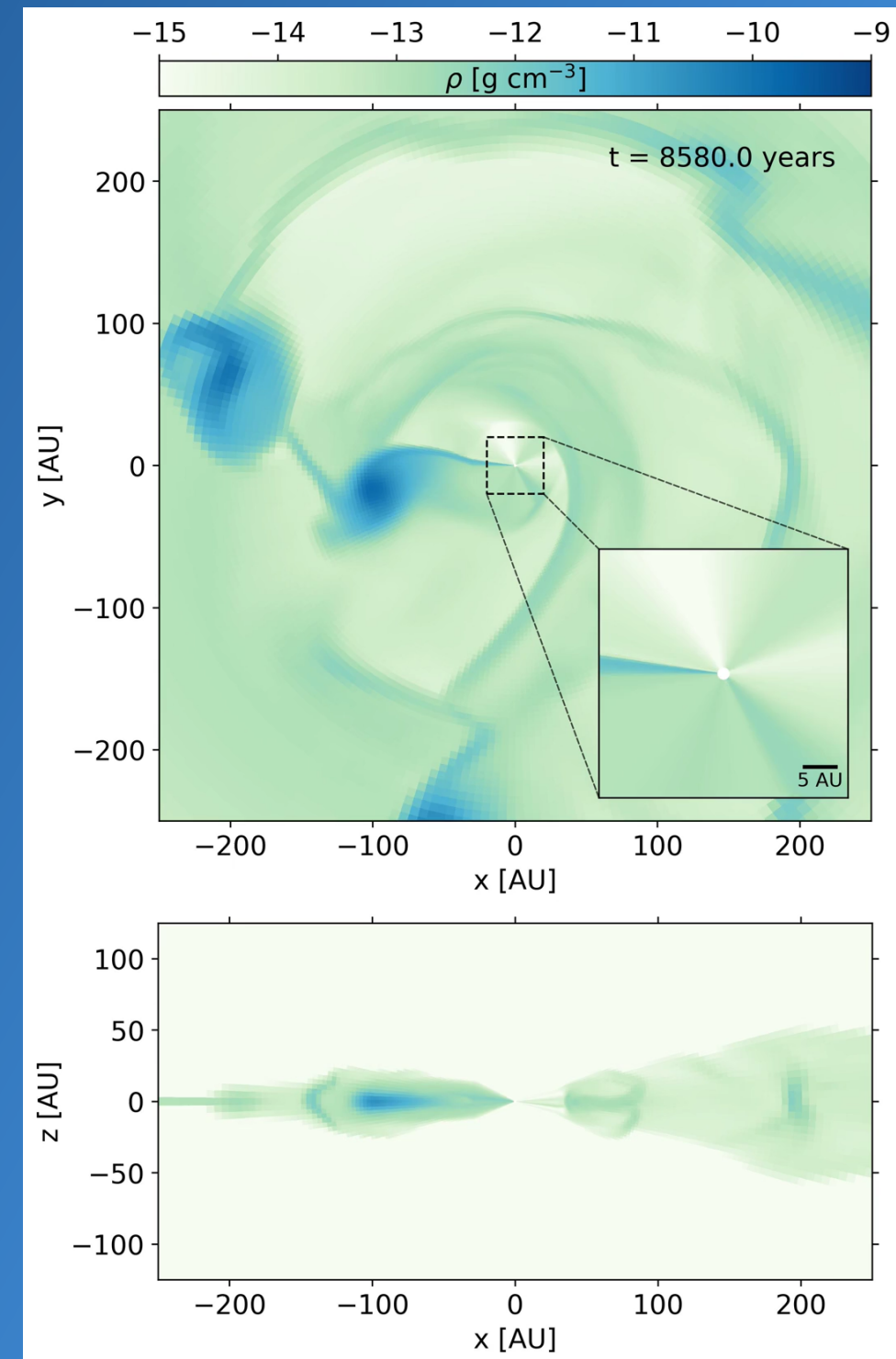
More on Disks ...

Thermally unstable Disks

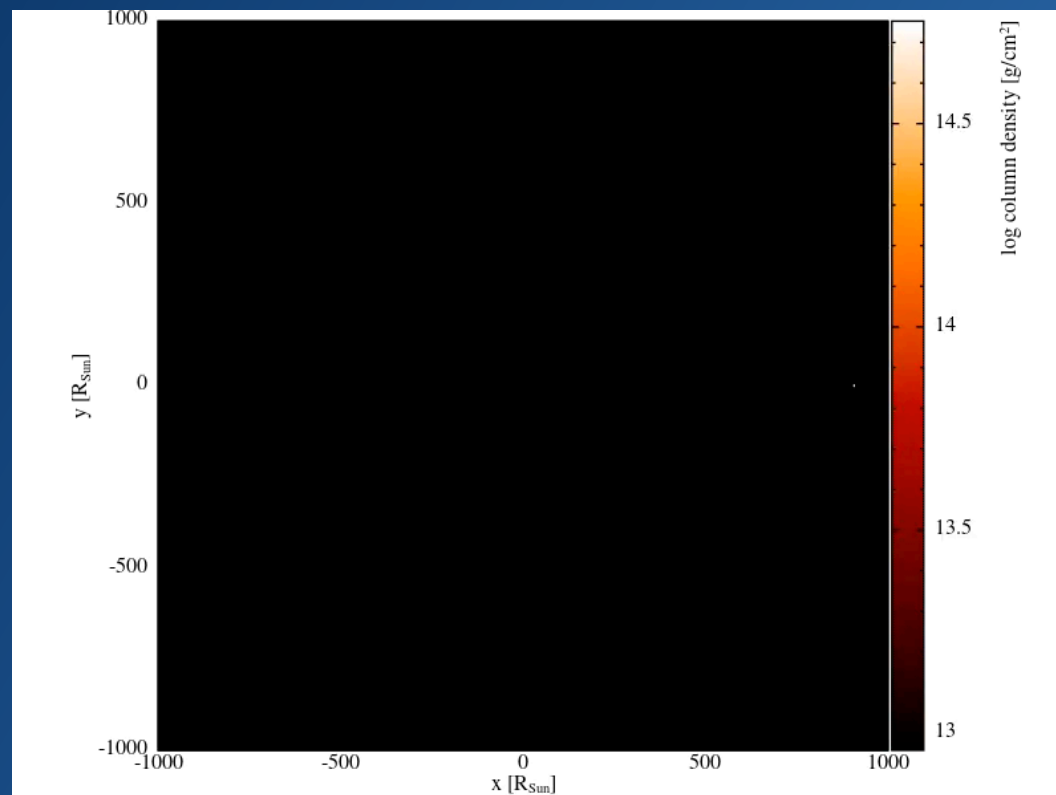


Vardan Elbakyan
(Postdoc)

Disk Fragmentation



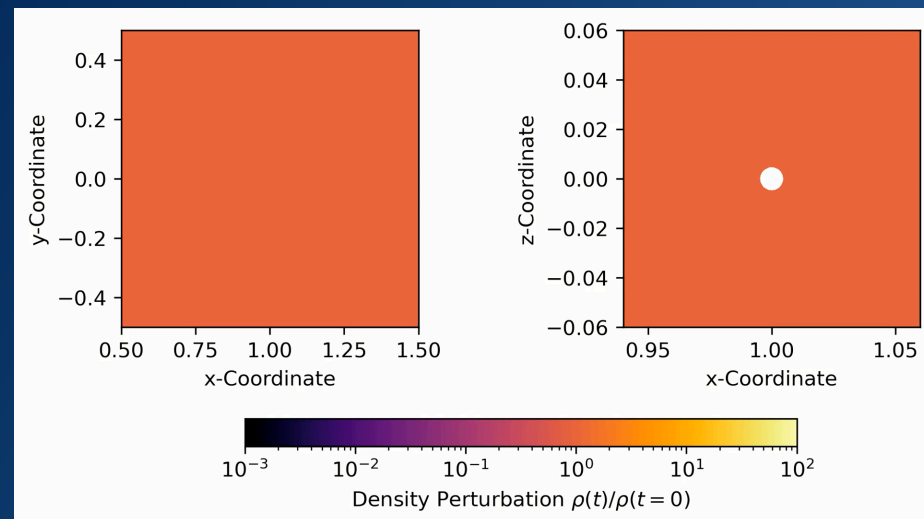
Tidal Disruption Events



Luke Conmy
(PhD)

More, more, more

Formation of Circumplanetary Disks

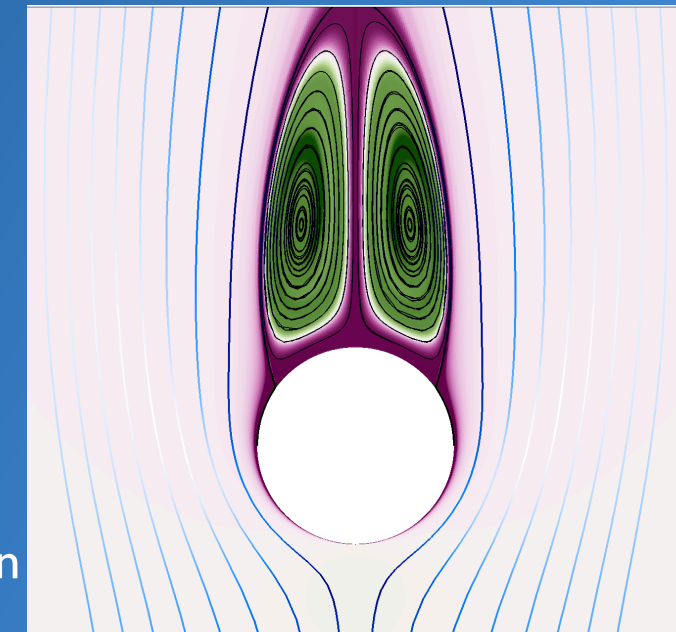


Dennis Wehner
(PhD)

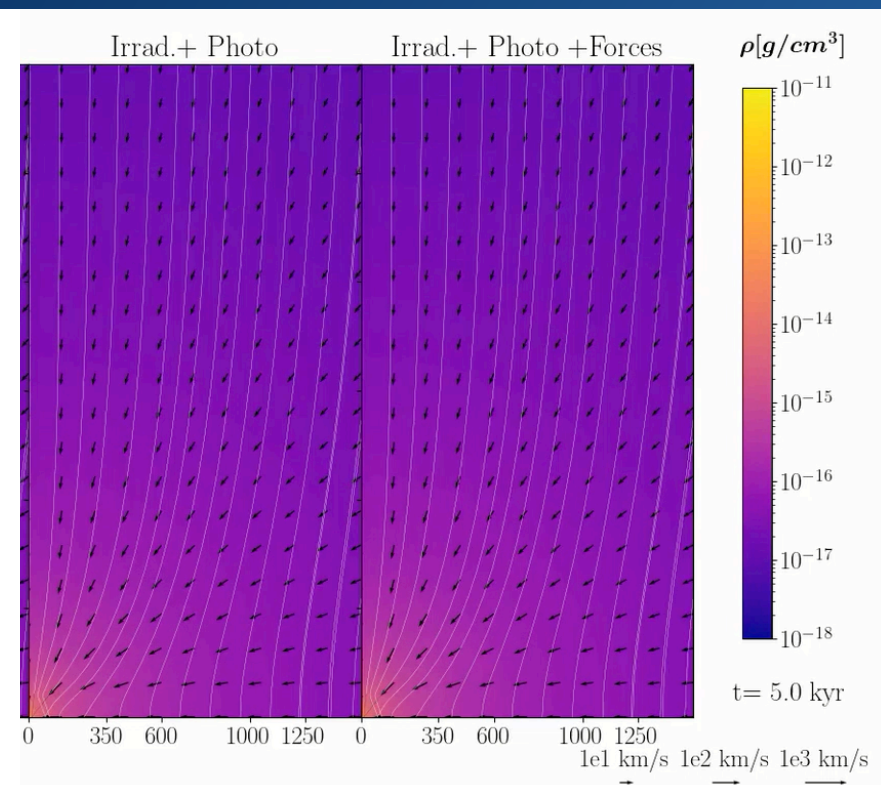


Shaghayegh Jolehkaran
(PhD)

Lava World Atmospheres



Jets and Feedback

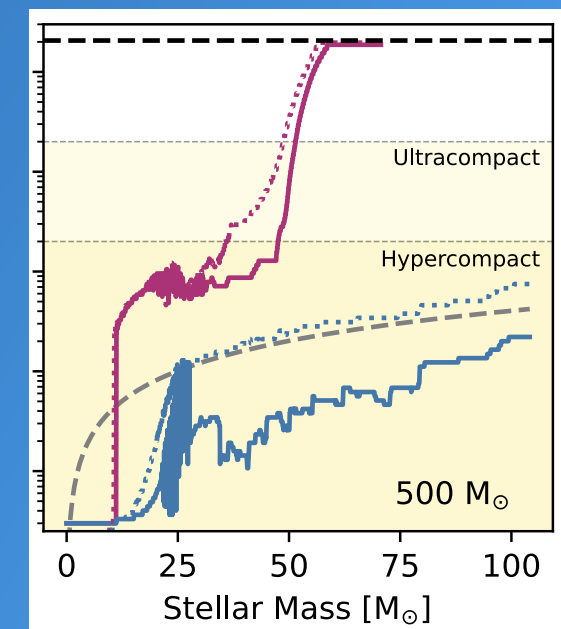


Joshua Alvarado Barquero
(PhD)



Lauren Martini
(Master)

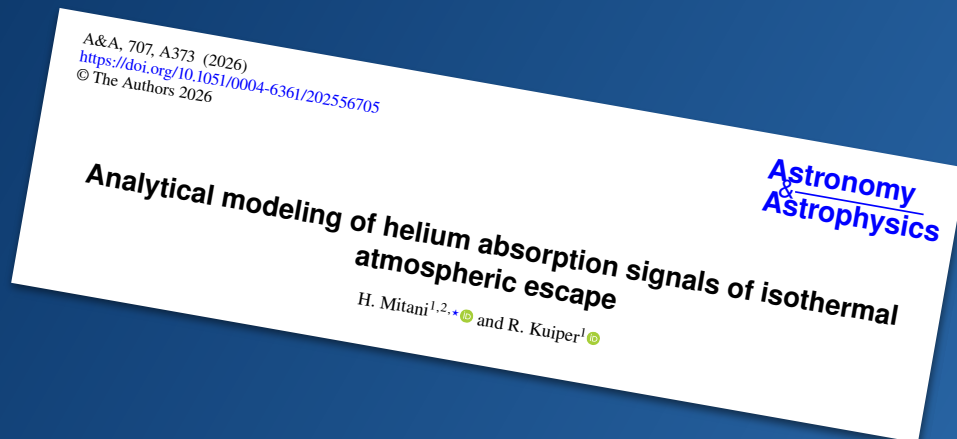
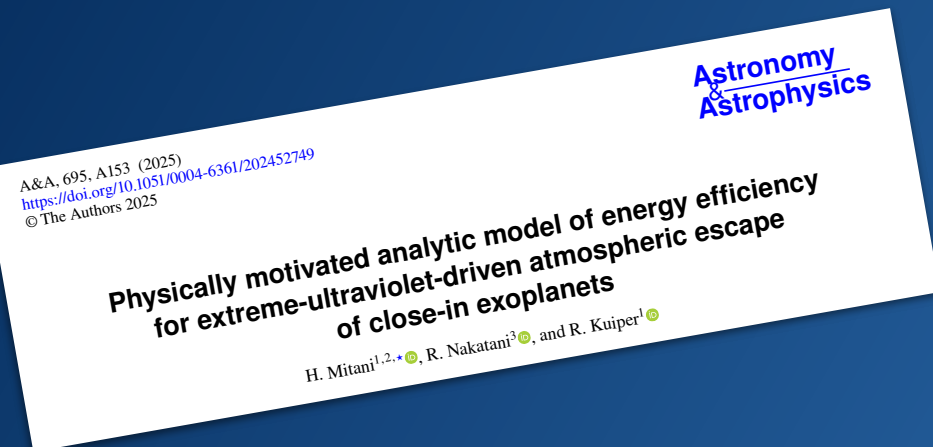
Trapped HII Regions



Martini et al. (2026)

Star - Disk/Planet Interaction

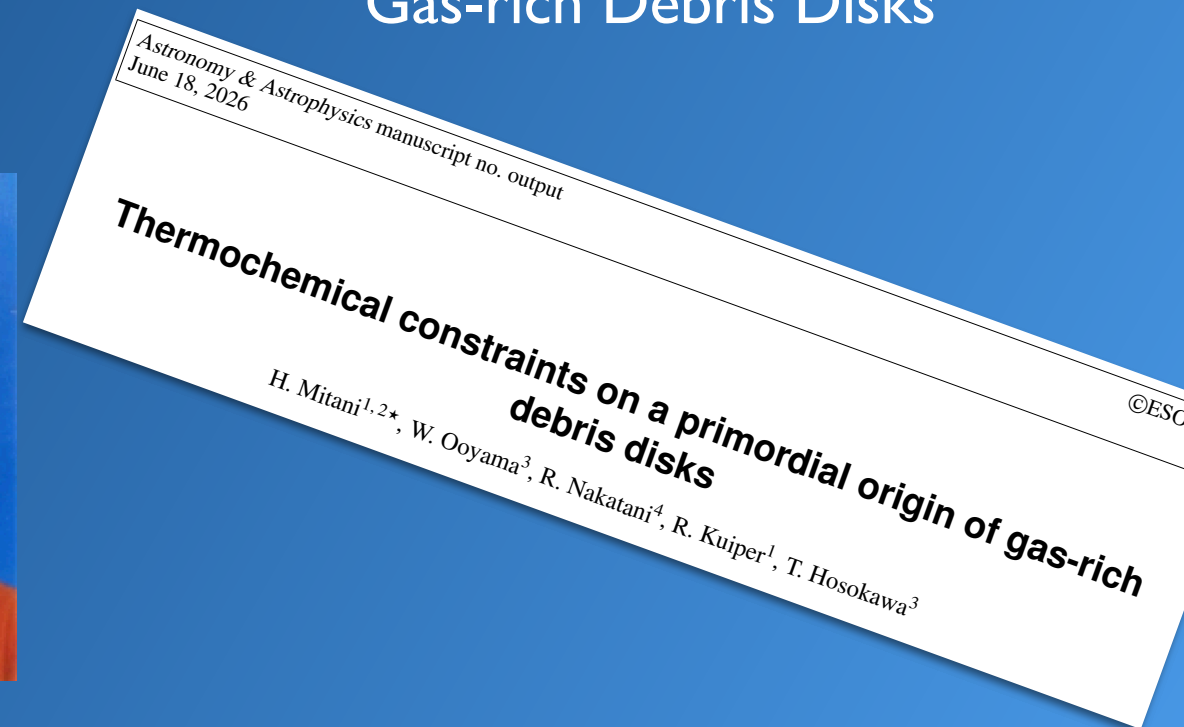
Planetary Atmospheric Escape



Hiroto Mitani
(JSPS Postdoc Fellow)

→ August 2026: Tohoku University!

Gas-rich Debris Disks



Everything you always wanted to know about accreting Gas Giants



Gabriel-Dominique Marleau
(Postdoc)

→ Talk on Thursday!

Special Thanks to the Team!

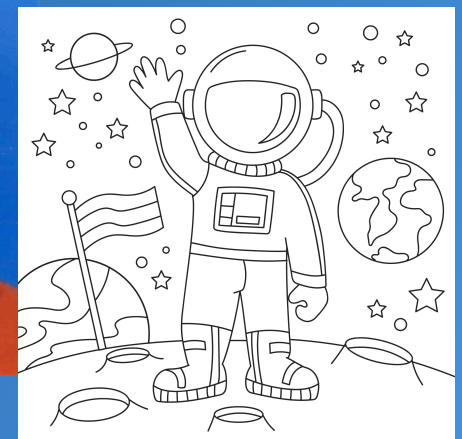
Staff



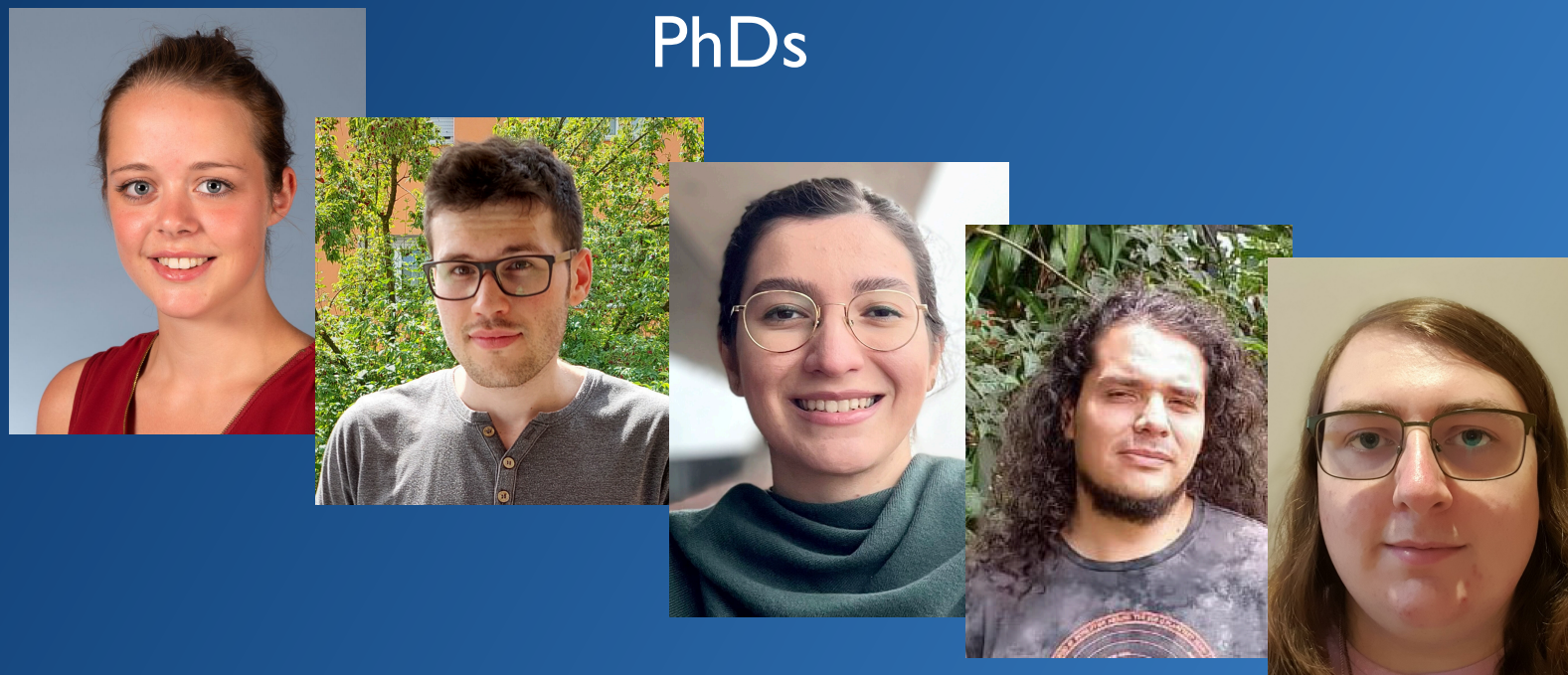
Postdocs



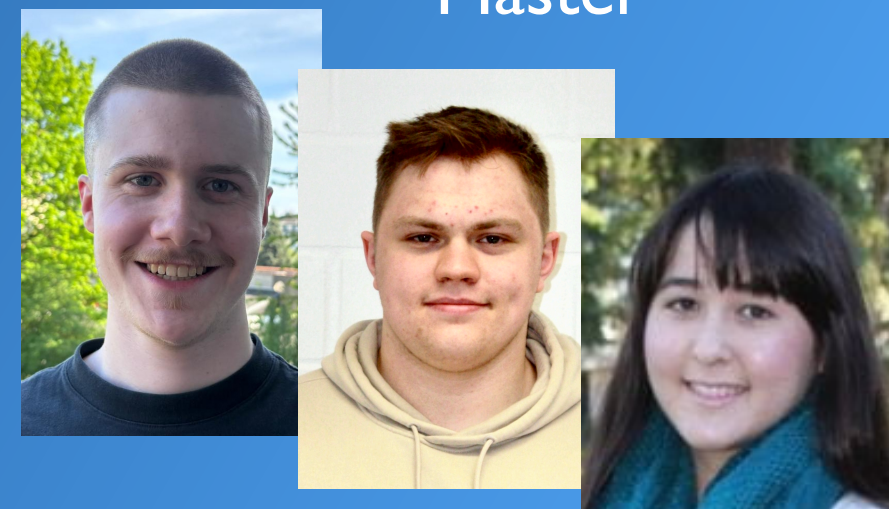
Hiring!



PhDs



Master



SPP Star Formation

Subscribe:

spp-sf-join@lists.uni-due.de

Jets from Massive Protostars

Moscadelli, ..., Oliva, & Kuiper (2022), NatAs 6
Moscadelli, Oliva, ..., & Kuiper (2023), A&A 680

- Very Long Baseline Interferometer (VLBI)
- Water Maser
- $\Delta x \sim 0.05$ au

Oliva & Kuiper (2023 a,b), A&A 669

- Radiation-Magneto-Hydrodynamics
- Including Ohmic Dissipation
- $\Delta x \sim 0.03$ au

- Direct Comparison of the Gas Dynamics of the Jet Launching Region!
 - Mass of the protostar
 - Disk size
 - Position of bow shock / jet's front
 - Position of collimation points along the jet
 - Helical structure and velocity of fast collimated flow
 - Structure and velocity of slower molecular flow at large scales
 - Magnetic field strength / polarization

Watching the w

