PLANET-FORMING DISKS AND ASTROCHEMISTRY GROUP

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More information and science on our group website

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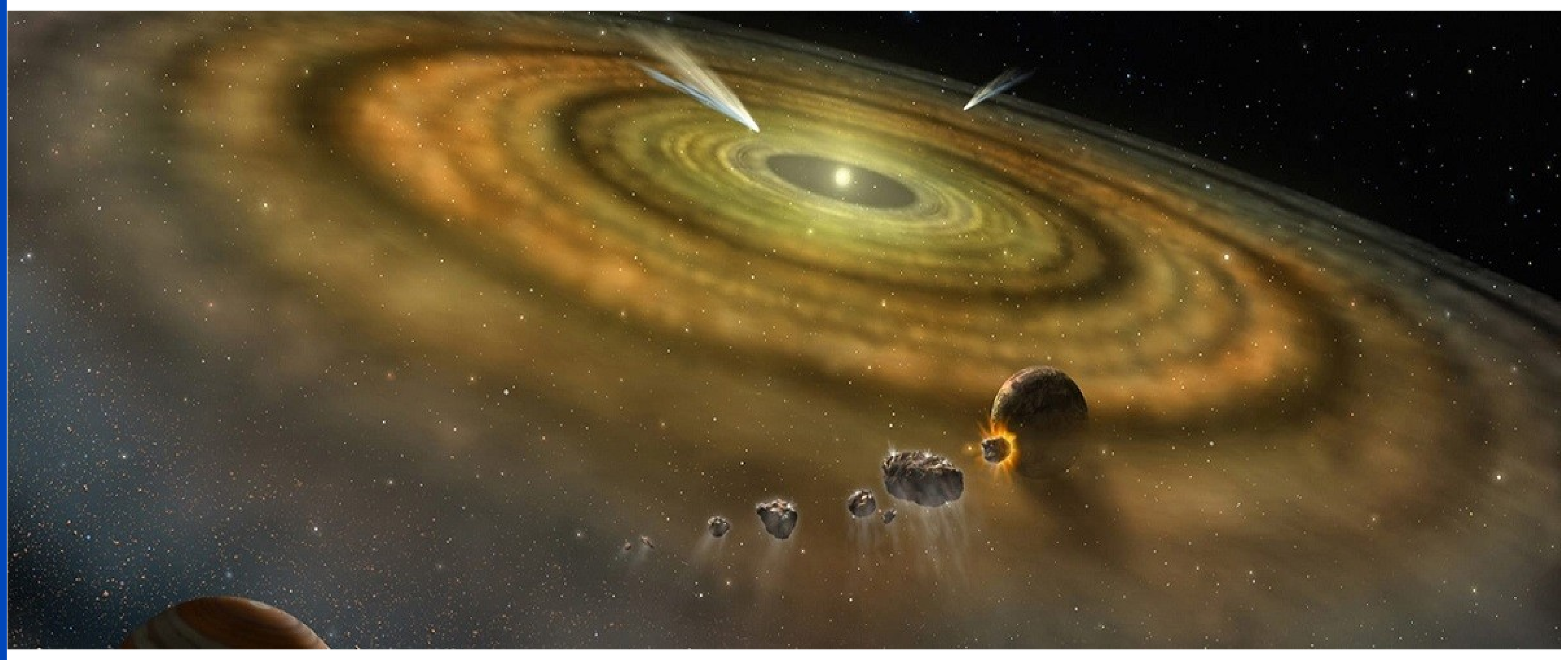
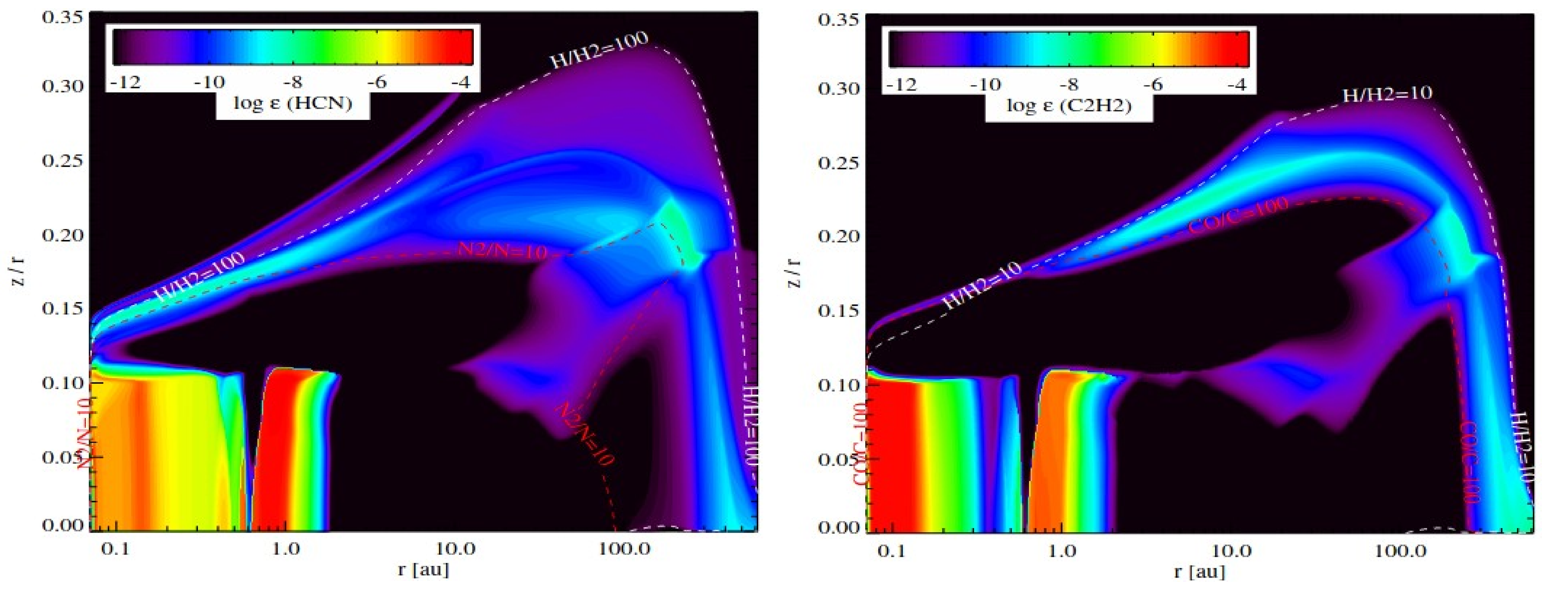
PLANET-FORMING DISKS

When molecular clouds collapse under their own gravity to form new stars, the leftover gas and dust will accumulate in these disks, and continue to rotate on nearly circular orbits around the new-born stars for a few million years. This environment sets the stage for planet formation.



ASTROCHEMISTRY

To understand the resulting numbers, sizes, and chemical composition of the resulting planets, we need to understand the physical and chemical evolution in these disks, prior and during planet formation. Our ProDiMo disc models predict the physical and chemical disk structure which are then used to predict multi-wavelength line and continuum observations.



ProDiMo models of two key molecules in protoplanetary disks (Woitke et al., 2023): HCN (hydrogen cyanide) and C2H2 (acetylene) in a 2D slice of a disk.

RESEARCH QUESTIONS

- What is the temperature and chemical structure in planet-forming disks?
- How do complex molecules and ice phases form in disks and evolve in time?
- What is the impact of the thermo-chemical structure on planet formation?
- What is the initial composition of the refractory materials that are formed during the earliest stages of disk evolution?
- How does the star-forming environment affect the evolution of a disk and its ability to form planets?
- How do disks evolve from the earliest protostellar phase, and how does the dust within them grow to form planets?

CURRENT TEAM AND PROJECTS @ IWF

Dr. Peter Woitke: group leader; main software developer of ProDiMo, astrochemistry

Thorsten Balduin: PhD candidate; charges and lightning in disks

Dr. Kundan Kadam: post-doc, disk hydro, dust evolution, planet formation

Till Käufer: PhD candidate; ML, Bayesian analysis, infrared molecular line emission

Dr. Sierk van Terwisga: postdoc, ALMA, disk environments and radiation chemistry

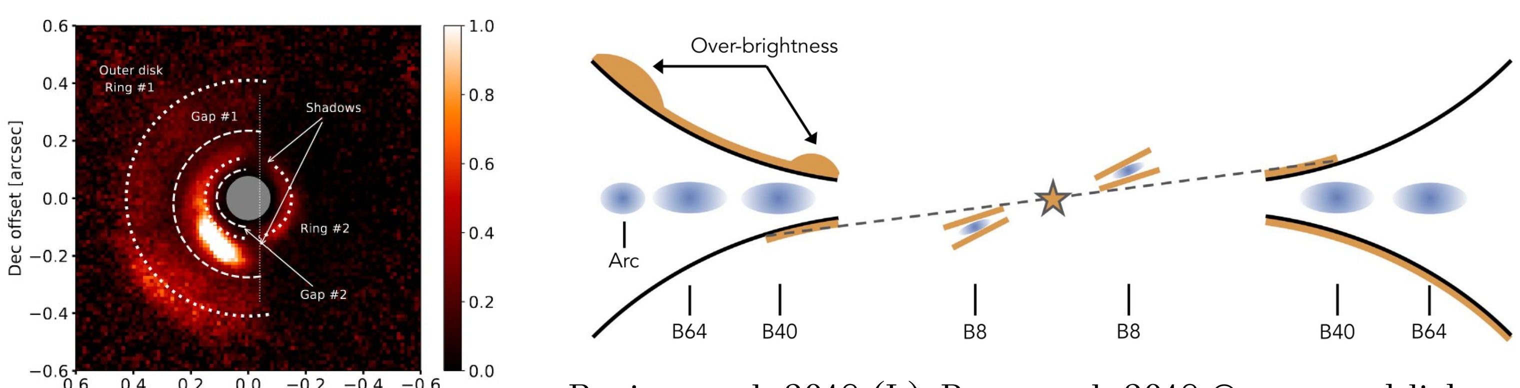
Elena Suslina: PhD candidate; edge-on disks: temperature and structure, ALMA

WHAT WE DO IN THE SHADOWS: SULFUR AND RADIATION-DRIVEN CHEMISTRY IN A WARPED DISK

Project summary:

Most protoplanetary disks are roughly azimuthally symmetric, but there are exceptions. The HD 143006 disk is a particularly extreme example. The outer (> 30 AU) disk is inclined relative to the inner disk, which causes half of it to be shadowed. This means we can use it as a chemistry laboratory: in half the disk surface, radiation from the star is important; in the other half, it is absent.

In this project, we compare our high-resolution observations of the CS molecule in HD 143006 to ProDiMo models. CS is the most commonly observed S-bearing molecule in disks. Sulfur is a key element for life and habitability, but its main reservoir in disks is not known and it shows puzzling asymmetries in other observations.



Benisty et al. 2018 (L), Perez et al. 2018 ®: scattered-light and schematic views of HD 143006

Requirements:

- Suitable for a MSc / BSc student in Physics and Astronomy
- Necessary knowledge:
- Basic physics, command line basics, programming (pref. Python), plotting (pref. Matplotlib)
- Knowledge of chemistry a bonus, but not required!

EFFECTS OF MHD DISK WINDS ON PLANETARY MIGRATION

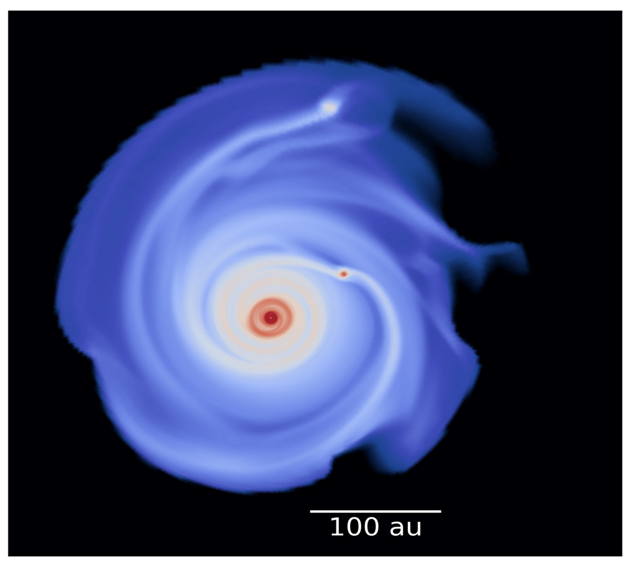
Project summary:

This project will focus on the effects of magnetohydrodynamic (MHD) disk winds on the migration of forming planets within a protoplanetary disk. When a forming planet interacts with its host disk, the planet migrates inwards and consequently also changes the disk morphology.

Recent evidence suggests that MHD disk winds dominate the accretion of matter onto the star, and the effect of disk winds on planetary migration have not yet been not well investigated. Initial studies indicate interesting effects, e.g., outward migration. We have a new global model of disk winds (Kadam et al. 2024, in prep) capable of evolving a protoplanetary disk over long (Myr) timescales. We will conduct hydrodynamic simulations of protoplanetary disks with planets and investigate the consequences of including the MHD winds, especially on the process of planetary migration.

Requirements:

- Suitable for Bachelor student in Physics and Astronomy
- Necessary knowledge:
- Basic physics, command line basics, programming (pref. Python), plotting (pref. Matplotlib)
- Knowledge of accretion disks a bonus, but not required



Kadam et al. 2016, MHD disk simulation with embedded planet