Spectroscopy of protoplanetary disks with JWST/MIRI

Inga Kamp

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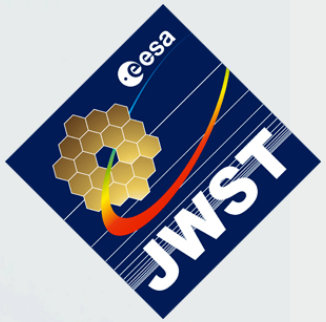
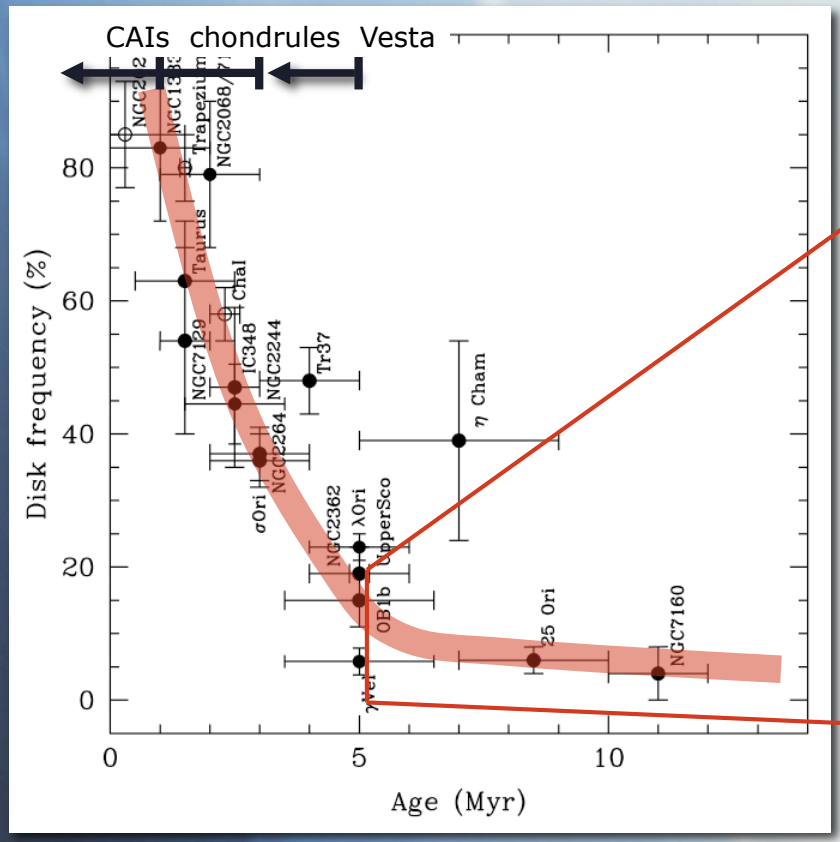
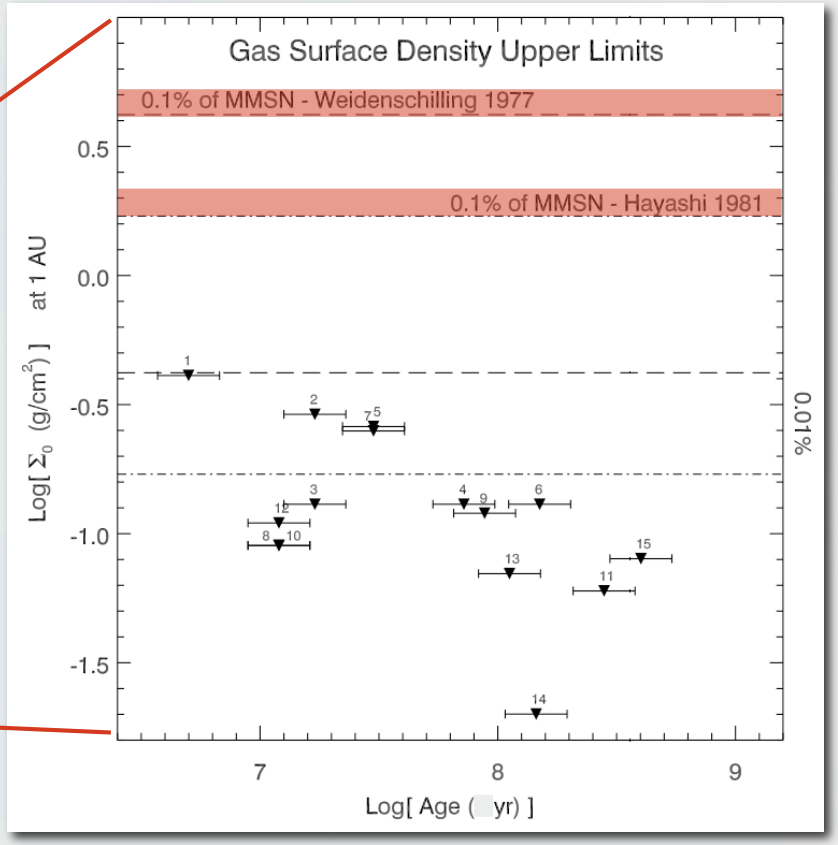


Protoplanetary disks - Exoplanets



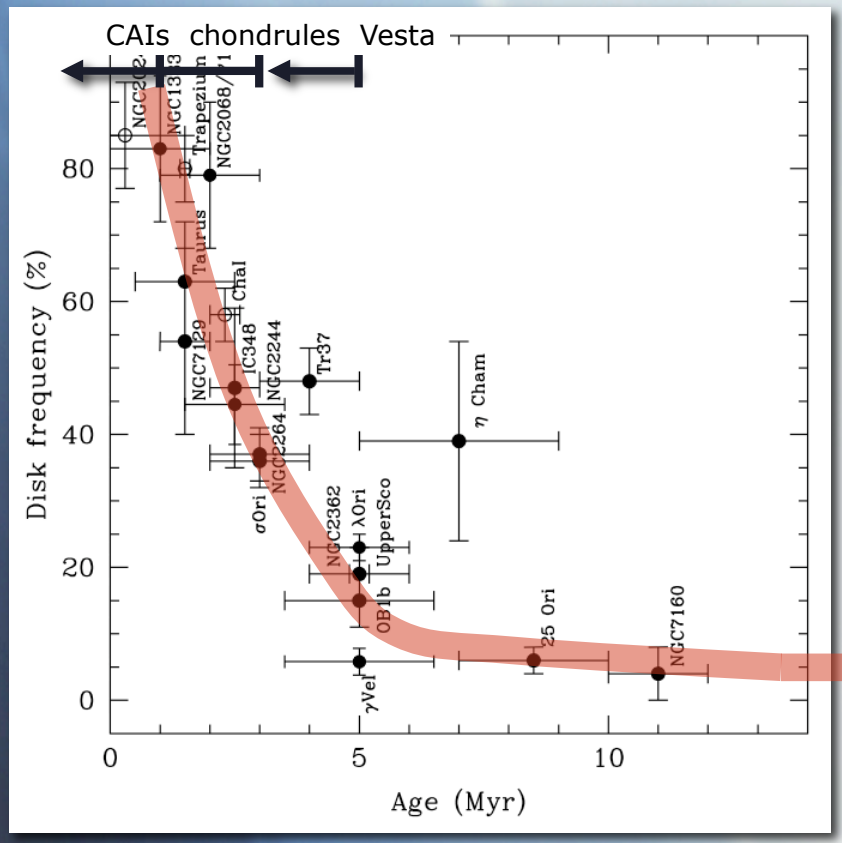
[Hernandez et al. 2008]



[Pascucci et al. 2009]

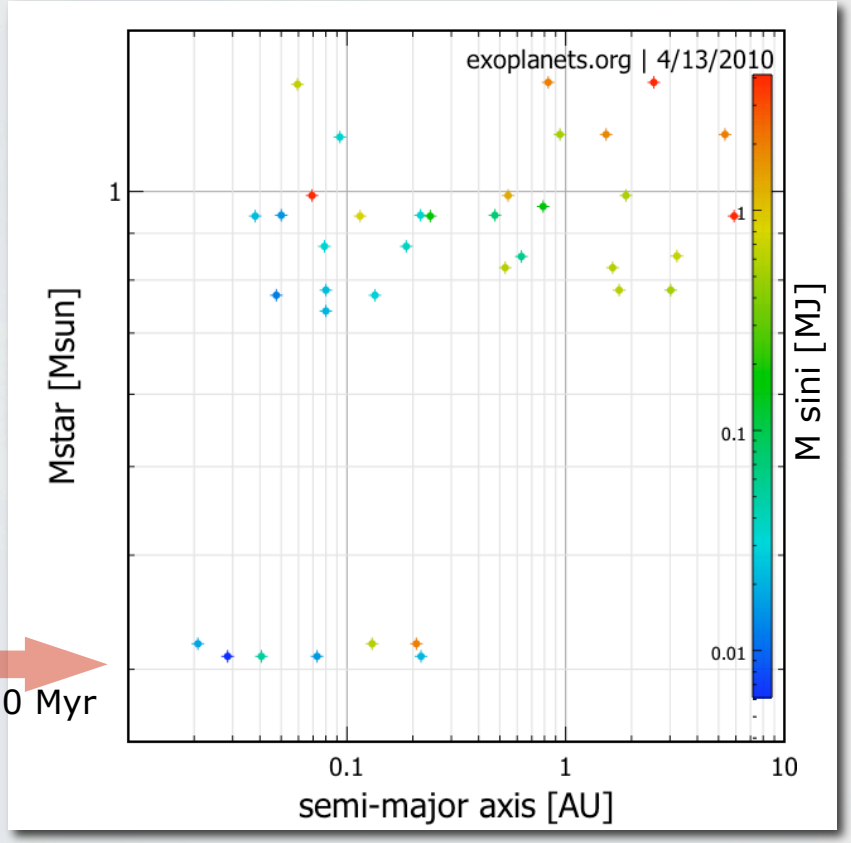
To which extent is the diversity of exoplanetary systems related to the initial conditions in the protoplanetary disks

Protoplanetary disks - Exoplanets



[Hernandez et al. 2008]

>few 100 Myr



[exoplanets.org 2010]

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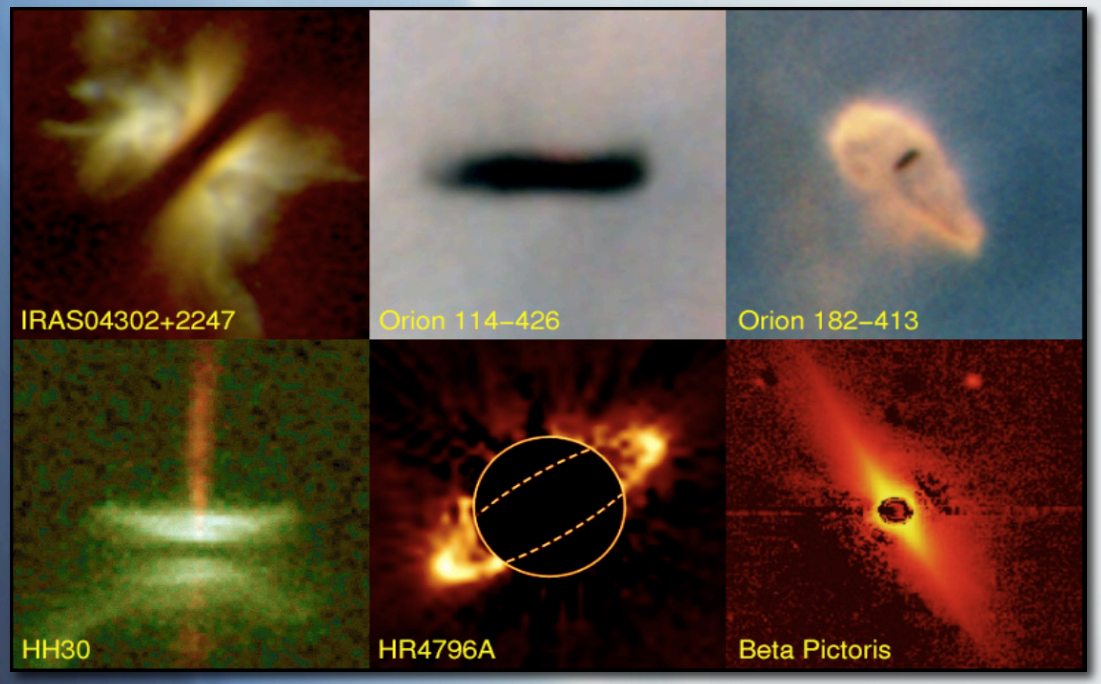
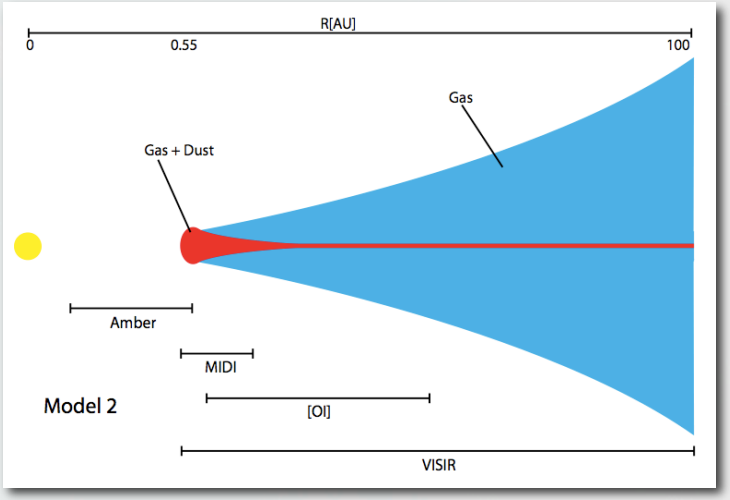
Structure of protoplanetary disks





[Fedele et al. 2008, Verhoeff et al. 2010]

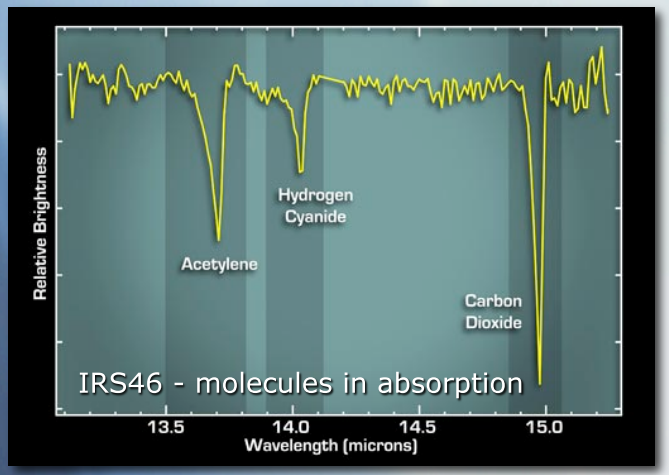
Spectroscopy as a key tool to reveal disk structure

- Probe vertical gas temperature gradients
- Coupling of gas and small dust in the "disk atmosphere" (PAHs, VSG)

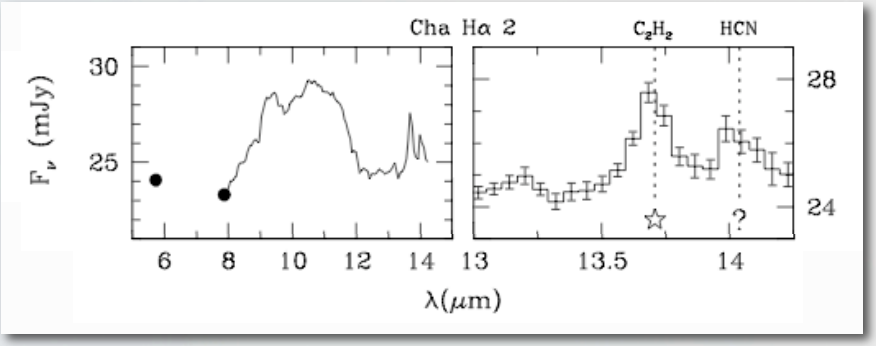
Current understanding strongly driven by Herbig disks

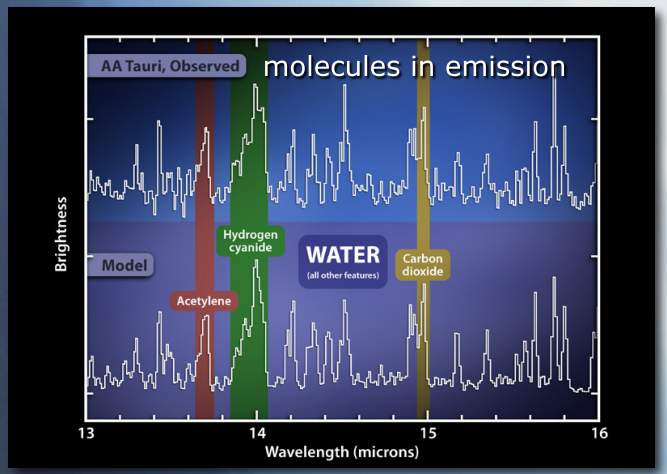
Disk chemical composition

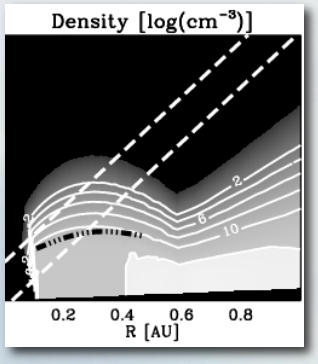
Rich organic chemistry (e.g. C_2H_2, HCN)
Water and oxygen bearing molecules (e.g. OH, H_2O)

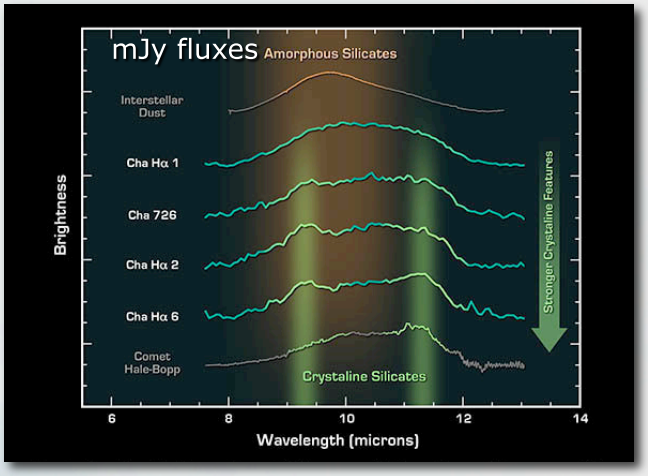


Faint BD disks - molecular lines & mineralogy



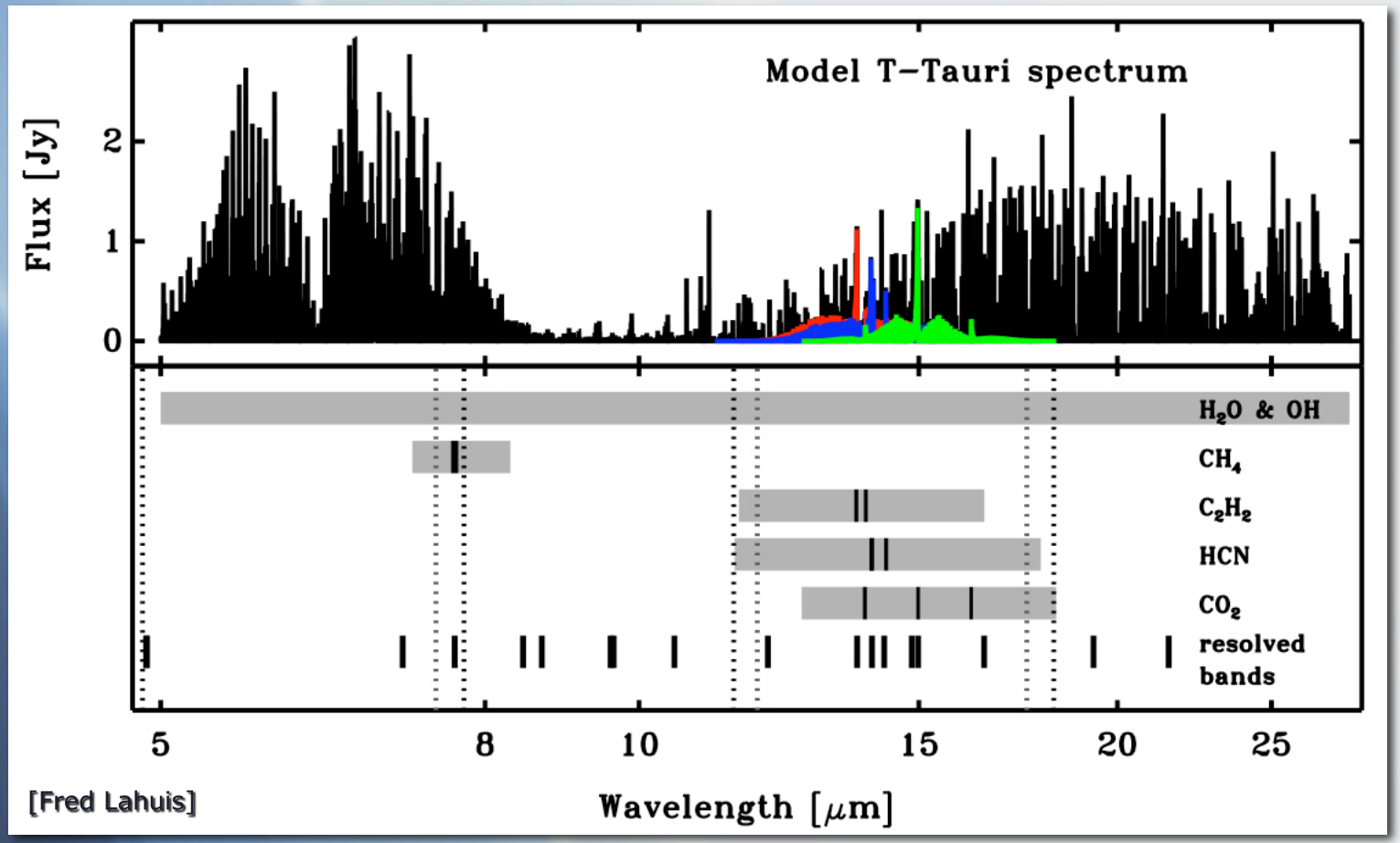






[e.g. Apai et al. 2005; Lahuis et al. 2007; Carr & Najita 2007; Pascucci et al. 2009]

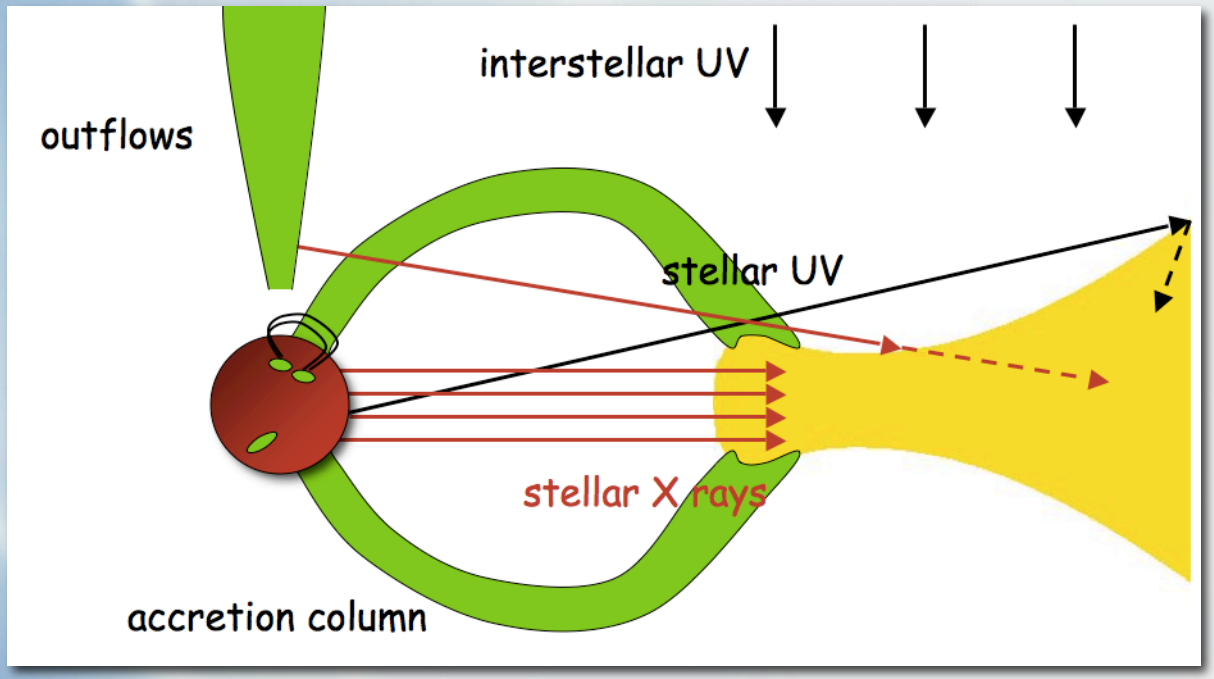
Uniqueness of MIRI



High spectral resolution, high sensitivity, continuous λ coverage:

- line-to-continuum ratio sufficient to detect minor species
- extent studies to faint brown dwarf disks (mJy @ 10μm)

Irradiated disks



Gas temperatures above few 100 K for mid-IR lines

→ only inner ~few AU of the disk (<0.1" @ 140pc)
in most cases not spatially resolved
exception: e.g. nearby transitional disks

ELT-METIS will spatially resolve the disks (no sensitivity gain)

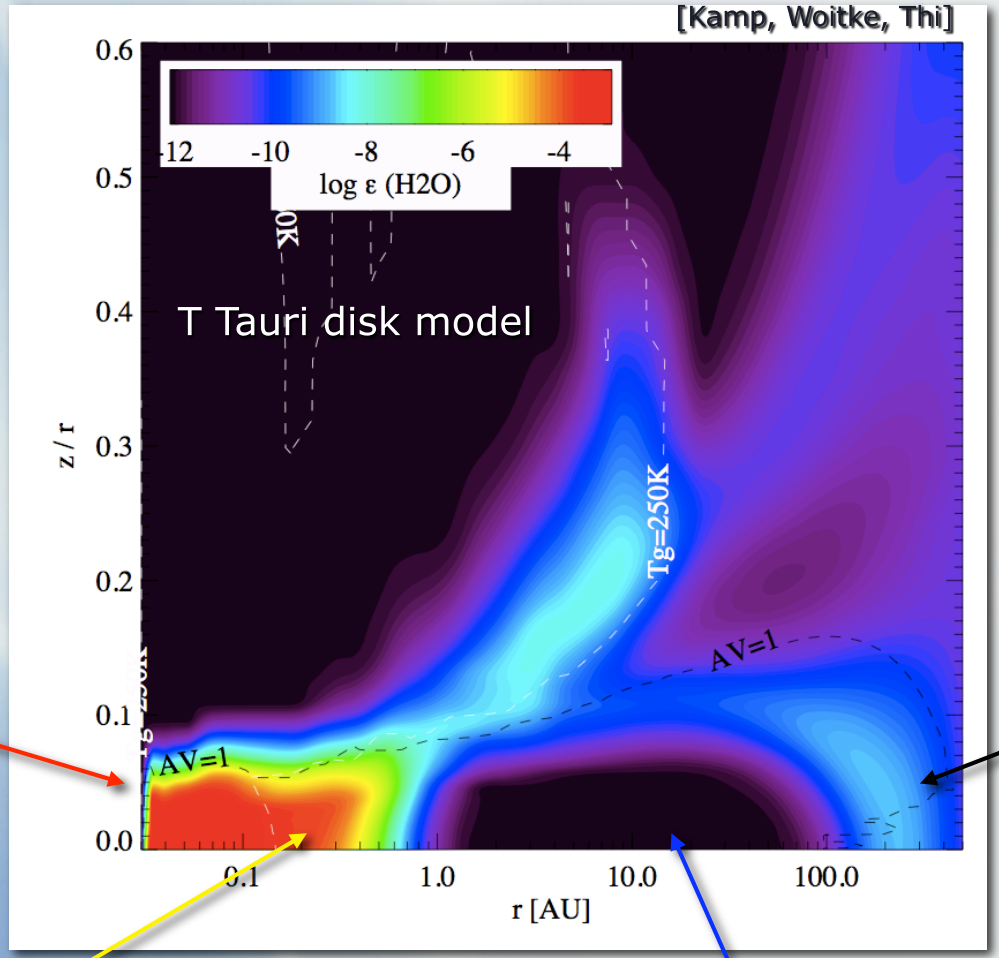
→ extend high resolution spectroscopy to N-band !

=> poster P1 (Brandl)

Protoplanetary disks

high densities ($n_{<H>} > 10^{13}$ cm^{-3}): all oxygen locked in gas phase water => carbon rich chemistry (CH_4)

long timescales !



low temperatures (T<20 K): all oxygen locked in CO ice (R > 100 AU)

warm temperatures (T > 150 K): oxygen locked in gas phase water AND CO (also CO_2 ring ~ 0.3 AU)

moderate temperatures (150 K < T < 20 K): all oxygen locked in water ice => carbon in CH_4 / CH_4 ice (40 K)

Proposed program

Full IFU Spectroscopy of disks:

- Selected targets from nearby SF regions (covering SpTypes)
- Selected targets from moving groups (few Myr - few 10 Myr)
- Small sample of Herbig disks

Immediate objectives:

- irradiation (OH, HCN)
- mixing and accretion flow (CH_4)
- vertical disk structure (NeII, O, H_2, …)
- ionization (HCO^+)
- identify the type of chemistry:

  photochemistry - e.g. OH, HCN
  neutral-neutral chemistry - e.g. H_2O
  carbon chemistry - e.g. C_6H_6 & CH_3OH
  nitrogen chemistry - e.g. NH_3)

Science goals:

- Link primordial disk structure to the diversity of planetary system architectures
- Understand what drives the chemical complexity and its implications for planet formation

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Thanks !