The chemistry and stability of the protoplanetary disk surface

Inga Kamp

In collaboration with:

Kees Dullemond (MPA)

Ewine van Dishoeck (Leiden)

Bastiaan Jonkheid (Leiden)

David Hardy, NASA
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Motivation

Protoplanetary disk in Orion

Debris disk
The basic model

- disk masses: $10^{-4} - 0.01 \, M_{\text{Sun}}$
- elemental abundances: molecular cloud abundances
- optical properties of dust grains: single 'mean' grain size
- dust temperature: radiative equilibrium
- gas-to-dust mass ratio: variable
- UV radiation fields: interstellar radiation field, photospheric radiation field, photosphere+chromosphere
Vertical density structure in a flaring T Tauri disk

[Dullemond et al. 2002]

UV radiation field of a T Tauri star

scaled solar chromosphere + IUE data + stellar atmosphere model

[Kamp & Sammar 2004]
The chemical structure

H$_2$ is chemically destroyed by O in the hot regions

H$_2$ + O $\rightarrow$ OH + H
OH + $\nu$ $\rightarrow$ O + H
The chemical structure

- warm $H_2$ present in disk surface layers (thermally excited, $T_{\text{ex}} \sim$ few 100 K)

- warm surface contains observable molecules such as e.g. CO, CH, OH
Gas and dust couple well above the superheated surface layer of the disk.
Gas and dust couple well above the superheated surface layer of the disk.
- Gas densities are high enough to couple H to the remaining species
- Disk surface evaporates inside of ~50 AU → verify with fully self-consistent disk models
Outlook: Disk structure models

- self-consistent stationary disk models

- comparison with observations by scanning through the disk with e.g. VISIR, IRAM, ALMA in the NIR to submm → feedback for the models
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- evaporation of the inner disk as a function of spectral-type of central star (include X-rays)
- compile heating/cooling tables for hydrodynamical modeling
The End