Witnessing Planet Formation in Circumstellar Transition Disks

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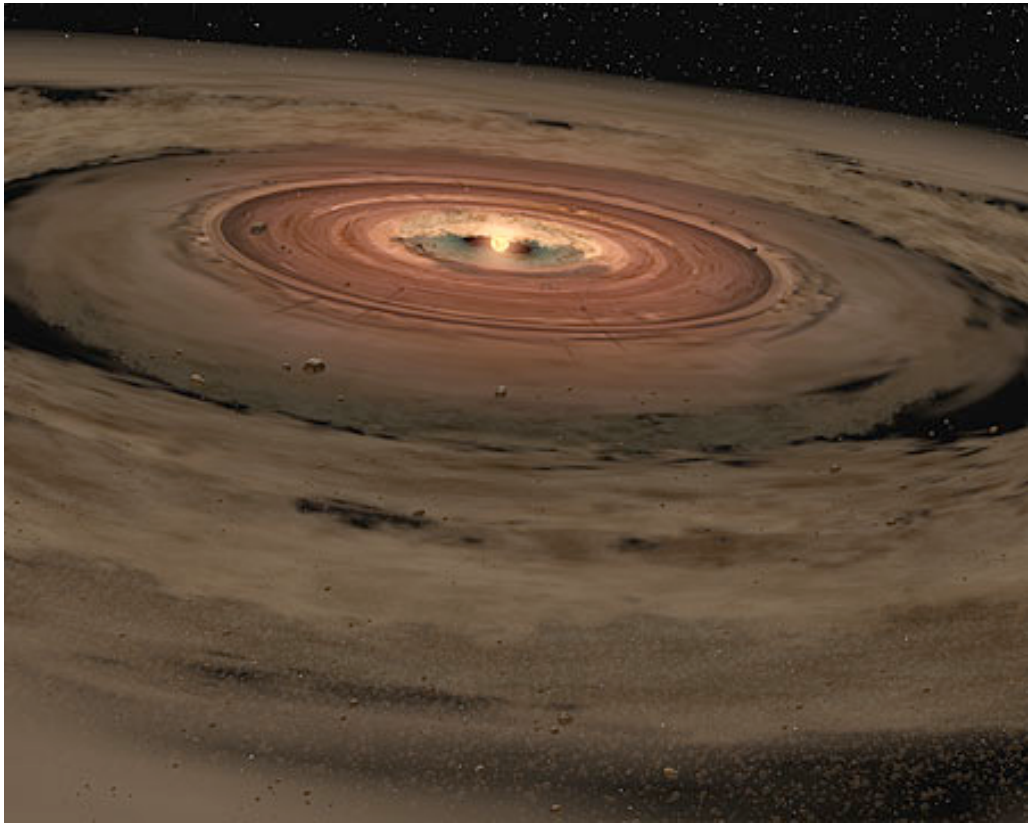


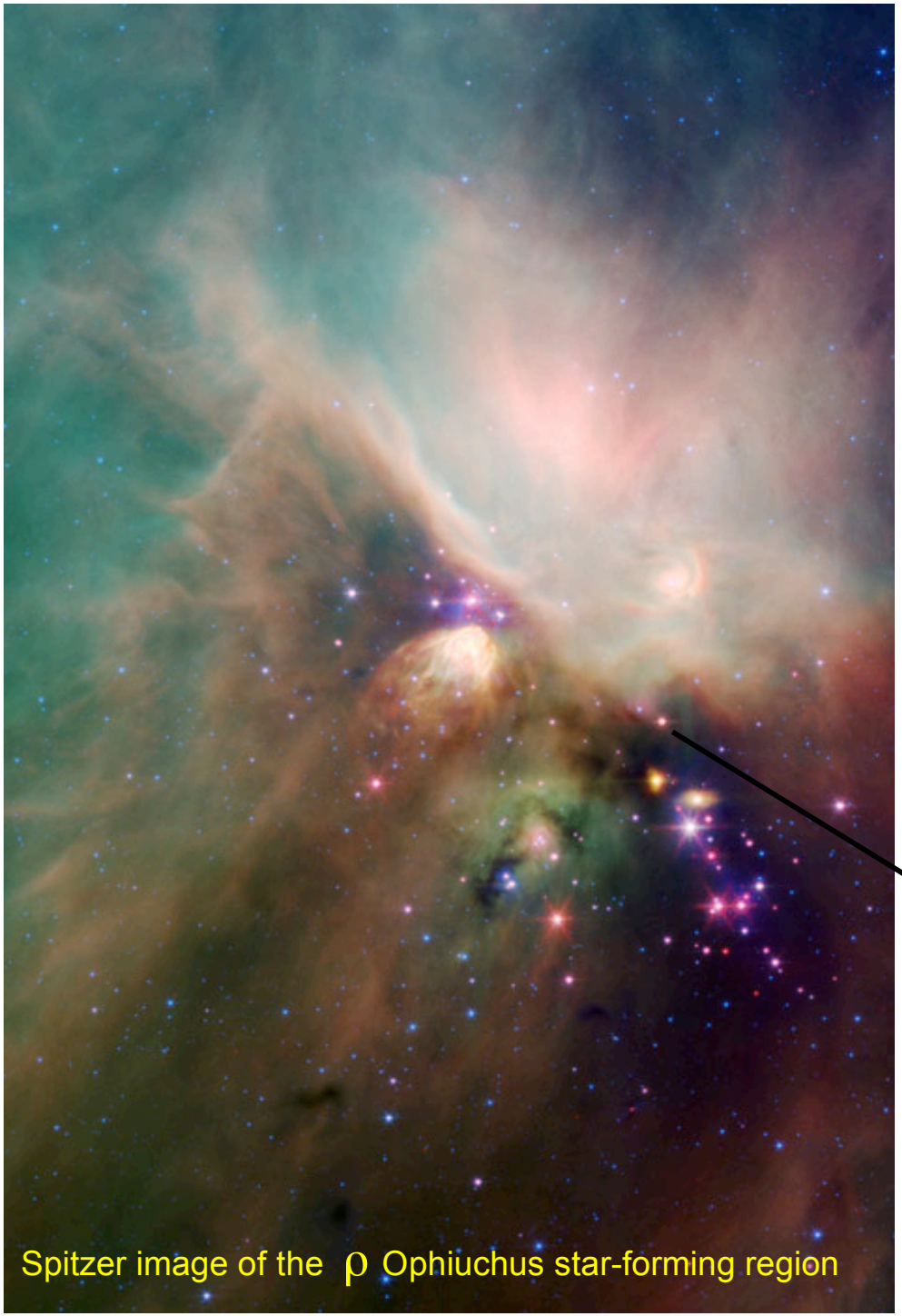
PROJECT SUMARY

• Multiwavelength study of circumstellar disks with evidence for ongoing planet formation, the so called “transition” disks.

• Plan to perform infrared spectroscopy with Herschel and Keck to constrain the mass, density, and temperature of the gas in the planet-forming regions of the disk.

• Plan to obtain high resolution images of transition disks with the SMA and eventually ALMA.

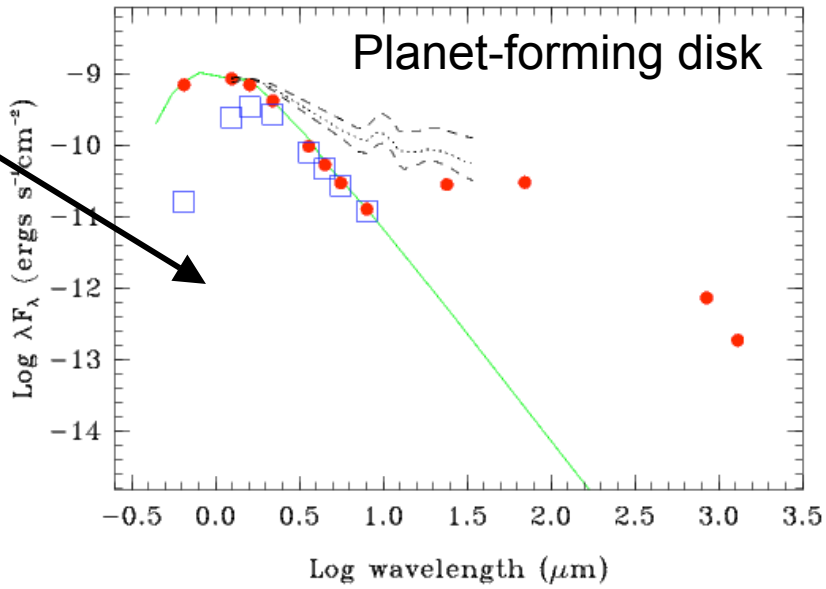
• Overall goal is to better constrain the conditions in which planets are formed and help to distinguish between competing planet formation theories.



Spitzer image of the ρ Ophiuchus star-forming region

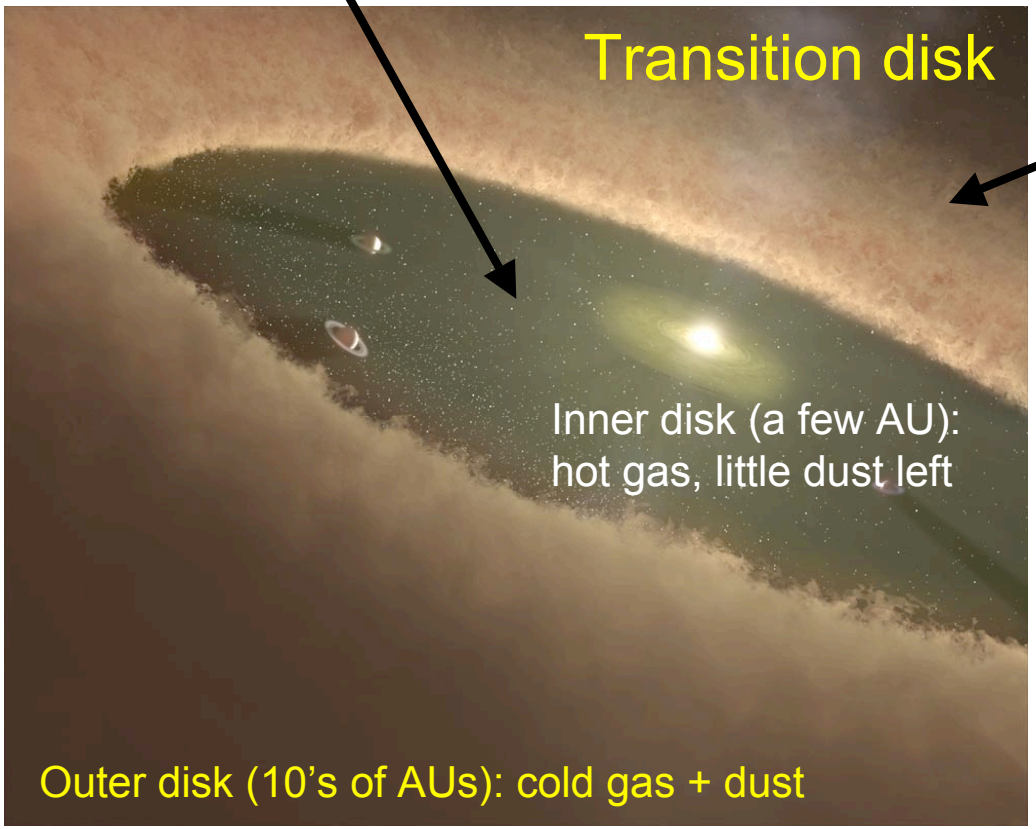
Sample selection:

- Spitzer-selected circumstellar disks with little or no near-IR excess, but strong mid- and far-IR excesses (i.e., disks with sharp, *dynamically* carved, inner opacity holes)
- They appear to be single stars (i.e., the inner hole is not produced by a stellar companion)
- They are accreting objects (i.e., there is still some gas flowing through the inner disk)
- They have relatively massive (> $M_{Jupiter}$) disks (i.e., there is still enough mass in the disk to form giant planets)



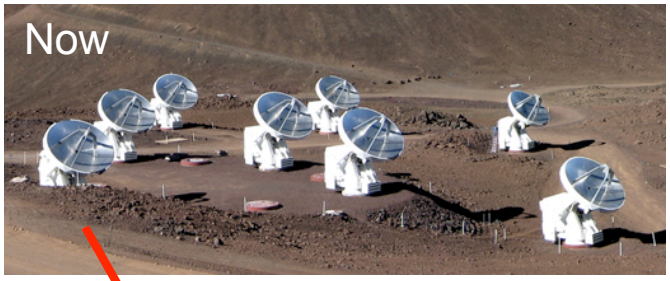
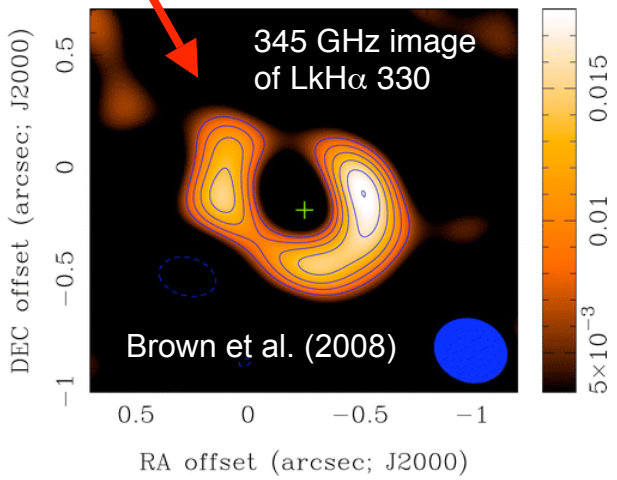
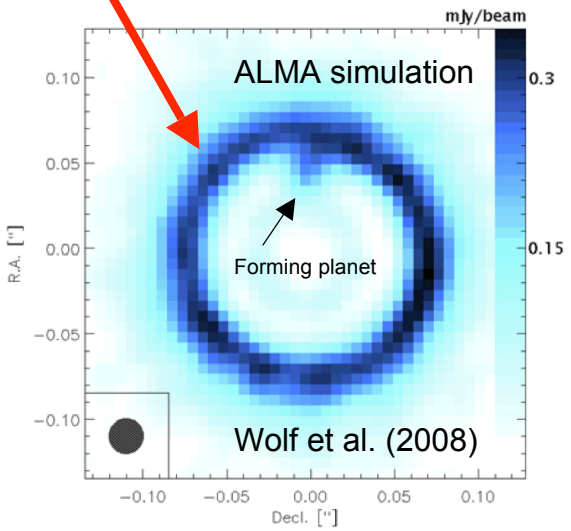
Planed observations: Infrared spectroscopy with Herschel and Keck

Will use NIRSPEC on Keck to perform M-band observations of rovibrational transitions of CO in order to constrain the mass, density, and temperature of the gas within the inner opacity hole (the forming region of rocky planets).



Will use the PACS spectrograph on Herschel to observe [CII] and [OI] fine structure lines in the far-IR in order to constrain the mass, density, and temperature of the gas in the outer disk (the forming region of giant planets)

Planed observations: Submillimeter imaging with the SMA and ALMA

The **SMA** (eight 6-m antennas): with a 0.3'' resolution can resolve the inner holes of transition disks. The SMA can constrain the size and sharpness of the inner hole and estimate the surface density profile of the disk.

ALMA (fifty 12-m antennas): will image disks at a 0.02'' resolution in the continuum and using molecular tracers. Will constrain grain size distribution as function of radius and measure gas turbulence. ALMA Will provide the first direct detection of forming planets.