STELLAR-MASS-DEPENDENT EVOLUTION OF PLANET FORMING DISKS. I. Pascucci[1] and D. Apai[1,2]. [1]Lunar and Planetary Laboratory, The University of Arizona. Email: pascucci@lpl.arizona.edu. [2]Steward Observatory, The University of Arizona

Introduction: Cool M dwarfs outnumber sun-like G stars by ten to one in the solar neighborhood. Due to their proximity, small size, and low mass, M-dwarf stars are becoming attractive targets for exoplanet searches via almost all current search methods. But what planetary systems can form around M dwarfs? And how will the conditions for planet formation differ around these stars from those around sun-like stars?

Here we review the key results of multiple analysis of space- and ground-based data we carried out over the past few years. We show that there is a statistically significant difference between the disk structure, dust properties, and gas-phase organics between two large sample of coeval disks around very low-mass stars/ brown dwarfs and sun-like stars. We discuss the implications of these differences for the formation of giant and terrestrial planets.

Methods: We targeted large samples of coeval very low-mass stars/brown dwarfs and sun-like stars with the Spitzer Space Telescope and with ground-based infrared and submillimeter telescopes. To increase our samples we also analyzed archival and/or published data. We modeled spectral energy distributions using continuum radiative transfer codes to constrain the flaring of protoplanetary disks; we identified the major dust components contributing to the 10 micron silicate emission feature and quantified the amount of crystalline versus amorphous grains; we modeled emission features from organic molecules to measure relative abundances. We used statistical tests to verify if the properties studied differ between the groups of very low-mass stars/brown dwarfs and sun-like stars.

Results: We identified statistically significant differences in several key disk properties:

– Disk structure. We show that disks around very low-mass stars/brown dwarfs are flatter than those around coeval sun-like stars [1,2,3]. The flatter disk structure is consistent with a more advanced stage of dust settling around these lower mass objects, an important step toward planet formation.

– Dust properties. Coeval very low-mass stars/brown dwarfs harbor dust grains which are larger on average than grains in the disk atmosphere of sun-like stars [1,4,5]. In addition, spectra of very low-mass stars/ brown dwarfs present more prominent crystalline silicate features than those of disks around sun-like stars (Fig. 1). Spectral decomposition models suggest that the terrestrial planet-forming disk regions around very low-mass stars/brown dwarfs contain a higher abundance of thermally processed material than those around sun-like stars [1,4].

– Disk mass. Comparing disk masses measured for the lowest-mass objects to those for sun-like stars, we show that the disk mass scales approximately linearly with the stellar mass [6].

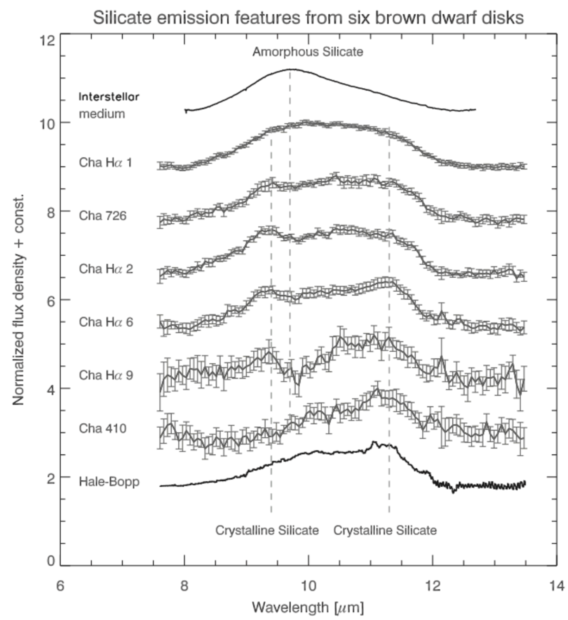

Figure 1: Continuum-subtracted and normalized silicate emission features for a subset of brown dwarf disks [1,4]. For comparison, the spectra of the amorphous silicate-dominated interstellar medium and the crystalline-rich comet Hale-Bopp are also shown.

– Organics. We report the first detections of organic molecules in disks around brown dwarfs. The detection rate statistics and the line flux ratios of simple, gas-phase organics show a striking difference between the samples of very low-mass stars/brown dwarfs and sun-like stars [4,7], see also Fig. 2. This difference is consistent with different stellar UV irradiation of the disk surface and hint to N-depleted chemistry around brown dwarfs.

Discussion: It is generally assumed that disks around lower mass stars are a scaled-down version of disks around more massive stars and that the organic compounds of the protosolar nebula are representative to all protoplanetary disks. The results presented here demonstrate that these assumptions do not hold in reality and disk evolution is stellar-mass-dependent. We discuss how the differences in disk properties are expected to influence the formation and bulk composition of planets [3]. In particular, a lower frequency of giant planets around low-mass stars is expected. In addition, we suggest that planets around lower-mass stars will have a different inventory of organic molecules with key ingredients to life possibly reduced in abundance. All in all these results suggest that planetary systems around very low-mass stars/brown dwarfs may be more different from those around sun-like stars than usually thought.

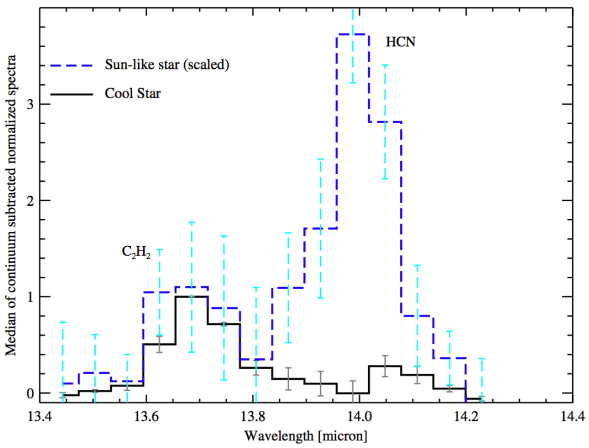

Figure 2: Median of continuum-subtracted and normalized spectra for the sun-like star (blue) and the very low-mass/brown dwarf star (black) samples [4]. The spectra are normalized to the peak of emission and scaled to match the C_2H_2 emission in the two samples. If cool stars had the same flux ratio of HCN vs. C_2H_2 as the sun-like stars do, HCN emission would have been easily detected toward them.

References: [1] Apai, D., Pascucci, I. et al. 2005 *Science* 310, 834. [2] Szucs, L. et al. 2010, *The Astrophysical Journal* 720, 1668. [3] Pascucci, I. et al. 2011, Cool Stars 16 (arXiv:1101.1913). [4] Pascucci, I. et al. 2009, *The Astrophysical Journal* 696, 143. [5] Apai, D. et al. 2004 *Astronomy & Astrophysics* 426, L53. [6] Klein, R. et al. 2003 *The Astrophysical Journal* 593, 57. [7] Pascucci, I. et al. in prep.