Probing Sub-AU Radii of Protoplanetary Disks with NIR Interferometry

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The structure of protoplanetary disks, and in particular the regions within 1 AU of the central star, has important implications for disk accretion and planet formation. We have observed a sample of T Tauri and Herbig Ae/Be stars with the Keck and Palomar Testbed Interferometers, supplemented by echelle spectroscopy and optical through near-IR photometry (Eisner et al. 2003, 2004, 2005). With these data, we constrain the geometries and temperatures of inner circumstellar dust disks on spatial scales of ~ 0.1-1 AU, and compare our measurements with the predictions of physical disk models.

Our observations show that the inner disks in our sample are truncated within a fraction of an AU of the central star, and that the inner disk edges are not geometrically thin, but probably "puffed up" (Figure 1), as expected for a directly-illuminated wall in hydrostatic equilibrium (Dullemond, Dominik, & Natta 2001). Since these truncation radii are smaller than 1 AU, there appears to be dusty material in the terrestrial region, as needed for planet formation. The inferred disk temperatures at 1 AU ($\gtrsim$ 200 K) are too high for the existence of water ice (e.g, Hayashi 1981), perhaps suggesting that the "late-veneer" hypothesis for the cometary or asteroidal origin of Earth's water (e.g., Morbidelli et al. 2000) may apply to other systems as well. However, we have not yet considered the effects of shadowing by the puffed-up inner rim, which may lead to somewhat lower disk temperatures, and

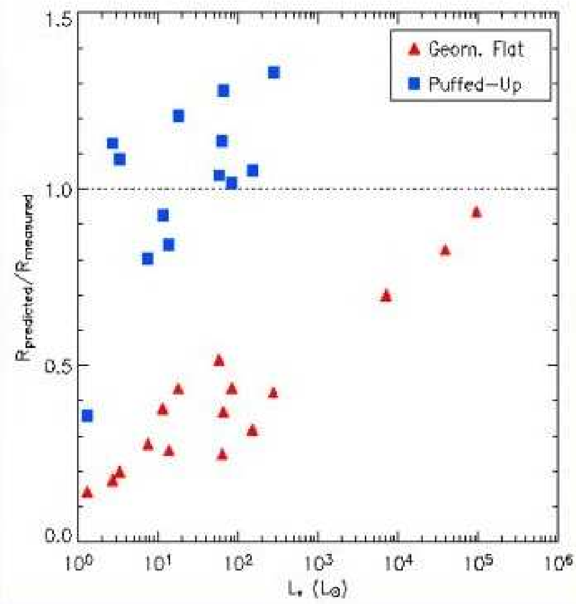

Fig. 1.— Ratio of predicted to measured sizes of inner disks in our sample for both geometrically thin and puffed-up geometries.

perhaps a snowline near 1 AU.

Our measured inner disk truncation radii are typically larger than those expected for magnetospheric accretion models (e.g., Königl 1991; Shu et al. 1994), providing evidence that gaseous disk material may extend further in toward the star than dust: while the gaseous component may be truncated close to the star by magnetic forces, the dusty disk material is probably destroyed by dust sublimation at larger radii. The measured dust truncation radii are also larger than expected based on the semi-major axis distribution of "hot-Jupiters" (e.g., Udry, Mayor, & Santos 2003), assuming that the pile-up

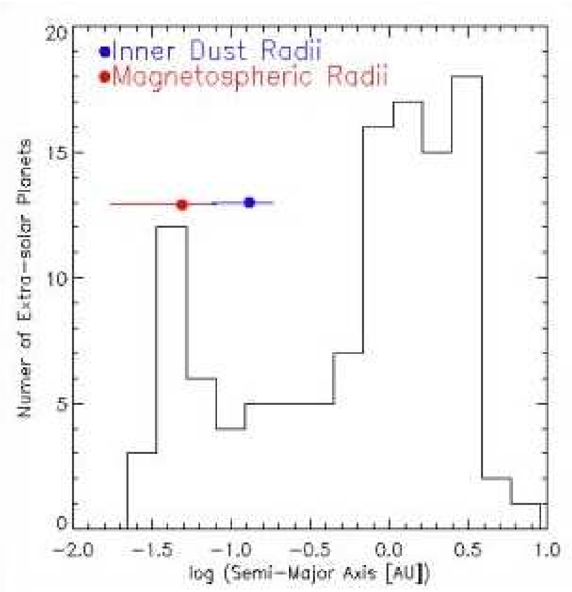

Fig. 2.— Comparison of the semi-major axis distribution of extra-solar planets (histogram) with the 2:1 resonances of inferred dust and gas disk truncation radii (blue and red points, respectively).

of these short-period planets arises from the halting of orbital migration in 2:1 resonances with the inner disk (Kuchner & Lecar 2002). However, predicted gaseous truncation radii agree reasonably well with the extra-solar planet semi-major axes, implying that orbital migration is more likely halted in resonances with the *gaseous* component of protoplanetary disks, as suggested by Lin, Bodenheimer, & Richardson (1996).

In addition to constraining the truncation radii of inner disks, our interferometric observations also enable determination of the disk inclinations and position angles in some cases. For objects with sufficient data to determine these geometric parameters, we find that the inner disks in our sample are typically inclined by $\sim 10-60°$. Moreover, the derived inner disk inclinations are consistent with outer disk geometries inferred from millimeter interferometric observations (where available; e.g., Mannings, Koerner, & Sargent 1997; Corder, Eisner, & Sargent 2005), suggesting that the disks around young stars are not substantially warped.

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