Grain Growth and Global Structure of the Protoplanetary Disk Associated with the Mature Classical T Tauri Star, PDS 66

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Abstract. We present ATCA interferometric observations of the old (13 Myr), nearby (86 pc) classical T Tauri star (CTTs), PDS 66. Unresolved 3 and 12 mm continuum emission is detected towards PDS 66, and upper limits are derived for the 3 and 6 cm flux densities. The mm data show a spectral slope flatter than that expected for ISM-sized dust particles, which is most likely a result of grain growth. We also present *HST*/NICMOS 1.1 μm PSF-subtracted coronagraphic imaging observations of PDS 66. The *HST* observations reveal a circumstellar region of dust scattering ~0.32% of the central starlight, declining in surface brightness as $r^{-4.53}$. The disk is inclined 32±5° from face-on, and extends to a radius of 170 AU. These data are combined with published optical and longer-λ observations to make qualitative comparisons between the median Taurus and PDS 66 spectral energy distributions (SEDs). By comparing the near-infrared emission to a simple model, we det ermine that the location of the inner disk radius is consistent with being at dust sublimation (~1400 K at 0.1 AU). We place constraints on the mass surface density of the disk at 5 AU assuming a flat-disk model and find that it is probably too low to form gas giant planets according to current models. Despite the fact that PDS 66 is much older than a typical classical T Tauri star (≤5 Myr), its physical properties are not much different.

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INTRODUCTION

PDS 66 is a Classical T Tauri star (CTTs) in Lower Centaurus Crux, a subgroup of the Sco Cen OB association [3]. The median age for CTTs is 3 Myr, yet PDS 66 is still actively accreting at an age of 13 Myr [2]. Such an evolved star with a spectral energy distribution (SED) characteristic of an optically thick disk [4] makes an interesting laboratory for studying the structure. The near-infrared (NIR) provides information about the inner edge of the disk, the mid- to far-infrared emission is a probe of the flared geometry, the slope of the mm-spectrum is a diagnostic of the maximum grain size, and the disk mass can be constrained from the mm-fluxes.

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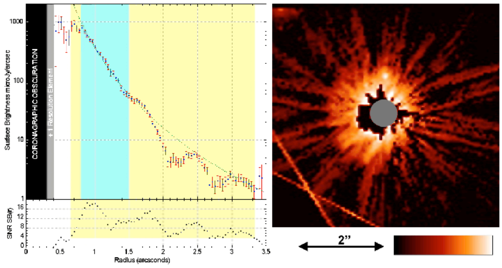

FIGURE 1. NIR-scattered light data at 1.1 μm (*Right*), and surface brightness profile (*Left*). Reproduced by permission of the AAS

DISK PROPERTIES OF PDS 66

We present NIR-scattered light data at 1.1 μm obtained with Hubble Space Telescope's Near-Infrared Camera and Multi-object Spectrograph (*HST*/NICMOS). Figure 1 shows the plot of the surface brightness profile medianed over the disk, which is robustly detected out to a radius of 1.5″ (130 AU). Lower surface brightness scattered light is detected out to 2″ (170 AU). The right image of Figure 1 is the 7.5x7.5″ field towards PDS 66. Based on the apparent major-to-minor axis ratio, we estimate an inclination of 32±5°. We estimate the 1.1 μm flux density of the disk (from $0.41 \leq r \leq 3.5''$) as 2.7±0.4 mJy, scattering 0.32% of the starlight.

At long-λ, the emission from a blackbody goes as ν^2, and if the disk material is optically thin, the flux is also proportional to the mass opacity: $\kappa_\nu \propto \nu^\beta$. Therefore, $F_\nu \propto \nu^{2+\beta}$, and we can derive β directly from the observed slope. For grain sizes $<< \lambda$ (ISM-like grains), $\beta \sim 2$; and for grain sizes $>> \lambda$ (blackbody), $\beta \sim 0$. We measure a slope of -2.4, so $\beta = 0.4$, indicating grain growth from the initial ISM grains. If we correct for optically thick emission [1], using values for the temperature and density power-laws that maximize the correction, we require $\beta_{corr} \leq 0.5$. There was no detection at 3/6 cm, so we conclude that stellar winds are insignificant at these wavelengths.

For a more detailed description of our analysis and conclusions about the circumstellar disk around PDS 66, see our paper in *T*he Astrophysical Journal.

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