

IN SEARCH OF THE “MISSING MASS”: MEASURING PROTOPLANETARY DISK DUST MASSES WITH ALMA

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Protoplanetary disks are an essential component of the planet formation process. The number and size of planets in a system are directly constrained by the amount of dust and gas in the disk. We present disk dust masses (M_{dust}) measured using spectral energy distribution (SED) modeling of 15 disks around T Tauri stars (TTS) in the Serpens star-forming region, using ALMA 1.33mm fluxes from the literature. Calculated M_{dust} are a factor of ~ 1.5 higher than those reported in the literature. Most works assume the disk to be optically thin at all mm wavelengths whereas our modeling finds that disks may be partially optically thick at these ranges. Our results show that disks around Serpens TTS may not have enough material to form planetary systems and do not completely alleviate the “missing” mass problem, known as the reported discrepancy between the available mass in protoplanetary disks and the observable mass in exoplanet systems.

We calculated disk M_{dust} for a sample of 15 TTS located in the Serpens star-forming region using multi-wavelength photometry and Spitzer IRS spectra, and by modeling their SEDs following Ribas (2020). The sample was obtained from an ALMA band 6 survey of Serpens (Anderson 2022). The aim is to compare SED-derived M_{dust} (that account for the effect of optical depth) with mm-flux-derived measurements. The key findings of this work are as follows: [1] SED-derived M_{dust} are ~ 1.5 times higher than literature values (see Figure 1); [2] The sample has a greater median M_{dust} than the populations shared average of 11 star-forming regions (0.5-10 Myr Rillinger 2023); [3] M_{dust} depletion is low, characteristic of younger regions (1-3 Myr) and follows $M_{\text{dust}} \propto t^{-1}$; [4] Serpens’ class II objects do not have enough material in their disks to solve the

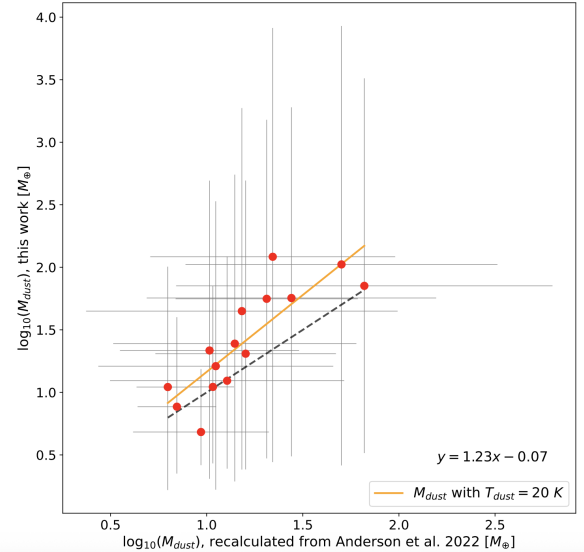


Fig. 1. SED-derived M_{dust} vs literature M_{dust} (Anderson et al. 2022). The panel displays a linear fit (solid orange line) to the comparison to dust masses recalculated assuming a constant dust temperature of 20 K. The black dotted line denotes a 1-to-1 fit. The line equation is displayed for the linear fit.

“missing mass” problem.

Our results show how SED-derived M_{dust} can constrain disk properties. This method allows for a broader study of diverse regions (environment and age). Future ALMA surveys can benefit this endeavor as (sub)mm observations can constrain the disks dimensions and increase the accuracy of the SED-modeling process. Thus providing a detailed view of the disk evolution timeline and a better understanding of the planet formation process that with the explosion in exoplanet detection is of high interest.

REFERENCES

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