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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 ($M_{\rm dust}$) 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 $M_{\rm dust}$ 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 et al. (2020). The sample was obtained from an ALMA band 6 survey of Serpens (Anderson et al., 2022). The aim is to compare SED-derived Mdust (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 $M_{\rm dust}$ are ~1.5 times higher than literature values (see Figure 1); [2] The sample has a greater median $M_{\rm dust}$ than the populations' shared average of 11 star-forming regions (0.5-10 Myr Rilinger et al., 2023); [3] $M_{\rm dust}$ depletion is low, characteristic of younger regions (1-3 Myr) and follows $M_{\rm dust} \propto t^{-1}$; [4] Serpens' class II objects do not have enough material in their disks to solve the "missing mass" problem.

Our results show how SED-derived $M_{\rm dust}$ can constrain disk properties. This method allows for a broader study of diverse regions (environment and age). Future ALMA surveys can benefit this en- deavor as (sub)mm observations can constrain the disk's 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.

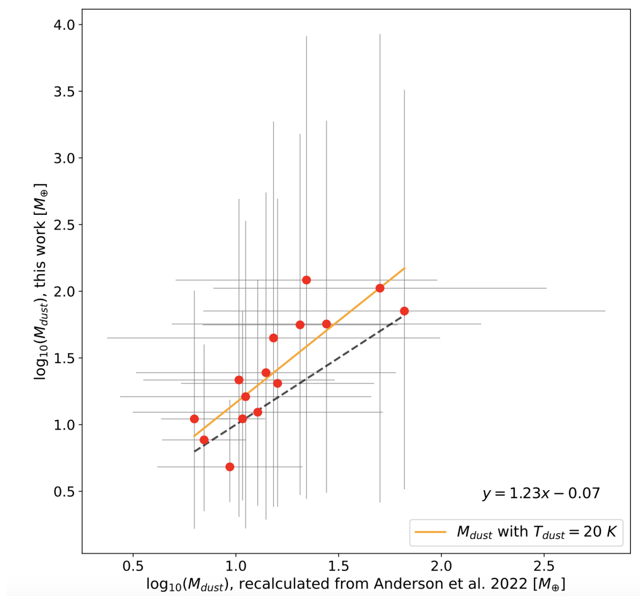

Figure 1. SED-derived $M_{\rm dust}$ vs literature $M_{\rm dust}$ (Anderson et al. 2022). The panel displays a linear fit (solid orange line) to the comparison to dust masses recalculated assuming a constant dust temperature of 20 K. The black dotted line denotes a 1-to-1 fit. The line equation is displayed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

References

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