AU-scale interferometric observations of the circumbinary environment of AK Sco

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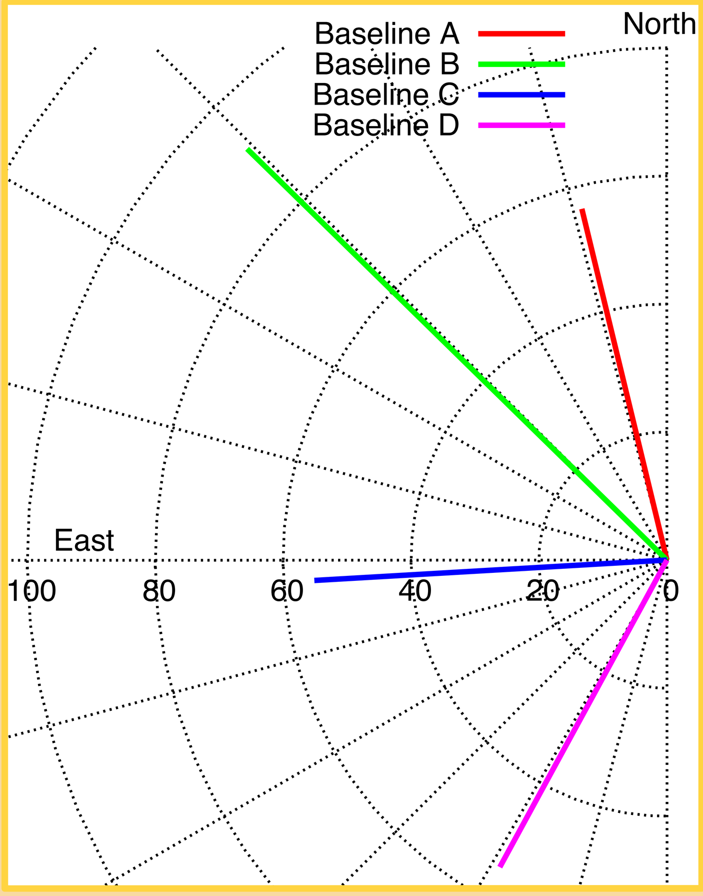
AK Sco is a Pre-Main Sequence (PMS) spectroscopic binary, consisting of two almost identical, F5IVe type star (Alencar et al., 2003 and references therein). It belongs to the Upper Centaurus-Lupus association, with a distance of 103 pc (van Leuween, 2007). The estimated age of the association is 16 Myr.



To study the circumbinary material, we performed mid-infrared interferometric observations with VLTI/MIDI (mid-infrared interferometric instrument at the Very Large Telescope Interferometer) in the MIDI Guaranteed Time program on 29-30 May 2005. Observations were conducted at four baselines. The region of the 8-13 μm emission was resolved by MIDI. Modeling it by Gaussian brightness profiles, we obtained a FWHM size of the emitting region of 10-20 mas, corresponding to 1-2 AU in the distance of AK Sco.

We constructed the SED of the source using archival optical and infrared data from the literature. We also used the Spitzer IRS low resolution spectrum taken on 2005 April 17, which was published in Juhász et al. (2010). Shortward of 1 μm, the SED is dominated by the stellar flux. Between 2 μm and 8 μm a near-infrared (nIR) bump can be seen. At 10 μm a strong silicate feature is present - also clearly visible in the Spitzer spectrum. The continuum part of the SED (between 7 μm and 70 μm) is approximately flat; F_λ decreases with increasing λ ($F_\lambda \sim \lambda^{-2}$) indicating an optically thick emission.

We modeled the circumbinary environment of the source with RADMC radiative transfer modeling code, assuming four different density structure:

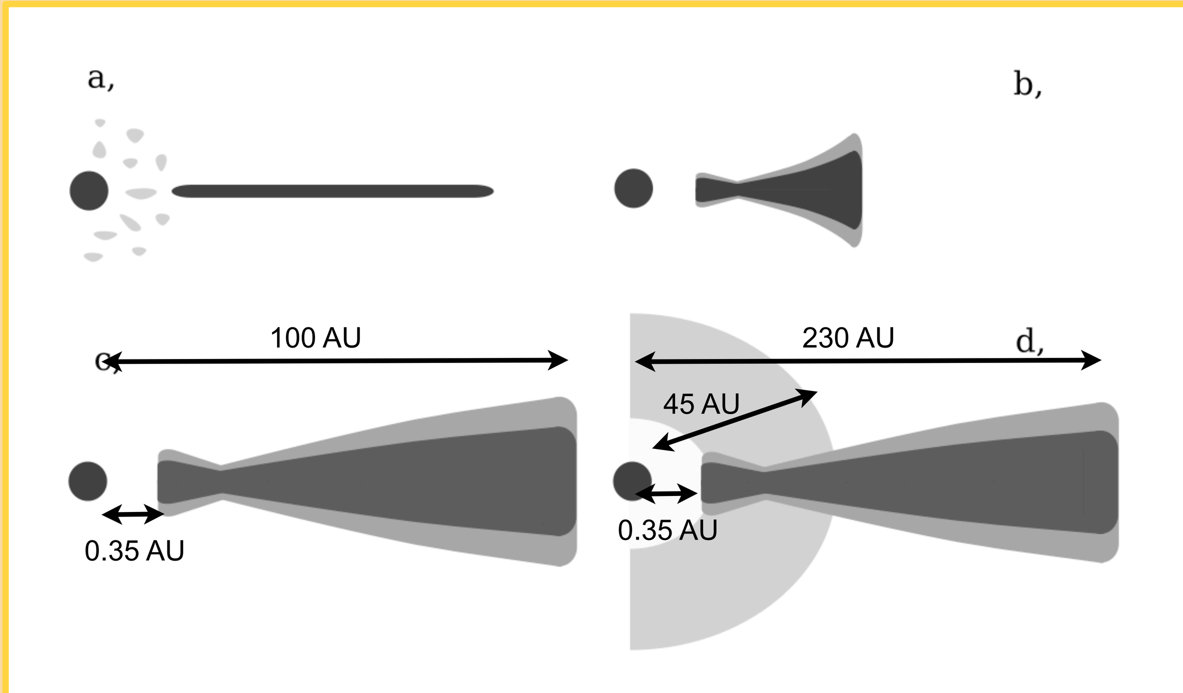
(a) Model of Jensen & Mathieu (1997): a geometrically thin, optically thick disk with dynamically cleared inner gap, filled with optically thin material producing nIR excess.

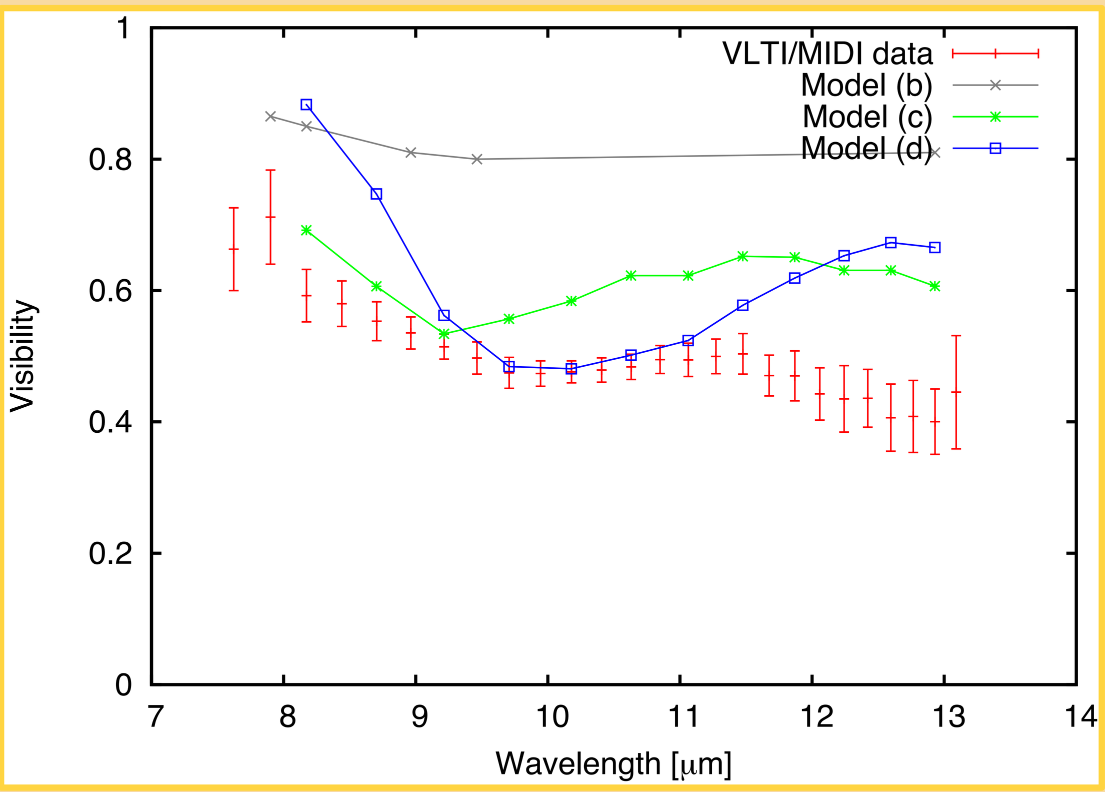
(b) Model of Alencar et al. (2003): an inner hole, a puffed-up inner rim and a flared outer disk.

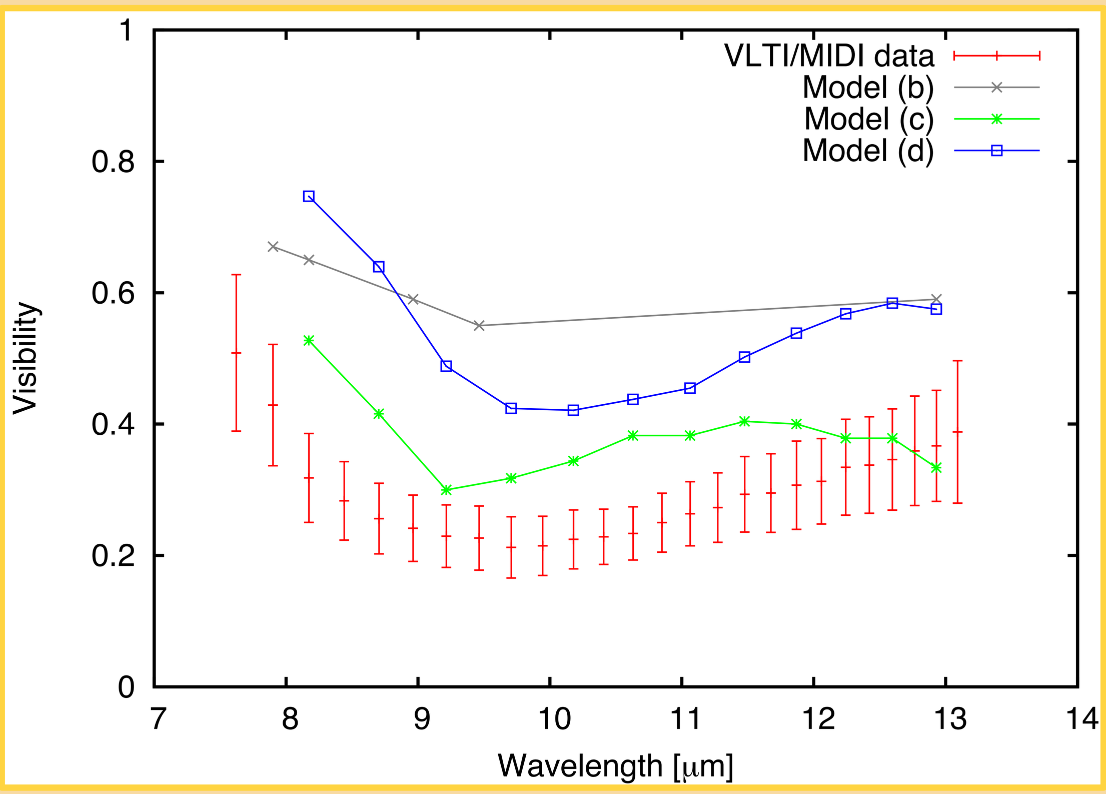
(c) Qualitatively similar to (b), but scaled up in size and scaled down in disk mass.

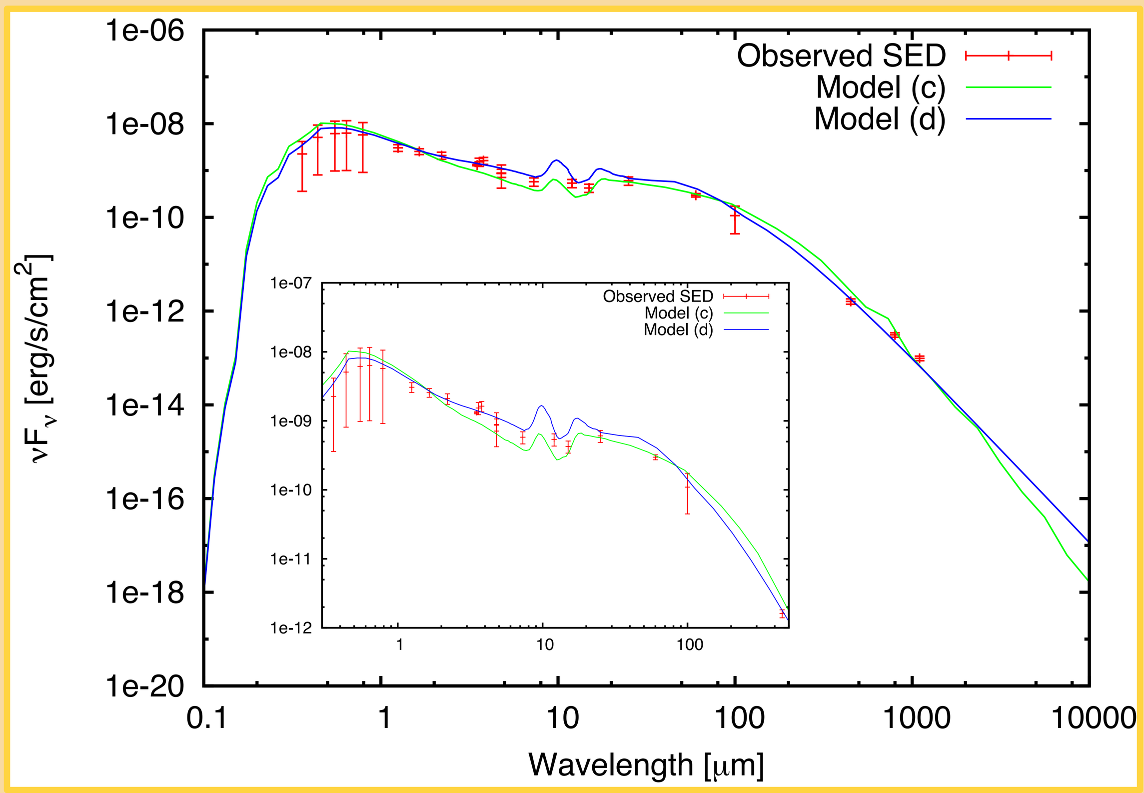
(d) Disk and an optically thin, tenuous halo.

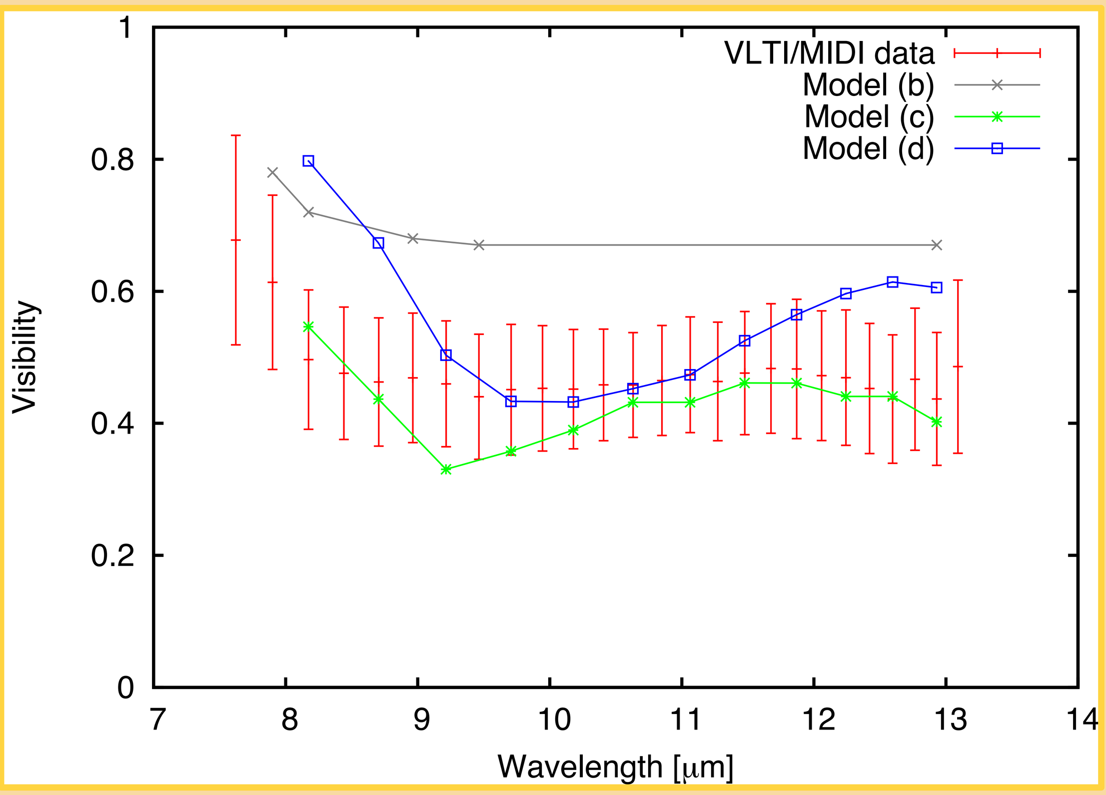
While all four models are able to roughly reproduce the observed SED, fitting the MIDI visibilities is more difficult. In model (a), the silicate emission is produced by the thin hot halo, with angular size of 3-4 mas, thus predcting visibilities of ~0.9. Model (b) model also predicts large visibility values suggesting a more compact emission region compared to the observations. Model (c) usually describes better the visibilities at shorter wavelengths, while model (d) represent them better between 9.5 μm and 11 μm. The Spitzer/IRS spectrum and corresponding predictions of (c) and (d) model indicates that even though the general trend is reproduced, further fine-tuning of the model is necessary.

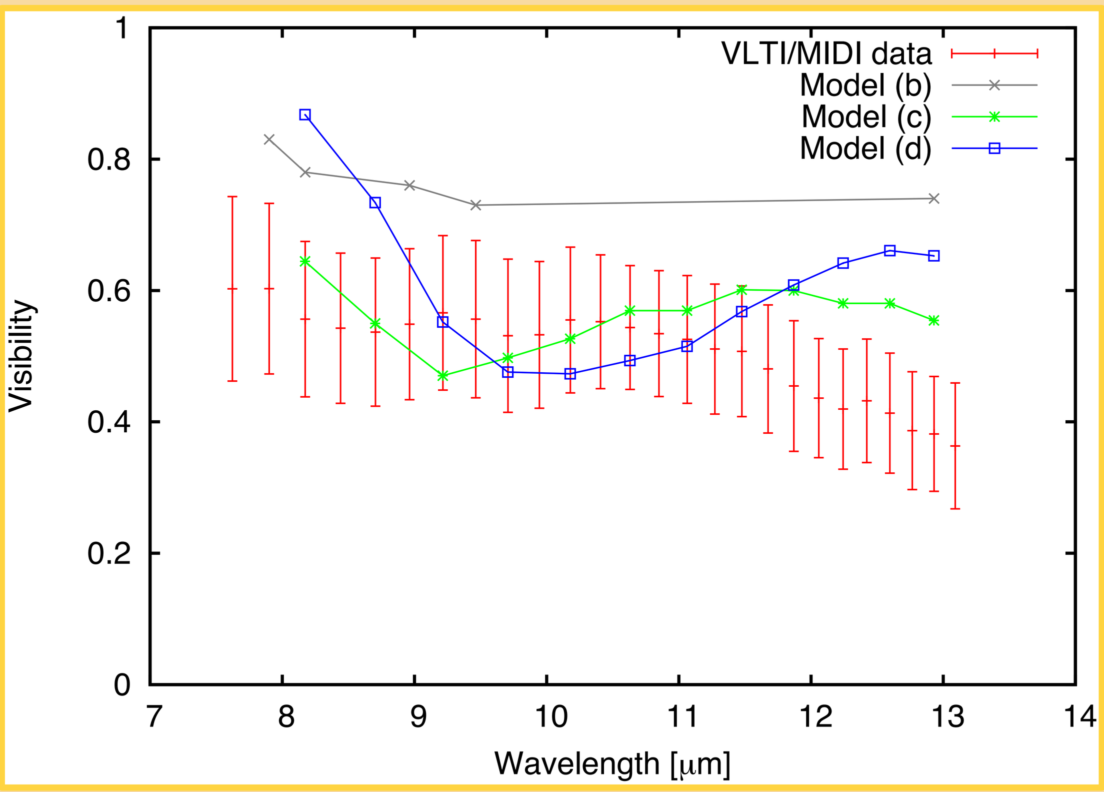


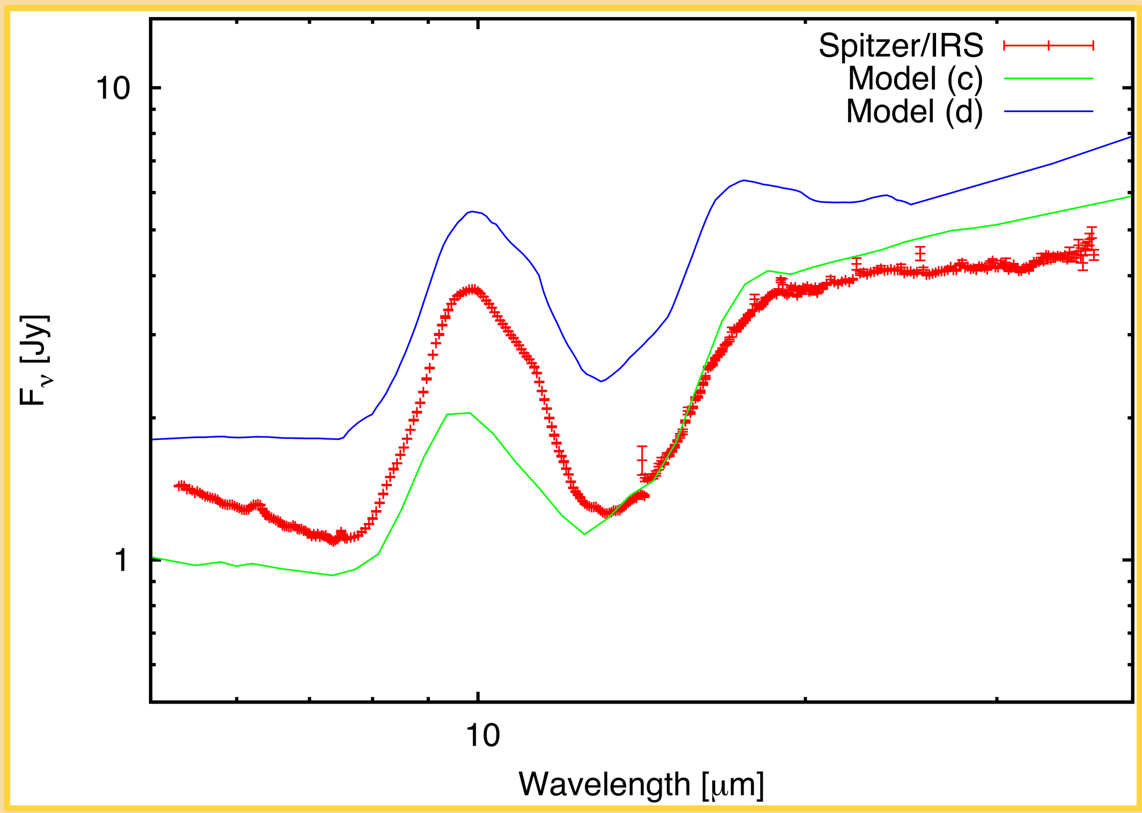












AK Sco was also observed at 345.796 GHz ($^{12}CO(J=3\text{-}2)$ line) with the SHeFI/APEX2 receiver (Vassilev et al., 2008) mounted at the 12-m APEX telescope. No CO(J=3-2) line was observed at an RMS=20.9 mK. Assuming a gas temperature of 20-100 K this would indicate that the mass of CO gas in the system must be less than 2.6×10^{-4} $M_\oplus$. Using the canonical H_2/CO gas ratio, this CO mass corresponds to an upper limit of the gas mass of only $2.6\times10^{-4}\times10^{4}\times(2/28)=0.2$ $M_\oplus$. In the dust radiative transfer models, we assumed a dust mass of 9 $M_\oplus$ for the system. Thus the gas and dust mass values are clearly disagrees with the standard assumption that the gas-to-dust ratio in the circumstellar system of young PMS stars are ~100. This discrepancy may indicate that **the sytem is in a later phase of its evolution**, when the amount of gas is considerably lower.

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