

# WARM CIRCUMBINARY DUST IN THE HD 98800 QUADRUPLE STAR SYSTEM

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HD 98800 is a  $\sim 10$  Myr, hierarchical quadruple with a significant dust component first detected by IRAS. This dust is present in spite of the multiple stellar components [A-B, a visual pair with  $\text{Sep} = 0.''8$ , Aa+Ab, a single-lined spectroscopic binary with  $P = 262$  d, and Bb+Ba, a double-lined spectroscopic binary with  $P = 315$  d (Torres et al. 1995, ApJ, 452, 870)]. In order to study the relationship between the multiple components and the dust distribution, we have carried out a diffraction-limited imaging study of this young multiple star system from  $1\text{--}18.2\mu\text{m}$  with the W. M. Keck 10-m telescopes using near-IR speckle imaging with NIRC, adaptive optics imaging with K-CAM, and mid-IR imaging with OSCIR. This high spatial resolution work compliments that recently presented by Soderblom et al. (1998, ApJ, 498, 385), Gehrz et al. (1999, ApJ, 512, L55) and Low et al. (1999, ApJ, in press). The emission from HD 98800 is easily resolved between the two  $0.''8$  components from  $1\text{--}18.2\mu\text{m}$  (see Figures 1 and 2). Our measurements are the first to resolve the system at multiple wavelengths through the silicate feature (see Figure 3).

In the HD 98800 system, the dust appears to be associated with only the northern component B. Even at  $18.2\mu\text{m}$ , the spectral energy distribution of the southern component, A, is consistent with a stellar photosphere. The location of the dust around the northern component is estimated from a blackbody fit to the excess emission, yielding a dust radius of 2.6 AU. This is comparable to the semi-major axis,  $a$ , of the spectroscopic binary in HD 98800 B ( $a \sim 1$  AU, with maximum separation at apastron of 1.8 AU). We therefore propose that the dust around HD 98800 B is *circumbinary*. Given the binary star parameters, numerical simulations by Artymowicz & Lubow (1994, ApJ, 421, 651) predict an inner disk radius of  $\sim 2$  AU, consistent with the observations. Furthermore, we suggest that the interaction with the central binary system has inflated the dust distribution, giving rise to the remarkably large fractional dust luminosity,  $\sim 0.2 L_{*A}$ .

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Mid-Infrared Images of HD 98800

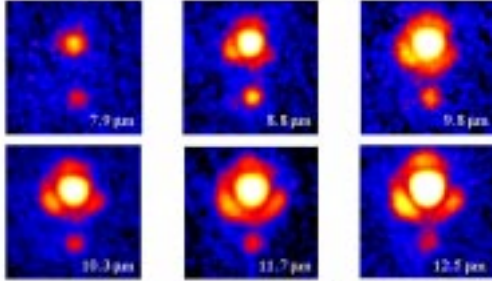
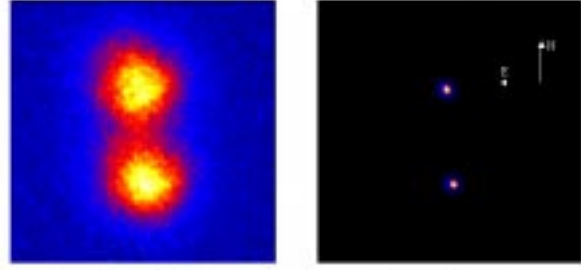


Figure 1: Narrow band silicate filter images of HD 98800 (the four broad-band filter -- K, M, N, TW16 -- images are not shown). The  $0.1''$  binary is easily resolved at all wavelengths with OSCIR.

High Spatial Resolution Imaging of HD 98800 With Adaptive Optics at Keck ( $\lambda = 1.6 \mu\text{m}$ )

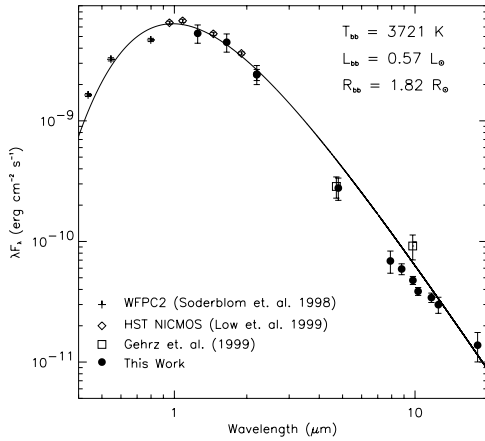


No Adaptive Optics  
 $10 \text{ mas} \pm 0.62 \text{ arc}$   
 $\text{FWHM} = 0.74$

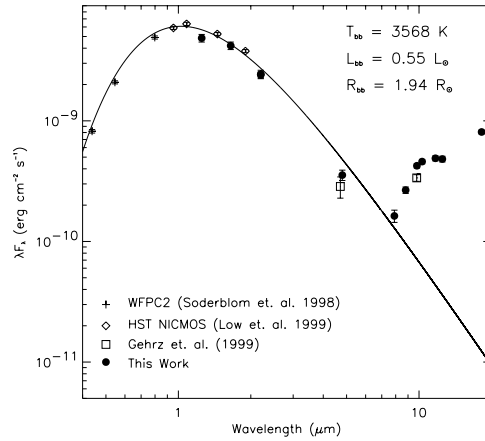
With Adaptive Optics  
 $13 \times 10 \text{ mas} \pm 0.62 \text{ arc}$   
 $\text{FWHM} = 0.76$

Figure 2

HD 98800 South (A)



HD 98800 North (B)



HD 98800 North: Dust Component Only

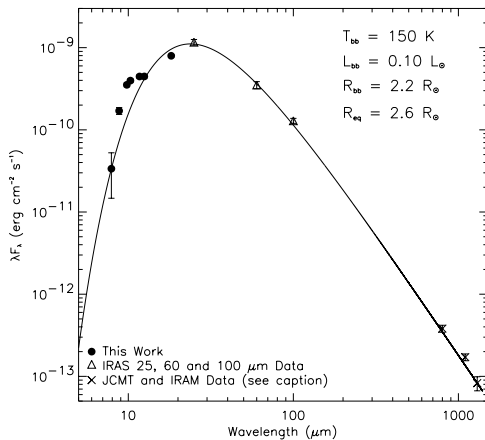


Figure 3: Spectral energy distributions for the stellar components A and B and for the component B dust with black bodies overplotted. The millimeter data are from Rucinski (1993, IAUC, 5788), Sylvester et al. (1996, MNRAS, 279, 915) and Stern et al. (1993, IAUC, 6003). HD 98800 A is fit with a single black body, consistent with a stellar photosphere. Two black body components are necessary to fit the SED of HD 98800 B, one for the stellar photosphere and one for the dust. Based on the cool dust temperature derived, we conclude that it must be *circumbinary*, i.e. around the spectroscopic pair Ba and Bb.