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The Planetary Debris System in HD98800

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Abstract. We present new data for the Planetary Debris System in the multiple star system HD 98800.

1. Introduction

The stellar system HD 98800 consists of two close binaries (Aa+Ab, Ba+Bb) with the photocenter of each pair currently separated from the other pair by $0.8''$ (e.g., Soderblom et al. 1998 and references therein). A planetary debris system (PDS) orbits HD 98800 Ba+Bb (Zuckerman & Becklin 1993; Gehrz et al. 1999 Koerner et al. 2000; Prato et al. 2001). Using high resolution near-IR photometry from the Near Infrared Camera and Multi-Object Spectrometer (NICMOS) aboard the Hubble Space Telescope (*HST*) to measure the luminosity of HD 98800B, Low, Hines & Schneider (1999) found that the debris system intercepts $\approx$ 19% of the luminosity from HD 98800B. The spectral energy distribution of the debris is fit remarkably well from 10μm - 1.3mm by a single temperature blackbody of T$\approx$ 160K, implying fairly large grains. The only significant deviation from a pure blackbody is an emission feature near 10μm from silicate emission (Sylvester et al. 1996; Sitko et al. 2000), but no scattered light is detected in the NICMOS images (Low, Hines & Schneider 1999). Assuming an upper limit to the debris particle albedos ($\sim$ 4%) places the majority of the debris between 2-4 AU from the photocenter of HD 9800B. Low et al. (1999) envision large ($\geq$ few hundred microns) particles orbitng HD 98800B in a "belt" similar to the Zodiacal dust bands in our solar system.

While this model is compelling, the data can also be explained by dust models with a range of particle sizes and distributed over a range of distances from HD 98800B (Koerner et al. 2000; Prato et al. 2001), including a very cool component surrounding both HD 98800 A & B (Zuckerman 2001). Herein we present new data for the system.

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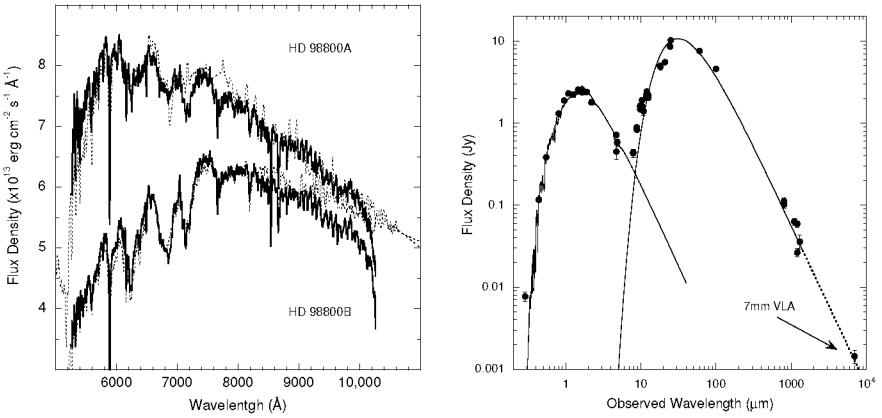

Figure 1. *Left:* STIS spectrophotometry of the components HD 98800 A & B. Kurucz models that bracket the (composite) spectral type of each pair are shown scaled to match the object spectrum at 7200$\mathring{A}$. *Right:* Spectral energy distributions (SEDs) for HD 98800B & the PDS. A K5V Kurucz model and a single temperature black body (fit to the NICMOS data as in Low, Hines & Schneider 1999) are shown. Except for the new VLA data, the photometry are from: Prato et al. (2001); Koerner et al. (2000); Low, Hines & Schneider (1999); Gehrz et al. (1999); Soderblom et al. (1998); Sylvester et al. (1996); Chandler, private comm. (VLA).

2. New Data

Spectra and imaging with the Space Telescope Imaging Spectrograh (STIS) aboard *HST* were obtained to better constrain the primary spectral types, to measure their U-band magnitudes, and measure their separation and position angles on the sky. From the ground, HD 98800 was observed at 7mm with the VLA to better constrain the spectral energy distribution.

Figure 1 (*left*) shows our STIS spectra for the two primary components HD 98800 A&B. Kurucz stellar atmosphere models are also shown that best match the new data. We find that HD 98800A is best fit by a K5 dwraf in agreement with Soderblom et al. (1996), but HD 98800B is is closer to M0V than K7V.

Also shown in Fig. 1 (*right*) is our updated SED for HD 9800B with two Kurucz model atmospheres that bracket the inferred spectral type of the composite HD 98800B spectrum. The HST "U-band" data are in excess of the Kurucz model, which may indicate chromopsheric activity, but the data are contaminated by a red leak in the STIS filter (the uncertainties attempt to account for this leak). A $T = 165K$ black body fit to the data from 12μm to 1.1mm is also shown. The dotted line shows an extrapolation of this fit to 7mm. The VLA DnC configured radio measurement (UV-tappered beam $\approx 3''$) falls nearly on top of the tail of the black body. This latter result suggests that the dust particles responsible for the majority of the IR to radio flux are large ($\sim$ 7mm).

3. The Debris System

The new results are consistent with the picture discussed by Low, Hines & Schneider (1999) in which the debris system in HD 98800B is composed primarily of large particles orbiting within a thin belt at about 2-4AU, and covering $\sim 20\%$ of the sky. The new VLA data do not resolve the debris and still do not rule out the possibility of a large cool disk surrounding both HD 98800A&B. Future 7mm observations with a larger VLA array configuration, thus higher resolution, should place even stronger constraints on the debris system.

4. The SIRTF (Spitzer) GTO Program

The properties of the PDS in HD 98800 suggest the presence of a failed terrestrial planet. While the unique configuration of this multiple system enabled detection by IRAS, less dramatic terrestrial debris systems may orbit other young nearby stars. The 1000 fold increase in sensitivity afforded by SIRTF compared with IRAS will enable detection of such systems. As part of a larger investigation of debris systems, we have dedicated a large fraction of our SIRTF GTO time to look for and characterize such systems.

References

Gehrz, R. D., Smith, N., Low, F. J., Krautter, J., Nollenberg, J. G., & Jones, T. J. 1999, ApJ, 512, L55

Koerner, D. W., Jensen, E. L. N., Cruz, K. L., Guild, T. B., & Gultekin, K. 2000, ApJ, 533, L37

Low, F. J., Hines, D. C., & Schneider, G. 1999, ApJ, 520, L45

Prato, L. et al. 2001, ApJ, 549, 590

Sitko, M. L., Lynch, D. K., & Russell, R. W. 2000, AJ, 120, 2609

Soderblom, D. R., Henry, T. J., Shetrone, M. D., Jones, B. F., & Saar, S. H. 1996, ApJ, 460, 984

Soderblom, D. R. et al. 1998, ApJ, 498, 385

Sylvester, R. J., Skinner, C. J., Barlow, M. J., & Mannings, V. 1996, MNRAS, 279, 915

Zuckerman, B. 2001, ARA&A, 39, 549

Zuckerman, B. & Becklin, E. E. 1993, ApJ, 406, L25