HUBBLE SPACE TELESCOPE IMAGING OF THE SCHWARTZ 82 DISK. D. L. Padgett, *Spitzer Science Center, Pasadena CA 91125, USA, (dlp@ipac.caltech.edu)*, K. R. Stapelfeldt, J. Krist, *Jet Propulsion Lab, Pasadena, CA 91101, USA*, F. Menard, *Observatoire de Grenoble, Grenoble, France*, G. Schneider, *Steward Observatory, Tucson, AZ, USA*.

Schwartz 82 (IM Lupi; HBC 605; IRAS 15528-3747) is an M0 T Tauri star located within the Lupus star forming clouds at a distance of $\sim$190 pc (Wichmann et al. 1998). It is one of four young stellar objects in a small ^{13}CO(1-0) core near the extreme T Tauri star RU Lupi (Tachihara et al. 1996). Unlike its more famous neighbor, Sz 82 displays only a modest amount of emission-line activity, with an Hα equivalent width which is known to vary from 7.5 - 21.5 Å (Batalha & Basri 1993). A detailed study of Hα emission in this star by Reipurth et al. (1996) concluded that the Hα feature shows an inverse P Cygni pro£le with evidence for infall. The relatively weak emission lines and lack of optical veiling caused Finkenzeller & Basri (1987) and Martin et al. (1994) to classify this object as a weak-line T Tauri star, although it is more properly catagorized as a borderline classical T Tauri star. The V-band linear polarization of Sz 82 is low, $0.5\% \pm 0.1\%$ at a position angle of 1° (Bastien 1985). The star is an irregular variable (Batalha et al. 1998), and has been observed to ¤are dramatically in the U band (Gahm et al. 1993). Hipparcos observations suggested a companion with a separation of only 0.4 arcsec (Wichmann et al. 1998); however, neither near-IR speckle observations (Ghez et al. 1997) nor the current HST observations con£rm the presence of a close companion. Ages for this system range from 10^5 yr to 10^6 yr (Hughes et al. 1994), depending on the pre-main sequence evolutionary track used. Sz 82 is not associated with any known optical or molecular out¤ow, although HH 55 is located nearby.

Despite the lack of accretion-related spectroscopic activity for Sz 82, longer wavelength observations reveal ample evidence for circumstellar material in the system. The near infrared spectral energy distribution has a slight excess beyond 3 μm (Hughes et al. 1994). Sz 82 was detected by IRAS with $S_{12\mu m}$ = 0.67 Jy, $S_{25\mu m}$ = 1.0 Jy, $S_{60\mu m}$ = 1.6 Jy, and $S_{100\mu m} \leq$ 8.4 Jy (Carballo et al. 1992). This infrared excess emission, combined with a single dish 1.3 mm continuum ¤ux of 260 mJy (Nuernberger et al. 1998), indicates the presence of a considerable amount of warm and cold dust around Sz 82. The ratio between the stellar and systematic luminosity for this young star suggests a disk (Batalha & Basri 1993). Using the method of Beckwith et al. (1990) and assuming κ_ν = 0.02 cm^2/g and dust temperature of 40 K, we estimate the mass of circumstellar material around Sz 82 = 0.04 $M_\odot$ based on the 1.3 mm continuum ¤ux. Thus, indirect evidence strongly suggests the presence of an optically thick disk around Sz 82.

We observed Sz 82 as part of an HST/WFPC2 snapshot survey of nearby T Tauri stars. The observations were obtained on 2-14-99 using the HST Planetary Camera 2. The data consist of short and long exposures through the F606W and F814W £lters (F606W 8 s and 100 s; F814W 7s and 80 s) which roughly correspond to Johnston R and I. In the long exposures, the star is heavily saturated in an attempt to reveal low surface brightness circumstellar nebulosity. After standard WFPC2 data reduction, the stellar point spread function (PSF) was compared to our large database of WFPC2 PSFs, and a suitable match was found in £eld position, color, and exposure level. The sub-pixel registration, normalization, and subtraction of the stellar PSF was performed following the method of Krist et al. (1997).

Figure 1, top shows the long F814W exposure after PSF subtraction. Obvious PSF artifacts remain in the subtracted image in the form of the saturation column bleed and residual diffraction spikes. However, PSF subtraction also reveals a compact nebula adjacent to the SW of the star. Morphologically, the nebula is a broad, gentle, symmetrical arc nearly 4" or about 760 AU in length. The nebula was also imaged at F606W, but no clear differences are found between the nebulosity at these two wavelengths despite the presence of Hα and other emission lines in the F606W £lter. Because of the similar appearance of the nebula in F606W and F814W, we conclude that it is dominated by scattered light from the star. A much fainter nebula is present about 2 arcsec below the £rst, at a S/N of about 2 over a broad arc. This feature is most obvious in the F814W image.

In 2005, we observed Sz 82 again using the coronagraphic camera on HST/NICMOS. **Figure 1**, bottom shows the F160W image obtained after combining images at two roll angles and subtracting M0 (left) and K5 PSF templates. These observations reproduce the basic morphology found by the WFPC2 imaging at higher S/N and con£rm the presence of a disk counternebula separated from the main nebula by a dust lane.

The re¤ection nebula around Sz 82 appears very similar to models of scattered light from an optically thick circumstellar disk seen at moderate inclination. Disk models of this sort have been successfully used to characterize the edge-on disk of HH 30 (Burrows et al. 1996), **Figure 1**,center shows a simulated F814W image from a model of an optically thick circumstellar disk seen in scattered light. This multiple scattering model was produced by the "Pinball" code written by A. Watson. Disk mass was set equal to the millimeter continuum mass estimate; outer radius was set by the extent of the nebula. Other parameters are similar to values derived for the HH 30 disk (Burrows et al. 1996). Iterative comparisons of the model with the images constrain the inclination to $\sim 50^\circ$. When we include the counternebula seen best in the F160W image, then the disk mass will be constrained by the thickness of the presumed dust lane separating the two nebulae. More detailed multiwavelength model £tting will allow us to constrain the scattering properties of the dust grains around Schwartz 82.

Schwartz 82 is a relatively weak-lined T Tauri star with a large and probably massive circumstellar disk. In this way it resembles the Taurus young star LkCa 15 which has weak Hα emission, but a sizable circumstellar disk resolved by millimeter interferometry (Qi et al.2003). However, unlike LkCa 15, Schwartz 82 is an example of a young stellar object whose disk morphology has been revealed instead by optical HST imaging. Located in the southern hemisphere, this star is beyond the reach of current millimeter interferometers which have imaged the disks of northern hemisphere T Tauri stars. After the discovery of the disk by HST, our team did not succeed in an initial attempt to detect the nebula with the CFHT adaptive optics system. Interestingly, Hipparcos may have marginally detected the nebulosity since it attempted to place a non-existent binary companion in the photocenter of the bright nebulosity! The detection of the Schwartz 82 disk by HST illustrates the utility of HST's unequalled resolution and PSF stability in performing imaging surveys for circumstellar nebulosity around young stars.

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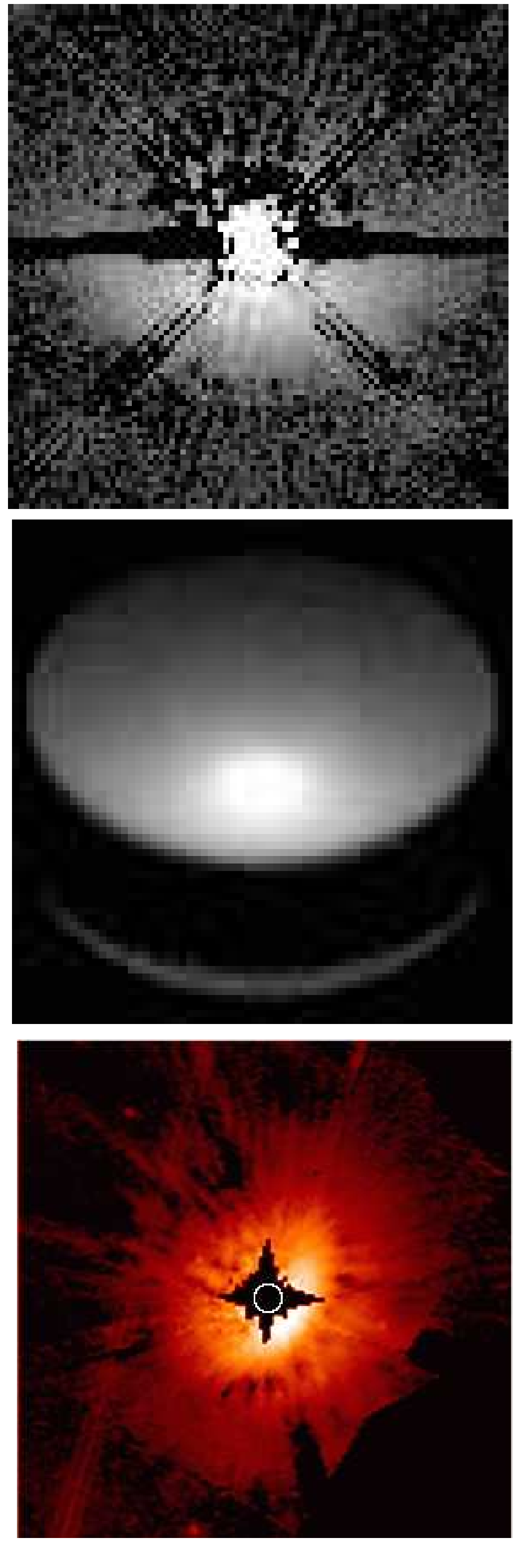

Figure 1: Top: PSF subtracted F814W HST/WFPC2 image of Sz 82. Image is 5 arcsec across. Middle: Multiple scattering model simulated image of a 400 AU radius circumstellar disk inclined 50 degrees from face-on. Bottom: F160W HST/NICMOS PSF-subtracted coronagraphic image of Sz 82 combined from observations at two roll angles. Image has been rotated so north is up, and the image size is approximately 10" on a side.