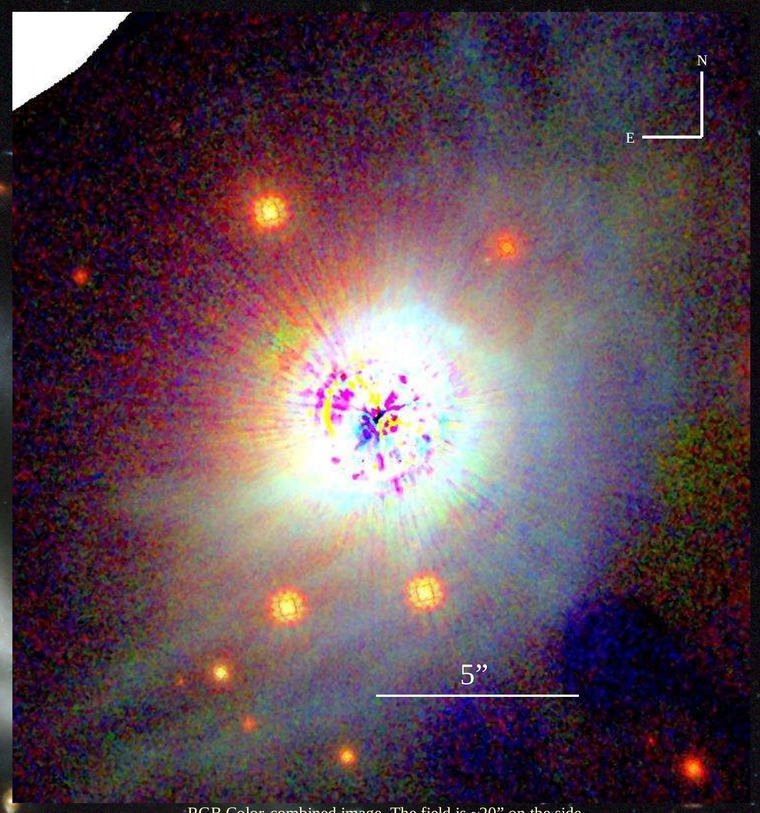
ACS Coronagraphic Observations of the Disk around HD 100546

D.R. Ardila (JHU), D. Golimowski (JHU), J. Krist (STScI), M. Clampin (GSFC) and the ACS Science Team

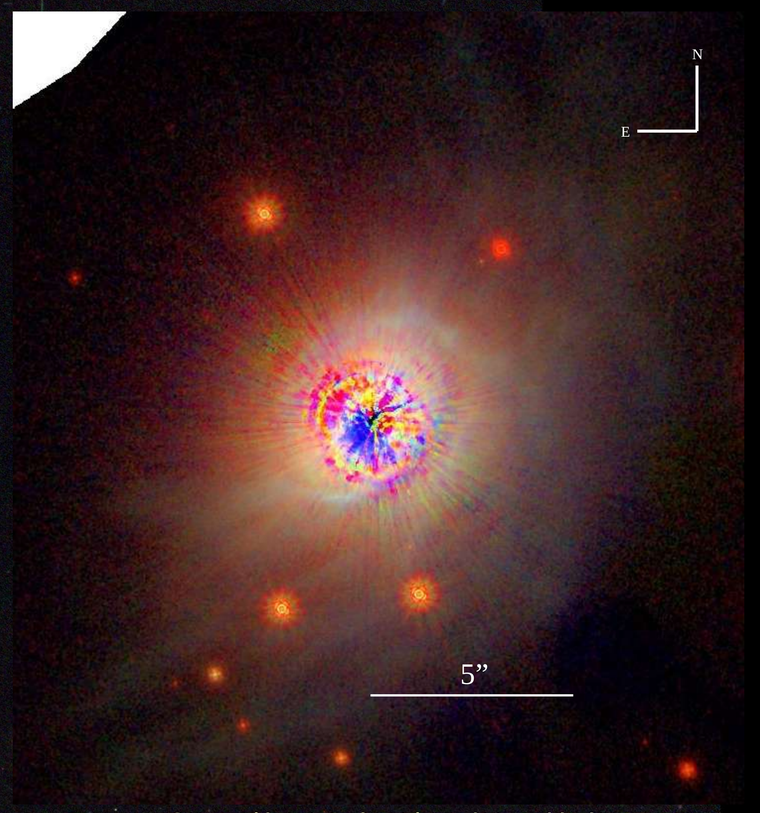
Introduction: We present new coronagraphic observations of the old Herbig Ae/Be star HD 100546. The disk around the star has previously been imaged using NICMOS (Augereau et al. 2001) and STIS (Grady et al. 2001). Those observations resolved an optically thick disk surrounded by reflection nebulosity. The disk may be in the process of making the transition between primordial protoplanetary disk, and reprocessed debris disk.

Background and Factoids:

- Spectral Type: B9.5 V; Distance: 103 ± 6 pc; Age: t > 10 Myr
- Spectroscopic evidence for wind and accretion (Vieira et al. 1999, Deleuil et al. 2004) and gap clearing within 10 AU (Bowman et al. 2003).
- $L_d/L_* = 0.51$. Mdust ~ 20 M_{earth} (Bowman et al 2003, Dominik et al 2003)
- These observations were performed with the ACS/HRC coronagraph (0.9” mask), in the F435W, F606W, and F814W bands. T_{exp}~2000 sec per band. A reference PSF (HD 129433) was subtracted from each image.
- All other point sources in the image are background stars
- Photometry (3% errors): F435W : 8.3 Jy (B = 6.68 mag)
  F606W : 6.9 Jy (V = 6.72 mag)
  F814W : 5.3 Jy (I = 6.67 mag)

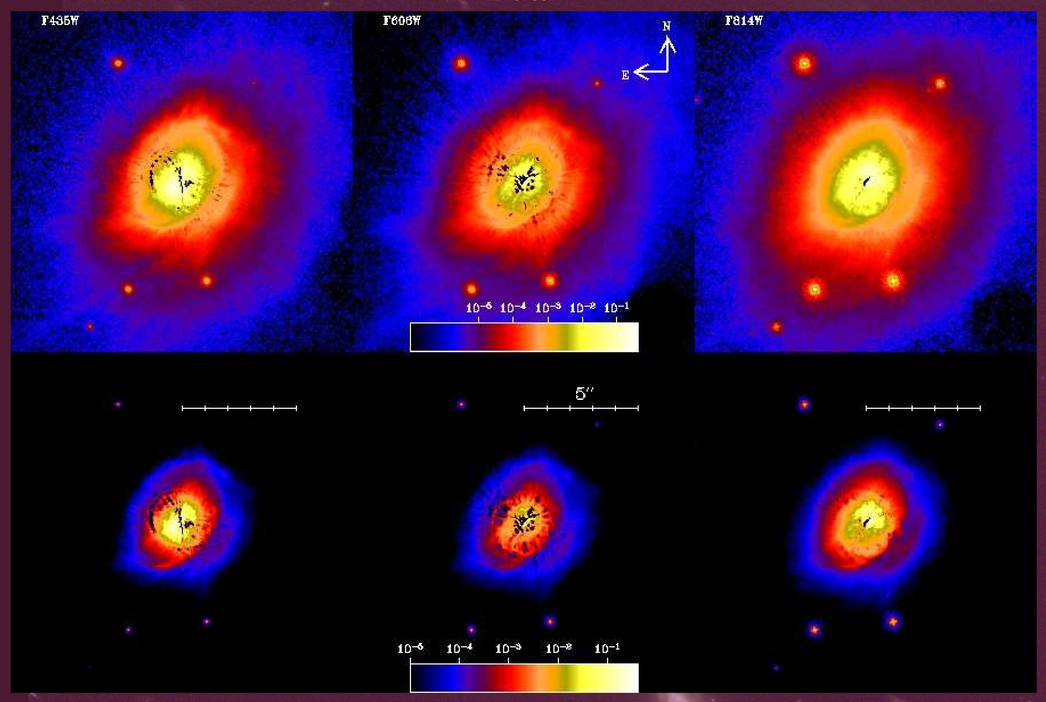


RGB Color-combined image. The field is ~20” on the side



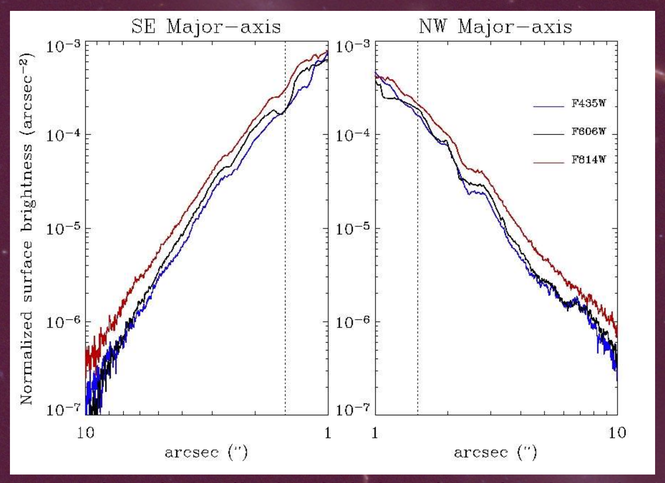
RGB image of the intrinsic colors. Before combining, each band is divided by the stellar brightness.

Data

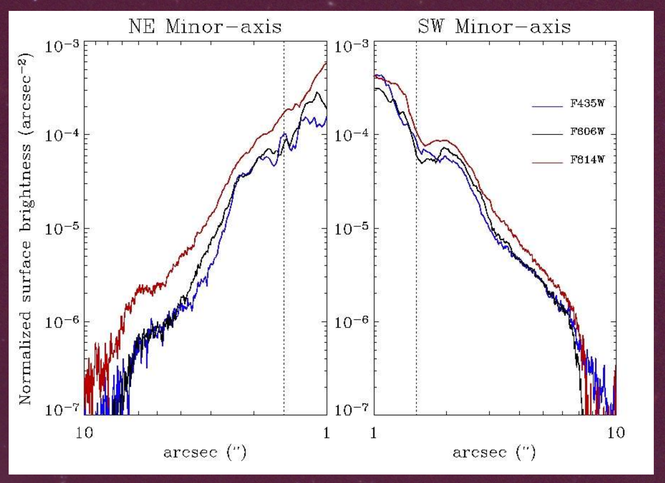


Data for each band, shown in logarithmic stretch. Each image has been normalized to the stellar flux in the band. Two different stretches are shown, to highlight different regions in the system.

Surface Brightness Profiles



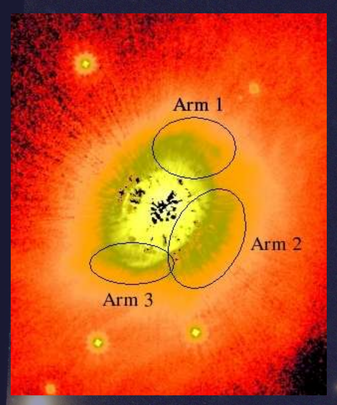
Surface Brightness profiles: The median brightness of a strip of 1” wide centered on the star. Normalized to stellar brightness in each band. Major axis is taken to be at P.A.=127 deg. Dotted lines mark the outer boundaries of the regions dominated by subtraction residuals

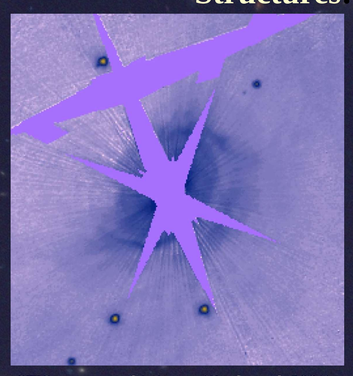


Minor axis profiles: The high surface brightness in the F814W NE is responsible for the red glare in the composite image.

- Two regions: inner disk (<3”) and outer nebulosity (>3”). All-bands average power law fits: 1”<r<3” $r^{-2.9}$; 3”<r<10” $r^{-3.4}$
- The disk becomes brighter to the red. No evidence of red halo (an instrumental defect in the HRC)
- Red excess to the NE

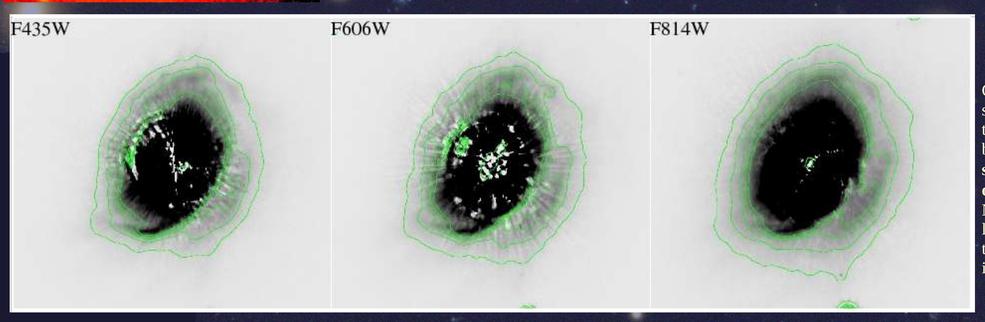
Structures:





STIS coronagraphic image (Grady et al. 2001)

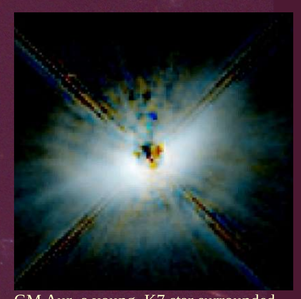
- In addition to the extended nebulosity, three elongated structures are observed (named **Arm 1, 2, and 3** on the far left)
- Also seen in the STIS image (near left)
- The Arms and the space between them and the disk becomes brighter as one goes to longer wavelengths.



Contour plots overploted on linear stretches of the images (normalized to the stellar brightness in each band). **Each image has the same scaling, and each contour is drawn on the same intensity**. Notice that the arms “fill-up” at longer wavelengths, as expected if the disk becomes less optically thick in the red.

Discussion, Conclusions, Thoughts:

- The observations are consistent with a ~50 deg. inclined disk, similar to those observed in young stars (see right). While this naturally explains the existence of Arm 2, it is not clear what arm 1 and 3 are due to.
- The morphology of the structures observed in the inner disk (arms 1, 2, and 3) is wavelength dependent, suggesting that they are not physical arms but the result of optical depth effects.
- Arms 1, 2, and 3 can be explained by a close encounter in the non-too-distant past, but no perturber is available (Quillen et al. 2005)
- Some of the red excess to the NE side may be due to more isotropic scattering in the longer band.



GM Aur, a young K7 star surrounded by a disk. Notice the dark lane, the result of shadowing of starlight by the disk midplane. NICMOS coronagraphic image (Schneider et al. 2003)

References:

- Augereau et al. 2001, A&A, 365, 78
- Bowman et al. 2003, A&AQ, 401, 577
- Deleuil et al. 2004, A&A, 418, 577
- Dominik et al. 2003, A&A, 398, 607
- Grady et al. 2001, AJ, 122, 3396
- Quillen et al., 2005, in preparation
- Vieira et al. 1999, A&A, 345, 559