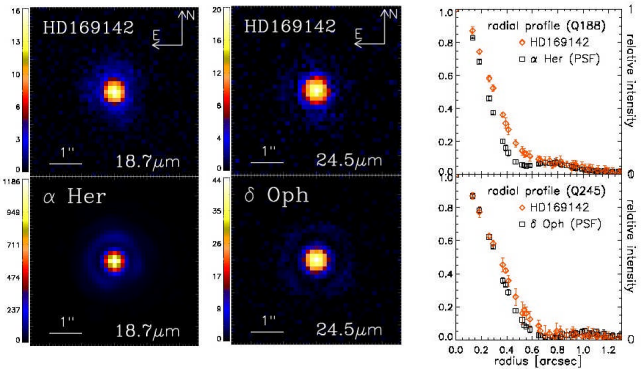
Another evidence for the inner hole in the disk around the Herbig Ae star HD169142

Mitsuhiko Honda (Kanagawa Univ.), Koen Maaskant (University of Amsterdam), Yoshiko Okamoto (Ibaraki Univ.), Hirokazu Kataza (ISAS/JAXA), Misato Fukagawa (Osaka Univ.), Takuya Yamashita (NAOJ), Hideaki Fujiwara, Takuya Fujiyoshi (NAOJ), Takashi Miyata, Shigeyuki Sako, Itsuki Sakon (Univ. of Tokyo)

Observations & Results



Telescope/Inst.: Subaru/COMICS
Pixel scale: 0.13″/pix
Imaging Filter:
18.7 ($\Delta\lambda$=0.9μm) ,24.6μm ($\Delta\lambda$=1.9μm)
Shift & Added off-line per 0.983s frame
(bad Strel ratio frame rejected)

Abstract

Honda, et al. 2011, in prep.

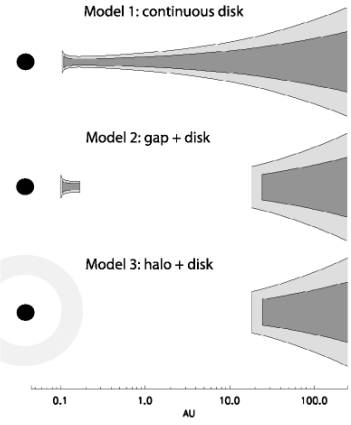
The disk around HD169142 was imaged and resolved at 18.7 and 24.5 μm using 8.2m Subaru/COMICS. Extensive model studies show that the wall has to be located at 23^{+3}_{-5} AU. However, these models also demonstrate that additional optically thin warm dust in the inner region has to be present as well. This dust can be present in a geometrically thin, optically thick disk or in a geometrically thick,optically thin halo.

Table 1. Observations Summary

object	filter	Date(UT)	Integ. time [s] used/total (%)	AirMass	Direct FWHM
δOph	Q245	2004/07/11	195/243 sec (80 %)	1.254-1.354	0.63"
HD 169142	Q245	2004/07/11	345/802 sec (43 %)	1.541-1.542	0.67"
αHer	Q188	2004/07/12	83/83 sec (100 %)	1.081-1.115	0.47"
HD 169142	Q188	2004/07/12	215/360 sec (60 %)	1.553-1.559	0.60"

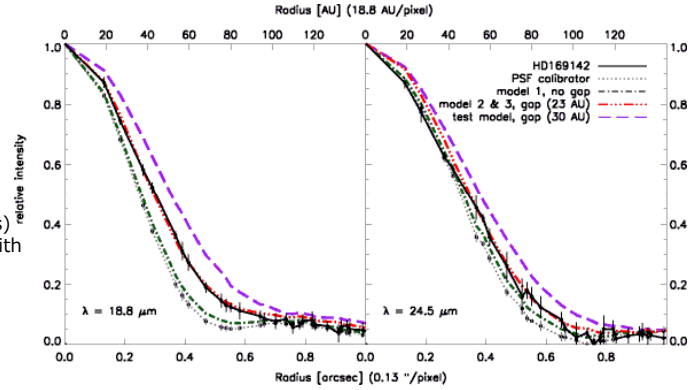
Disk thermal emission was resolved in 18.7 and 24.5μm
Assuming Gaussian profile, the source FWHMs are 0.37″ (54AU) in 18.7μm
And 0.23″ (33AU) in 24.5μm
(cf. 0.32″±0.05″ in 18μm by Marinas et al. 2011)

Modeling the disk geometry: A wall at 23^{+3}_{-5} AU

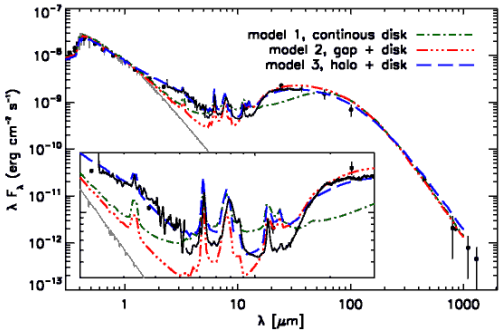


Simplified cartoons of the models described in the text. Model 3 results in the best fit to our data.

(Right) Radial brightness profiles (RBPs) normalized at the center. Test model with the wall at 30AU show too much extended emission compared to the observed RBPs.



	RBPs in 18.7 & 24.5μm	Rising SED at ~20μm	NIR flux in SED
Model 1 continuous disk	NG	NG	NG
Model 2 gap+disk	**OK**	**OK**	NG
Model 3 Halo + disk	**OK**	**OK**	**OK**



Spectral energy distribution of HD169142. The black line represent the ISO/SWS [2.3 - 5.3 μm] and Spitzer/IRS [5.3 - 37 μm] spectra.

Table 2. Parameters of HD169142 system used in our best-fit model

parameter	value	Remarks
Spectral type	A5Ve	Dunkin et al. (1997)
Extinction	Av=0.46±0.05	Ancker (which papaer ? 1197? 1998?)
log g	4.22	Ancker
Temperature	7500-7800K	Meeus et al. (2010)
Distance	145±15 pc	de Zeeuw et al. (1999)
Age	6^{+6}_{-3} Myr	Grady et al. (2007)
Stellar luminosity	15.33±2.17 $L_\odot$	Ancker
Stellar Mass	2.28±0.23 $M_\odot$	Ancker
Stellar Radius	1.94±0.14 $R_\odot$	Ancker
Dust disk mass	2.16×10^{-4} $M_\odot$	Panić et al. (2008)
Gas disk mass	$(0.16\text{-}3.0)\times10^{-2}$ $M_\odot$	Panić et al. (2008)
Inclination	13°	Raman et al. (2006); Dent et al. (2005)
accretion rate	$\leq10^{-9}M_\odot$ yr^{-1}	Grady et al. (2007)
R_{in}	0.1 AU	dust sublimation radius
R_{out}	235 AU	Panić et al. (2008)
R_{gapin}	0.2-10 AU	depends on thickness of the inner disk
R_{gapout}	23^{+3}_{-5} AU	fit to imaging data
halo	0.1-1 AU	geometrically heigh, optically thin component to fit the NIR
surface dens. exp.	-1.0	Hydrostatic equilibrium
Particle size	a ={0.03μm,1cm }	68.5% is in large grains (≤1mm)
Silicates	70%	Mulders et al. (2011)
Amorphous carbon	30%	To fit the sub mm data (Zubko et al. 1996)
M_{PAH}/M_{dust}	1.5×10^{-4}	uniform PAH distribution

Origin of the structure

Origin of the halo:
Dynamical scattering of planetesimals and subsequent collisional dust formation caused by a planet migration ? (Krijt & Dominik 2011)

Origin of the gap:

- Photo-evaporation will be difficult, because the survival time scale of the inner disk is 10^5 years (Alexander et al. 2006)
- Grain growth could have occurred, but it is not clear why it has occurred only in the gapped region
- Dynamical interaction between planets/companions and the disk can be the possible cause for the gap formation