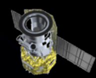
Hot Debris Dust around HD 106797

Please also see Fujiwara et al. 2009, ApJ, 695, L88



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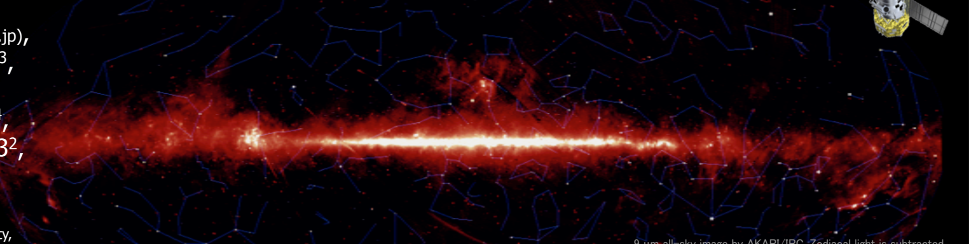


9 μm all-sky image by AKARI/IRC. Zodiacal light is subtracted.

ABSTRACT

Photometry of the A0 V main-sequence star HD 106797 with AKARI and Gemini/T-ReCS is used to detect excess emission over the expected stellar photospheric emission between 10 and 20 μm, which is best attributed to hot circumstellar debris dust surrounding the star. The temperature of the debris dust is derived as Td~190 K by assuming that the excess emission is approximated by a single temperature blackbody. The derived temperature suggests that the inner radius of the debris disk is ~14 AU. The fractional luminosity of the debris disk is 1000 times brighter than that of our own zodiacal cloud. The existence of such a large amount of hot dust around HD 106797 cannot be accounted for by a simple model of the steady state evolution of a debris disk due to collisions, and it is likely that transient events play a significant role. Our data also show a narrow spectral feature between 11 and 12 μm attributable to crystalline silicates, suggesting that dust heating has occurred during the formation and evolution of the debris disk of HD 106797.

1. Debris Disk

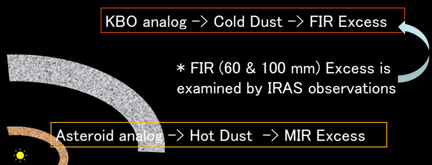
Infrared Excess

- "Vega-like stars"
  - Main-sequence stars with infrared excesses
- Infrared Excess
  - Thermal emission from circumstellar dust disks

Origin of Dust

- Dust around Vega-like stars are NOT primordial protoplanetary dust
  - Timescale of blow-out mechanism << Age
- Secondary generated dust
  - Collision of planetesimal?
  - "Debris Dust" or "Debris Disk"
- Final stage of planet formation?

Comparison with Solar System



2. Target

HD106797

- A0 V Main-Sequence Star
- D=96+/-3pc (Hipparcos)
- A possible member of Lower Centaurus-Crux (LCC; de Zeeuw et al. 1999)
  - Age ~ 10-20Myr

Infrared Excess toward HD106797

- One of new debris disk candidates discovered from AKARI/IRC Mid-Infrared All-Sky Survey
- Large 18μm excess

AKARI Mid-Infrared All-Sky Survey

- λ=9μm (S9W) & 18μm (L18W)
- More than 90% of the sky is covered
- Higher sensitivity and spatial resolution than IRAS

Channel	S9W	L18W
Wavelength	6-12 μm	14-26 μm
Detection Limit	50 mJy	120 mJy
Saturation	36 Jy	96 Jy
Spatial Resolution	<9.4"	<9.4"

3. Gemini Observations and Results

Gemini Observations

- Gemini/T-ReCS
  - Subaru/Gemini Time Exchange Program
- Jun-Jul 2008
- λ=8.8, 9.7, 10.4, 11.7, 12.4, 18.3μm
- Diffraction limit 0.3" @ 11.7μm
- Standard star (HD110458) is also observed

Table 1
Summary of *Gemini*/T-ReCS Observations

Object	Filter (μm)	Date & Time (UT)	Integration (s)	Air Mass	Comment
HD 106797	18.3	2008 Jun 10 04:18:04	811	1.79	...
HD 110458	18.3	2008 Jun 10 05:09:19	116	1.91	Standard
HD 106797	12.3	2008 Jun 12 03:10:34	174	1.50	...
HD 106797	11.7	2008 Jun 12 03:20:49	116	1.52	...
HD 106797	10.4	2008 Jun 12 03:27:48	58	1.54	...
HD 106797	9.7	2008 Jun 12 03:31:32	174	1.56	...
HD 106797	8.8	2008 Jun 12 03:41:48	58	1.59	...
HD 110458	8.8	2008 Jun 12 03:48:42	58	1.45	Standard
HD 110458	9.7	2008 Jun 12 03:52:26	58	1.46	Standard
HD 110458	10.4	2008 Jun 12 03:56:10	58	1.48	Standard
HD 110458	11.7	2008 Jun 12 03:59:55	58	1.50	Standard
HD 110458	12.3	2008 Jun 12 04:03:39	58	1.52	Standard

Results

- SED
  - IRC fluxes and T-ReCS fluxes are consistent
  - IR excess is certainly associated with the star
  - IR excess at λ > 10μm
  - SED Model

$$F_{\nu,\mathrm{model}}(\lambda) = \mathrm{Kurucz}(T_{\mathrm{eff}} = 9750\,\mathrm{K}) + \mathrm{BB}_\nu(\lambda, T_\mathrm{d})$$

- Td=192K provides the best-fit
  - Inner radius of debris disk ~ 14AU
- Ldust=0.008Lsun
- Ldust/Lstar=0.0002
- Dust features around 11-12μm exist

Table 2
Infrared Photometry of HD 106797

λ (μm)	F_ν (mJy)	Instrument	Photosphere[a] (mJy)	Significance, χ[b]
8.8	201 ± 20	T-ReCS	206	−0.3
9	216 ± 15	IRC	214	0.1
9.7	165 ± 17	T-ReCS	166	−0.1
10.4	159 ± 15	T-ReCS	145	0.9
11.7	180 ± 14	T-ReCS	115	4.6
12.4	160 ± 13	T-ReCS	104	4.2
18	128 ± 19	IRC	55	3.8
18.3	119 ± 59	T-ReCS	47	1.2

Notes.
[a] Fitted from Kurucz model to 2MASS K_s-band data.
[b] χ = (Observed − Kurucz)/noise.

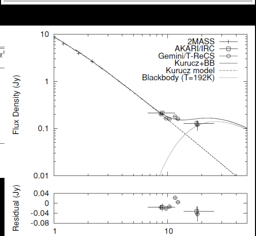
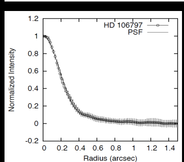


Figure 1. Top: the NIR and MIR SED of HD 106797 and the results of SED fitting with a model which is consistent with a Kurucz model for photospheric contribution and a blackbody of a single temperature T_d = 192 K for dust emission. Open squares and circles indicate the photometry with the *AKARI*/IRC and *Gemini*/T-ReCS, repectively. The solid, dashed, and dotted lines indicate the total SED, photospheric contribution, and dust emission of the blackbody model, respectively. Bottom: the residuals subtracted by the best-fit SED model in the MIR region.

- Radial Profile
  - Spatially unresolved at 11.7μm
  - No significant structures in the radial profile
  - Disk size < 0.43" ~ 41AU at 96pc
    - Harmonic with the inner radius derived from the SED



The peak-normalized azimuthally averaged radial profile of HD106797 (open circles) and PSF standard (solid line) at 11.7μm.

4. Discussion

Features in the N-band

- Significant bump at ~11-12μm in the excess emission
- Additional model fit

$$F_{\mathrm{excess},\nu}(\lambda) = a\kappa(\lambda)\mathrm{BB}_\nu(\lambda, T_\mathrm{d}),$$

- κ(λ): mass absorption coefficients of forsterite, fayalite, 0.1 and 2.0 sized amorphous silicates
- Crystalline silicate (fayalite) is likelier carrier than amorphous sllicates
- The observed feature seems to be located at slightly longer wavelength than the peak of crystalline silicate
  - Possible existence of other species?

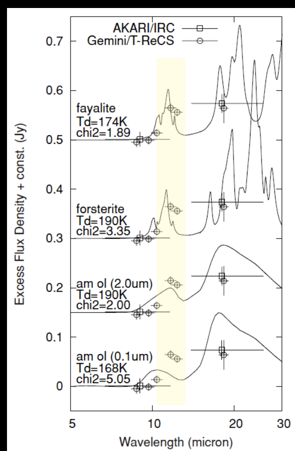


Figure 2. Excess flux densities together with model fit results of various dust species. The open squares and circles indicate the residual flux densities with the *AKARI*/IRC and *Gemini*/T-ReCS, repectively. The solid line indicates the best-fit result for each of the dust species (0.1 μm- and 2.0 μm-sized amorphous olivine (Dorschner et al. 1995), crystalline forsterite (Koike et al. 2003), and crystalline fayalite (Koike et al. 2003)). The resultant best-fit dust temperature and χ^2_ν-value for each dust species are also shown. As seen in this figure, crystalline fayalite provides the best-fit result.

Origin of Hot Dust

- Fractional luminosity Ldust/Lstar~2e-4
  - x1000 larger than our zodiacal dust
- Simple model for the steady state evolution of debris disks due to collisions by Wyatt et al. (2007)
  - Ldust/Lstar>1e-4 is obtained only in young debris disks (age < a few Myr)
  - Transient dust production events must undergo around HD106797 (10-20Myr)
  - Late Heavy Bombardment?
- LHB seems to tend to cause dust heating and generate crystalline silicates efficiently?

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