A search for debris disks
based on the *AKARI* mid-infrared all-sky survey

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

ABSTRACT

After the IRAS observations, main-sequence stars that have circumstellar debris disks and thus show infrared excess have been discovered. Since debris disk is thought to be the final stage of planet formation, it is very important to property and evolution of debris disks statistically. The AKARI is the first Japanese infrared astronomical satellite dedicated for infrared astronomy. The mid-infrared survey was carried out with the 9 μm and 18 μm bands using the Infrared Camera with higher sensitivity and spatial resolution than IRAS. We are carrying on the unbiased survey of debris disk candidates that show mid-infrared excess by using the AKARI/IRC mid-infrared all-sky survey data. So far, we have seven new debris disk candidates that show large 18 μm excess. More systematic survey is also ongoing based on Hipparcos and 2MASS catalog. In this presentation, we show the initial results of the debris disk survey.

1. Debris Disk

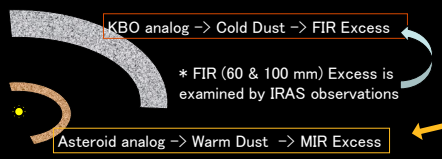
Infrared Excess

- "Vega-like stars"
  - Main-sequence stars with infrared excesses (λ>25μm)
- 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



AKARI MIR all-Sky Survey is very powerful to study dust generated by collision of "asteroids"!

2. AKARI Observations

AKARI

- Japanese Infrared Satellite
- Launch: 2006/2/22
  - Lhe: ~2007/8/27
  - Now: Warm mission (NIR)
- IRC (InfraRed Camera)
  - Near-/Mid-Infraerd
- FIS (Far-Infrared Surveyor)
  - Far-Infrared

IRC Mid-Infrared All-Sky Survey

- λ=9μm (S9W) & 18μm (L18W)
- More than 90% of the sky is observed at least twice
- 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″

* Parameters of AKARI/IRC MIR All-Sky survey

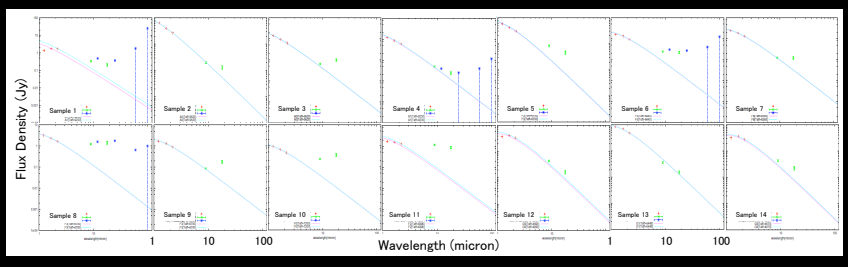
3. Results of the Pilot Survey

Strategy

- Take main-sequence stars and their position from Tycho-2 spectral type catalog (Wright et al. 2003)
- Look for nearby Infrared counterparts in AKARI MIR images and get their MIR fluxes
- Take Ks-[L18W] colors as MIR excess indicators for the 18μm-detected sources
- Find stars which show significant 18μm excesses based on the Ks-[L18W] colors (Ks-[L18W] > 0 -> Excess)
- Remove contaminated or mis-identified sources by comparing the AKARI images with DSS and 2MASS images

Identified 18μm Excess Sources

- 14 stars are identified as debris disk candidates that have large 18μm excesses (larger than 50% of photosphere level)



Statistics

Spectral Type	Detect at 18um	Excess at 18um	Freq (%)
A	217	4	1.8
F	331	7	2.1
G	204	3	1.5
K	153	0	0.0
M	23	0	0.0
Total	910	14	1.5

- Excess Frequency = 14/910 ~ 1.5%
- Lower value than Spitzer's results
  - A stars ~ 31% (Su+ 2006)
  - FGK stars ~ 6% (Beichman+2006)
- Due to the difference in detection threshold?
  - Spitzer can detect fainter excesses (~10% of photosphere)
- Spectral type dependency?
  - Early-type: higher frequency
  - Late-type: Lower frequency
  - Due to the difference in stellar lifetimei

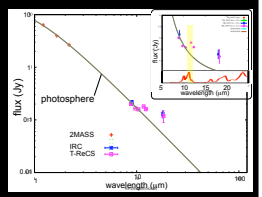
4. Ground-based Follow-up Observations

Merits

- Follow-up observations of the newly-discovered debris disk candidates were made with Subaru/COMICS and Gemini/T-ReCS
- High spatial resolution
  - Elimination of contaminations and mis-identification
  - Spatial distribution of debris dust
- Multi-band photometry

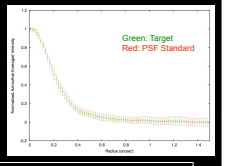
Case of Sample 2

- Observations
  - Gemini/T-ReCS
  - Jun-Jul 2008
  - λ=8.8, 9.7, 10.4, 11.7, 12.4μm
  - Diffraction limit 0.3″ @ 11.7μm
- Properties of Sample 2
  - SpT=A0V, d=100pc



Results

- SED
  - AKARI/IRC <-consistent-> Gemini/T-ReCS
    - IR excess is certainly associated with the star
  - IR excess at λ > 11μm
    - Max Td ~300K, Inner Radius ~ a few AU
  - Feature at ~11μm -> Crystalline Forsterite?
- Radial Profile
  - Spatially unresolved at 11.7μm
  - Disk size < 0.3″ ~ 30AU at 100pc
    - Harmonic with the inner radius derived from the SED



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