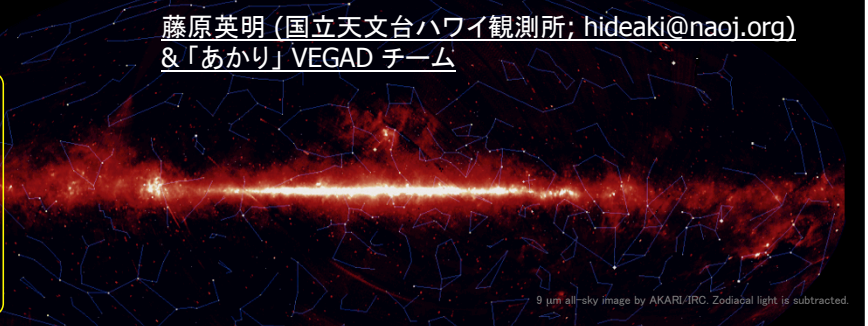
「あかり」による温かいデブリ円盤の観測

AKARI Observations of Warm Debris Disks

藤原英明 (国立天文台ハワイ観測所; hideaki@naoj.org)
& 「あかり」 VEGAD チーム

ABSTRACT

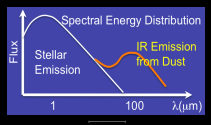
We report results from our search for warm debris disks with large MIR excess from the AKARI/IRC All-Sky Survey. 24 stars are identified as candidates of warm debris disks. We also report detections of rare dust compositions (silica and ensitatite) in the Spitzer/IRS spectra of two AKARI-indentified sources, HD 15407A and HD 165014, suggesting variety of mineralogical features of dust in warm debris disks.

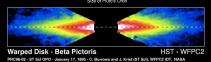


1. Debris Disk

Infrared Excess

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

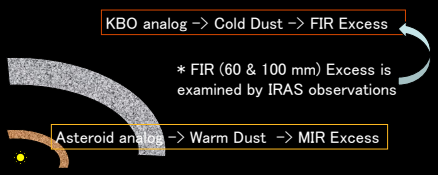




Origin of Dust

- 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. AKARI/IRC MIR Survey of Warm Debris Disks

- Red: Newly Discovered by AKARI
- Yellow: 1st confirmation after IRAS

AKARI Mid-Infrared All-Sky Survey

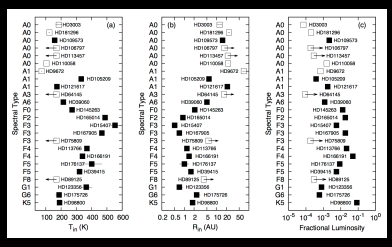
- λ=9μm (6-12μm; S9W) & 18μm (14-26μm; L18W)
- More than 90% of the sky is covered with higher sensitivity and spatial resolution (<10") than IRAS

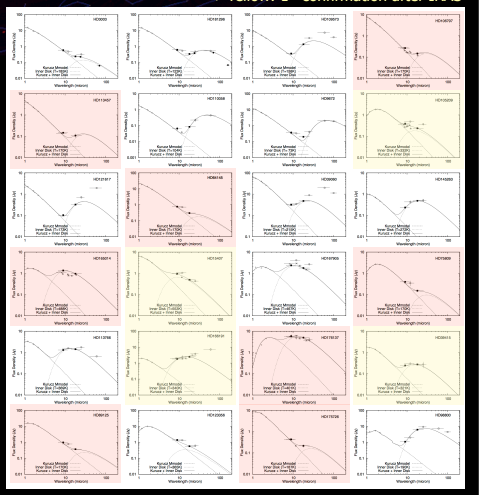
Procedure of Debris Disk Search

- Cross-correlation with dwarf (V) stars in Tycho-2 Spectral catalog and 2MASS catalogs
- Search stars with [Ks]-[18] significantly > 0
- Derive temperature (T_d), radius (R_{in}), fractional luminosity (L_d/L_*) of debris material emitting MIR excess

Results

- 24 sources identified from 856 stars (2.8%)
- Different characteristics between A and FGK stars

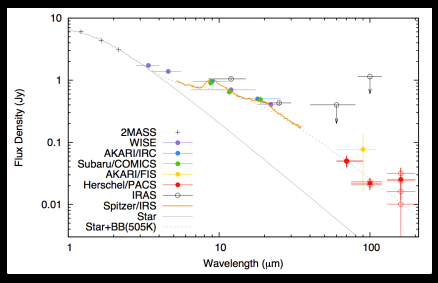




- FGK stars; Higher T_d (>~300K), Larger L_d/L_* (~10^{-3}-10^{-1})
- A stars; Lower T_d (<~200K), Smaller L_d/L_* (~10^{-5}-10^{-3})
  - Possibly due to dissipation of small dust by radiation pressure around earlier-type stars

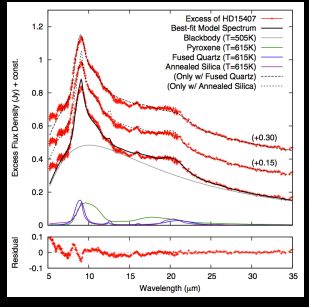
3. Follow-up Observations of AKARI-detected Debris Disk

HD 15407A: Bright Silica-Rich Warm Debris Disk w/o Cold Dust



NIR-FIR SED

- HD 15407A
  - F3V star at d=55pc
  - Age: 2Gyr – 80Myr (Melis+10)
- Excess Emission at ~5-160μm
- Continuum component
  - Consistent with ~500K blackbody
  - R_{dust} ~ 0.6-1.0 AU
  - L_d/L_* ~ 0.005 – (x10^3-10^5) larger than Steady-state model of planetesimal collisions (Wyatt+07), suggesting transient event
  - Mass ~ 3x10^{23} kg ~0.05 M_{Earth} assuming dust size of $n(a) \propto a^{-3.5}$, a_{min}=10μm, a_{max}=1km



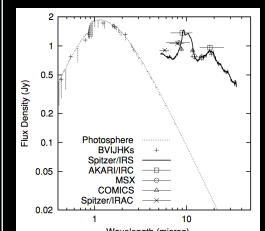
MIR Spectrum by Spitzer/IRS

- Prominent Dust Feature at ~10 and ~20μm
  - Well-fitted with silica (SiO_2) and μm-sized amorphous silicate of ~500-600K
  - Mass ~ 7x10^{17} kg ~10^{-7} M_{Earth} for fine dust
  - Silica – Possible sign of hyper-velocity impact (Lisse+10)

Origin of Warm Debris Disk around HD 15407A

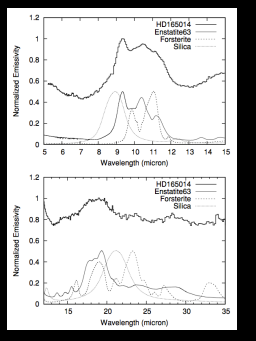
- From the surface layer of differentiated large rocky bodies?
- NIR-FIR SED suggests the absence of cold dust (~50-70K)
  - Late heavy bombardment-like event is not supported as an origin of warm debris dust around HD 15047A
- Giant Impact-like event?
- Trap mechanism of μm-sized dust against radiation pressure

HD 165014: Enstatite-Rich Warm Debris Disk



NIR-MIR SED

- HD 165014
  - F2V-B8V star at d=70-190pc with large Av (1.9-3.0)
- Excess Emission at ~5-35μm
- Continuum component
  - Consistent with ~500-300K blackbody
  - L_d/L_* ~ 0.005
  - R_{dust} ~ 0.7-4.4 AU



MIR Spectrum by Spitzer/IRS

- Dust Feature at ~10 and ~20μm
  - Consistent with (crystalline) enstatite ($MgSiO_3$)
  - The first debris disk sample that has enstatite as a dominant form of crystalline silicate rather than forsterite (Mg_2SiO_4)
  - Possible link to E-type asteroids and Aubrite in the solar system
  - Trap mechanism of μm-sized dust against radiation pressure around early type star

See also: Fujiwara et al., ApJ 695, L88–L91 (2009); Fujiwara et al., ApJ 714, L152–L156 (2010); Fujiwara et al., ApJ 749, L29 (2012a); Fujiwara et al., ApJ 759, L18 (2012b); Fujiwara et al., A&A, 550, A45 (2013).