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# Nearby debris disk systems with high fractional luminosity reconsidered

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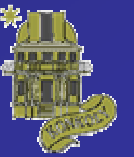


## Discovery of main-sequence stars with IR excess

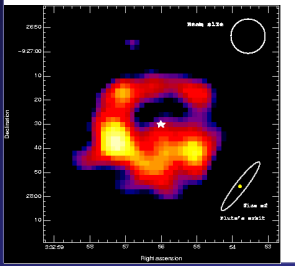
- One of the major discoveries of the InfraRed Astronomical Satellite:

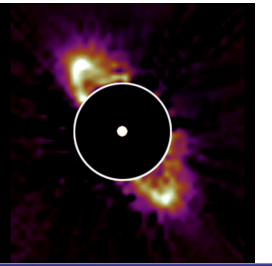
  ~15% of main-sequence stars show infrared excess!

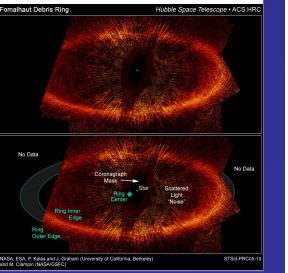
- Origin of the excess:

  thermal emission of dust grains.

- Dust grains are relatively cold (T~50-90K) in these disks, very few warm disks (Earth temperature) have been found.





## Debris disks

- Lifetime of dust grains orbiting main-sequence stars << age of the central star:

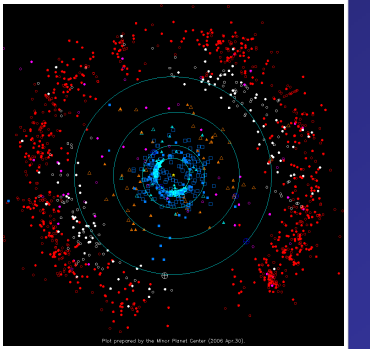
  observed dust grains must be replenished!

- Best explanation for replenishment process:

  collisons between planetesimals in exosolar Kuiper belts.

- Debris disks are composed of second generation material, released after planetesimals have formed.

- The formation and evolution of debris systems could be intimately linked to the formation of planetesimals and to the evolution of the established planetary system!



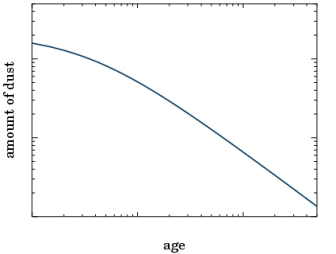

Planets and minor bodies in our solar system.

Red symbols: Kuiper belt objects

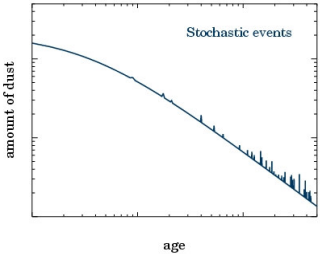
## Theoretical predictions for the evolution of debris disks

- According to recent models for the evolution of planetesimal disks:

  the amount of dust decrease with time in a debris system.




- Stochastic events (e.g. collisions between large asteroids) may modify this general trend temporarily.



## Observational results I

- Infrared Space Observatory (1995-1998):

  - debris disks are more common around young stars than around old ones

  - old debris disks are less massive than younger ones.

  (Decin et al. 2000, Silverstone 2000, Habing et al. 2001, Spangler et al. 2001, Decin et al 2003)

- Spitzer Space Telescope (2003 - )

  - observed a general decay in the degree of IR excess on a timescale of 150Myr around A-type stars (Rieke et al. 2005).

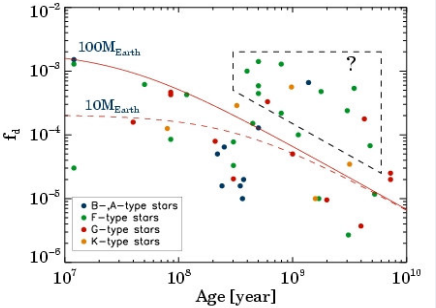
## Observational results II

- Decin et al. (2003) reinvestigated the ISO results:

  - the amount of dust in a debris disk was characterised by its fractional luminosity $f_d = L_{IR} / L_{bol}$

  - in several cases revised ages of stars

  - relatively high number of old stars (age > 500Myr) with high fractional luminosity were found!




- IRAS based searches also revealed several old debris candidates with high $f_d$ (Zuckerman & Song, 2004).

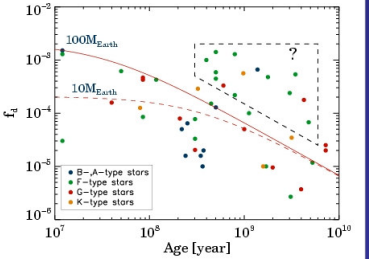
## Possible observational artifacts

- The presence of these peculiar old systems might partly be observational artifact:

  - in the last few years several IRAS-based debris candidates turned out to be misidentifications (source confusion, excess emission has interstellar origin rather than circumstellar …)

  - errors in the far-infrared photometry

  - uncertainties in the age determination.




Bogus disks have to be identified and discarded!

## Goals of our study

**Main goals:**

1. to study the evolution of debris disks
2. to check the existence of special systems, whose evolution deviate from the general trend
3. to test the hypothesis that a significant fraction of debris disks with high fractional luminosity are much younger than was previously thought

## Input list

- Input list for our study:

  - we identified debris disk candidates (B9-M0 type main-sequence and subgiant stars with IR excess) in the IRAS and ISO databases.

- IR catalogues: IRAS Faint Source Catalog; IRAS Serendipitious Survey Catalog; Catalogue of far-infrared observations of normal measured with the ISOPHOT in mini-map mode.

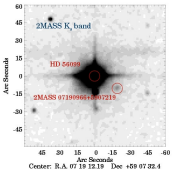
- Star catalogues: Hipparcos Catalogue; Tycho2 Spectral Catalogue.

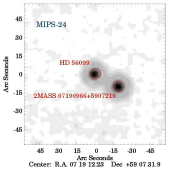
364 candidate stars were found.

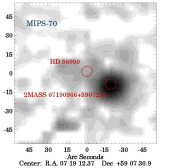
## Rejection of bogus disks and suspicious candidates

- Known young stellar objects (T Tauri, Herbig Ae/Be stars) were excluded.
- For part of the sample (110 candidates) higher spatial resolution infrared maps are available (ISOPHOT, MIPS). 24 bogus disks were identified (reasons: source confusion, or extended nebulosity) and discarded.
- Where neither ISO nor Spitzer maps were available:

dubious candidates were filtered out by searching the immediate vicinity of IRAS objects for other possible sources of the observed emission (galaxies, Mira stars, …).



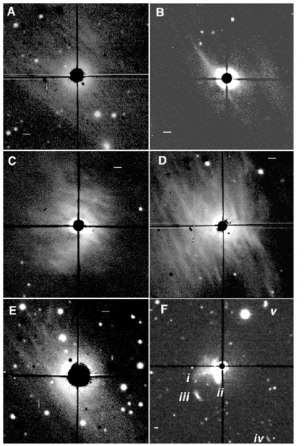
## Constructing a volume-limited sample

- Earlier studies (Kalas et al. 2002) suggested:

  - a significant fraction of IRAS-based debris candidates beyond the Local Bubble might be bogus (star illuminates nearby interstellar matter rather than a circumstellar disk).

- Location of our candidates were checked considering the wall of the Local Bubble (Lallement et al, 2003) and discarded all objects situated in the wall or beyond.

- We defined a maximum distance limit of 120pc for our candidates.




Diffuse nebulosity around former debris candidates

## Final list

- For the remaining sample the fractional luminosity was calculated.
- For the further analysis debris sytems with high fractional luminosity ($f_d > 10^{-4}$) were selected.
- The final catalogue contains 60 debris systems. Eleven of them are new discoveries.

## Age estimates

- Age determination for main-sequence field stars is challenging. On the other hand the ages of young stellar kinematic groups (e.g. β Pictoris moving group, Tucana-Horologium association) are relatively well determined.

  - We performed a systematic investigation of the possible relationship between excess stars and nearby moving groups and stellar associations

  - Our 60-object sample 26 could be linked to nearby young stellar groups (13 new discoveries)

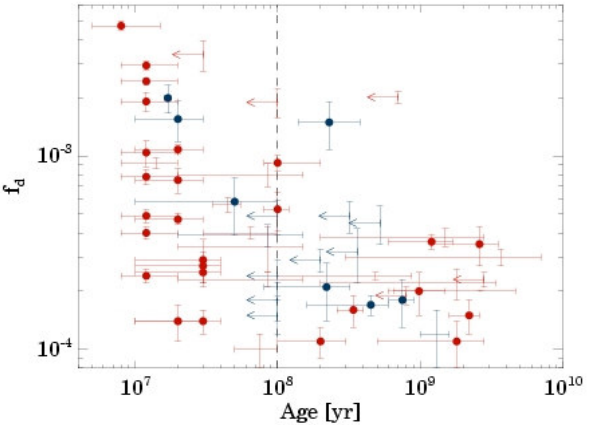
  - Incidence of moving group members in the sample is very high (26/60). Our study indicates that debris disks of high fractional luminosity are much more intinately linked to the nearby young stellar kinematic groups than the ensemble of normal stars in the same volume!

- For the rest of the sample age estimates were:

  1/ taken from the literature

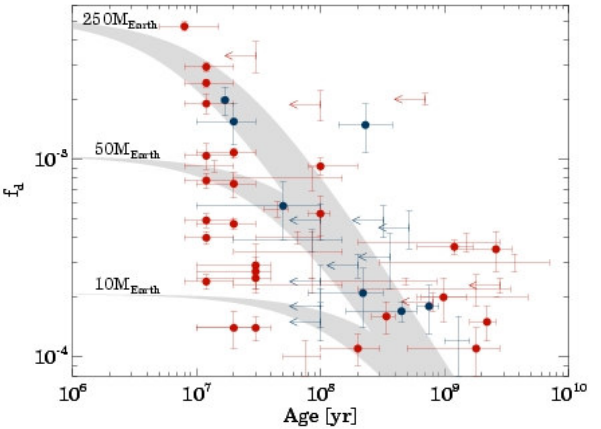
  2/ made by ourselves (isochrone age, strength of Ca II H&K line, X-ray luminosity)

## The relationship between fractional luminosity and age




Red symbols mark those debris systems whose existence was explicitely confirmed by an instrument independent of IRAS.

## Debris disk evolution and the cases of old systems



## Conclusions

1. We compiled a list of 60 debris disk systems of high fractional luminosity. Eleven of them are new discoveries, and 4 out of this 11 have been confirmed by Spitzer observations.
2. Disks with high fractional luminosity often belong to young stellar kinematic groups, providing an opportunity to obtain improved age estimates for these disks.
3. Practically all objects with $f_d > 5*10^{-4}$ are younger than 100Myr.
4. The number of old systems with high $f_d$ seems to be lower than was claimed before, mainly as a consequence of the age revision in connection to the young stellar kinematic groups.
5. Comparing the theoretical evolutionary model of Dominik&Decin with the observations in the fractional luminosity versus age diagram, good general agreement was found.

Thank you!

## Example: HD 56099

- HD 56099 was identified as debris system with high fractional luminosity based on IRAS observations (Silverstone 2000, Zuckerman & Song 2004).