Large surveys of nearby stars in the far-IR and submillimetre will soon provide improved statistical insight into debris disks, complementing Spitzer results at shorter wavelengths.

Introduction

We wish to determine how debris detection rates and the masses and radial distributions of dust vary as a function of all stellar parameters e.g. age, metallicity, stellar mass/temperature, binarity, planet host status etc. To do this in general requires large samples of stars chosen in an unbiased manner (e.g., so that we obtain general results, not just results for particular groups of stars). It also requires wide wavelength coverage extending out to the submillimetre to detect dust at all possible temperatures.

Spitzer has been revolutionary in its sensitivity to debris disks warmer than ~50K, detecting many new disks around Sun-like (F-K) and A-type stars (e.g. Su et al. 2006, Trilling et al. 2007). However most Spitzer surveys have suffered from selection effects in their samples and varying sensitivities which mean that drawing general statistical conclusions is not easy.

Large surveys at longer wavelengths with Herschel and JCMT/SCUBA-2 will soon start to provide the statistics we seek. The surveys outlined here will observe nearby A-M type main sequence stars. As well as providing broad distributions of stellar parameters, stars in the solar neighbourhood are of particular interest because of their potential to be spatially resolved, both partially with Herschel and SCUBA-2, and in exquisite detail with ALMA in future.

Longer wavelengths also probe larger dust grains in the midplane of disks, which can interact gravitationally with planets. This means the prescence of planets may be inferred from some detections.

The SCUBA-2 Unbiased Nearby Stars Survey

The SUNS survey (Matthews et al. 2007) will perform an unbiased flux limited search of 500 nearby main-sequence star systems for debris disk emission at 850μm with SCUBA-2 / JCMT. This will be the first unbiased debris disk survey since IRAS, and will be over an order of magnitude larger than any previous survey of stars in the submillimetre.

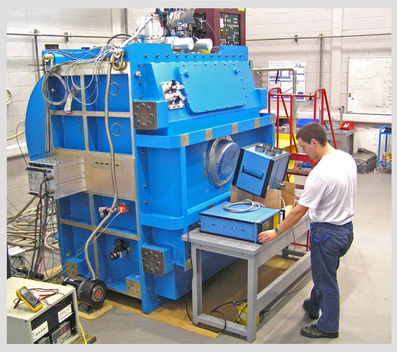
Goals and Motivation

- Determine unbiased statistics on the incidence of disks around nearby stars.
- Constrain disk masses and temperatures for mid/far-IR detections (e.g. by IRAS, ISO, Spitzer, AKARI, Herschel)
- Discover numerous disks too cold to be detected in the mid/far-IR
- To be the basis of source lists for ALMA, which will be able to map disks with 20 mas resolution
- Provide limits on the presence of dust around nearby stars that are vital to exoplanet imaging missions such as Darwin and TPF

Strategy and Timeline

- Target list: 5 volume limited samples of 100 systems with main-sequence primaries of spectral types A, F, G, K, M. These are the nearest systems with -40° < δ < +80° from Phillips et al. samples
- Observation depth: σ = 0.7mJy. chosen to equal the 850μm extragalactic confusion limit of JCMT
- Expect to start observing summer 2009
- Allocated 390 hours of observing time, 330 in first 2 years => survey largely complete by 2011
- Although SCUBA-2 will simultaneously observe at 450μm we will propose deep 450μm follow-up observations of disks detected at 850μm to take full advantage of the 7″ resolution at 450μm.

JCMT



SCUBA-2

The DEBRIS and DUNES surveys with Herschel

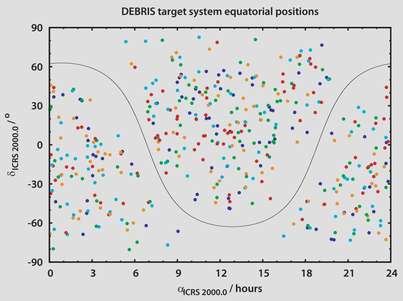
Herschel is a 3.5m diameter satellite with imaging instruments operating at 70-500μm (PACS: 70,110,170μm; SPIRE: 250, 350, 500μm). This coverage is ideal for detecting and characterising debris disks. In particular the 110μm band, corresponding to the peak of emission from ~30K dust, offers the best chance ever of detecting cold disks like our Kuiper Belt. On the downside interstellar dust (*Cirrus*) also emits most strongly at these wavelengths, limiting sensitivity towards many stars. Two Open Time Key Programs have each been allocated 140 hours of time to study nearby stars:

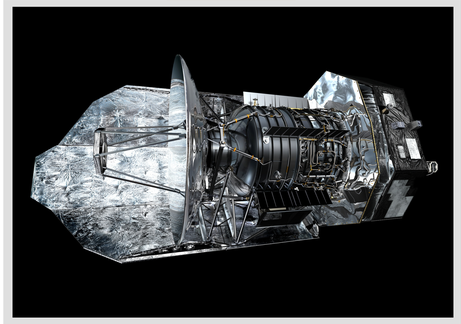
- DEBRIS (Disk Emission via a Bias-free Reconnaissance in the Infrared/Sub-millimetre): Designed as a complement to the SUNS survey. Focus on detection statistics for a large sample of stars. Primarily using PACS at 110μm, with SPIRE follow-up.

- DUNES (DUst disks around NEarby Stars): An in depth study of nearby K-F stars using many wavelengths. Contrast limited strategy (as opposed to flux limited for DEBRIS and SUNSS). Focus on characterisation of known disk and planet systems.

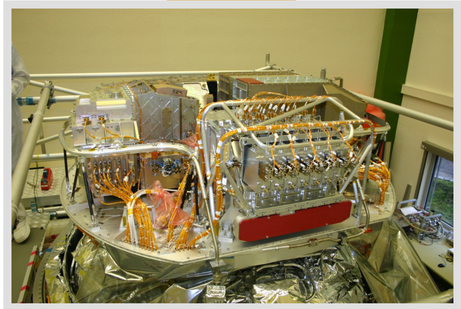
The DEBRIS survey

- flux limited [σ(110μm) = 1.2 mJy] 110+170μm for all targets plus 100 SPIRE follow-up observations
- Targets: 450 total systems, 5 volume limited subsamples of A,F,G,K,M types, each the nearest ~90 systems from Phillips et al. samples with predicted 110μm confusion < 1.2 mJy. See figure.
- Probe lower dust masses for 20K < T < 70K than ever before => can detect true Kuiper Belt analogs
- Collaboration with DUNES team, particularly for targets both teams had proposed to observe.





Herschel satellite



PACS, SPIRE and HIFI

Dust mass sensitivity vs. dust temperature / orbital radius for typical observations with various instruments for the Sun placed at the median distance of G type stars in the SUNSS/DEBRIS surveys (lower is better). The three coloured bands show the temperature ranges where Spitzer/MIPS (blue), Herschel/PACS, and JCMT/SCUBA-2 are the most sensitive.

References

Gray R.O. et al., 2003, AJ, 126, 2048

Gray R.O. et al., 2006, AJ, 132, 161

Henry T.J. et al. ,2006, AJ, 132, 2360

Matthews et al., 2007, PASP, 119, 842

Phillips et al. in prep. for MNRAS

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Su K.Y.L. et al., 2006, ApJ, 653, 675

Trilling D.E. et al., 2008, ApJ, 674, 1086

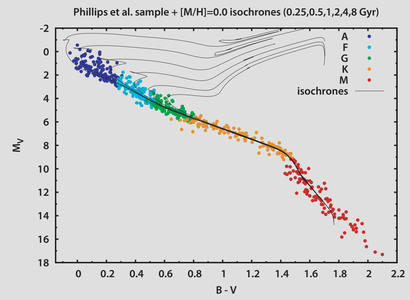
van Leeuwen F., 2007, book

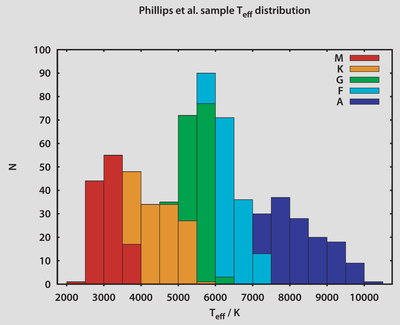
Target selection for SUNSS and DEBRIS

To maximise the legacy value of these surveys clear selection criteria were required, and to avoid any unknown biases these criteria had to be fulfilled as accurately as possible. A single sample of star systems has been created from which both surveys draw their targets (Phillips et al. in prep.).

- Targets are stellar systems where the primary is a main sequence (hydrogen burning) star
- 5 complete volume-limited subsamples of systems with primaries of spectral type A, F, G, K, M. Distance limits are: 45.5, 24.1, 21.3, 15.6, 8.6 pc. All have ~130 systems.
- Late-type (low temperature) cutoff at M7.0 to avoid contamination by young brown dwarfs
- Early-type (high temperature) cutoff at A0, as O and B stars are too rare

We have used parallaxes and spectral types from many sources (e.g. Leeuwen 2007, Gray et al. 2003/6, Henry et al. 2006), with the goal of making our sample as complete as possible at the time (late 2007). Nearby M dwarfs are still regularly being discovered e.g. by the RECONS team. We used photometry as a cross-check for spectal types and for determining whether A-G stars are main sequence.





For simplicity our subsamples are defined by spectral type rather than effective temperature or stellar mass. This leads to the temperature distribution shown on the left. The peak around 6000 K is due to the F and G spectral types covering a small temperature range compared to A, K and M types. The distribution is flat enough for statistical conclusions to be drawn as a function of stellar temperature.

Debris Disk Surveys with SCUBA-2 and Herschel

Neil Phillips (1), and the SUNSS and DEBRIS colaborations

(1) Institute for Astronomy, University of Edinburgh

SUPA

The University of Edinburgh

Royal Observatory Edinburgh

Science & Technology Facilities Council
UK Astronomy Technology Centre