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DUst around NEarby Stars (DUNES): description of the project and results.

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Abstract

DUNES is an Open Time Key Programme of the *Herschel* Space Observatory aimed at detecting and studying cold dusty –debris– discs, i.e. Kuiper-belt analogues, around FGK stars of the solar neighbourhood, in a volume-limited sample of 133 stars. The sensitivity and wavelengths of the two instruments used, namely PACS (70, 100, and 160 μm) and SPIRE (250, 350, and 500 μm) are the appropriate ones for these tasks. Debris discs are the result of collisions of planetesimals formed at early stages of the star formation episode, when the star is younger than about 30 Myr, and the discs, so-called protoplanetary, are composed of gas and dust. The whole sample is already observed and the team is currently analysing the data. We outline here some of the main results we have found.

1 Introduction

DUNES is a *Herschel* [12] Open Time Key Programme (OTKP) designed to detect and characterize cold, faint, debris discs, i.e., extra-solar analogues to the Kuiper belt, around a statistically significant sample of main-sequence FGK nearby stars, taking advantage of the unique capabilities of the PACS [13] and SPIRE [5] instruments. The survey has been designed to address fundamental questions that will help to evaluate the prevalence of planetary systems in the solar neighbourhood, putting the Solar System into context. The following

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are the main drivers behind our choice of the observing strategy and target selection: (1) what fraction of stars do show faint, cold discs? (2) what is their collisional and dynamical evolution?, (3) what are the dust properties and grain-size distribution?, and (4) what is the incidence of Kuiper-belt-like discs when compared with the presence of planets? A description of the project and some preliminary results were described in the Proceedings of the IX Scientific Meeting of the Spanish Astronomical Society [10].

The data are being analysed with radiative, collisional and dynamical dust disc models. The objectives of the DUNES survey are complementary to those of another OTKP, called DEBRIS [11]. Both projects share some sources and the corresponding data.

DUNES requires the detection of very faint excesses at the mJy level, comparable to the photospheric emission and only a few times the measurement uncertainties. The primary observing strategy was designed to integrate for as long as needed to detect the 100 μm photospheric flux, subject only to confusion noise limitations. Note that the minimum photospheric flux at 100 μm we are dealing with is around 4 mJy, whereas we would receive a similar flux at that wavelength from an analogue to our Kuiper belt placed at 10 pc.

The sample contains 133 stars, with spectral types FGK, at distances less than 20 pc. Also, all the stars with known planet candidates at less than 25 pc and all the stars with debris discs at less than 25 pc discovered by *Spitzer* are included.

2 Results

Table 1 shows a summary of the outcome of the project. Although the final numbers may change slightly, no big deviations should be expected when compared with those given in the table. In boldface characters we give the numbers corresponding to new detections.

Table 1: Results as of November 2012

	F-type	G-type	K-type	Total
Observed	27	52	54	133
No excess	18	39	44	101
Excess **(new)**	9 **(2)**	13 **(4)**	9 **(6)**	31 **(12)**
Resolved **(new)**	6 **(5)**	6 **(4)**	4 **(4)**	16 **(13)**
Stars with planets:	5	10	5	20
excess **(new)**	2	2 **(1)**	2 **(1)**	6 **(2)**

One of most striking results is that six out of the 31 excess sources show little or no infrared excess at 100 μm, but a significant excess emission at 160 μm. The spectral energy distributions (SEDs) of two of these objects, namely HIP 29271 and HIP 49908, are shown in Fig. 1. This excess emission has been attributed to circumstellar dust and suggested to stem from debris discs *colder* than those known before. Since the excess emission of the cold disc candidates is extremely weak, there is a danger that some –or even all– of the sources could be background galaxies, galactic background features, or even instrumental noise. In [6] we have carried out a deep study of these issues with several methods, concluding that

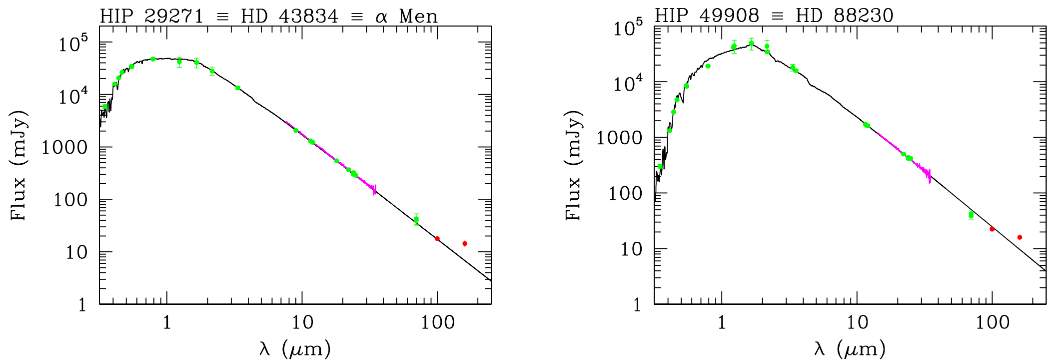

Figure 1: Spectral energy distributions for HIP 29271 (G5 V) and HIP 49908 (K8 V), two of the cold disc candidates. Green dots are the optical, near-IR and *Spitzer*/MIPS photometry, red dots are the PACS fluxes at 100 and 160 μm, in magenta the *Spitzer*/IRS spectra and in black the corresponding normalized model photospheres. The discovery of these discs is one of the main results from this project.

some of the candidates are likely to be true circumstellar discs, although a definite conclusion with the observational data currently available cannot be drawn. Assuming this to be the case, the dust temperatures inferred from the spectral energy distributions, and the disc radii estimated from the images, both suggest that the dust is nearly as cold as a blackbody. This requires the grains to be large, even if they are rich in ices or are composed of any other material with a low absorption in the visible. Our work shows the feasibility of an scenario of discs with unstirred primordial macroscopic grains. It is shown that such discs can survive for gigayears, largely preserving the primordial size distribution. They should be composed of macroscopic solids larger than millimeters, and smaller than a few kilometers in size. If larger planetesimals were present, they would stir the disc, triggering collisional cascades and thus producing small debris, which is not seen. This would imply that planetesimal formation, at the least in the outer regions of the systems, has stopped before “cometary” or “asteroidal” sizes were reached.

Since the beginning of the project, the following results have been published. We refer the reader to these papers for more details. Only works that have already appeared in refereed journals are listed:

- “Cold DUst around NEarby Stars (DUNES). First results. A resolved exo-Kuiper belt around the solar-like star ζ^2 Ret” [1].
- “Resolving the cold debris disc around a planet-hosting star. PACS photometric imaging observations of q^1 Eridani (HD 10647, HR 506)” [7].
- “A Herschel resolved far-infrared dust ring around HD 207129” [9].
- “Herschel discovery of a new class of cold, faint debris discs” [2].

- "Modelling the huge, Herschel-resolved debris ring around HD 207129" [8].
- "A peculiar class of debris discs from Herschel/DUNES. A steep fall off in the far infrared" [4].

3 Conclusions

All 133 DUNES targets have been observed. The main goals of the project have been achieved. The observational strategy, designed to make exposures for each target going as deep as necessary to reach the photospheric flux at 100 μm, has proven to be successful since all the targets have been detected. In addition to the results outlined in the text, other interesting targets are being modelled, the impact of the background contamination and of coincidental alignments is being studied, and a general paper describing the sample and analysing the results from an statistical point of view [3] will be published soon.

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