Herschel-SPIRE Observations of Debris Discs

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Abstract

Following its launch in early 2009, the Herschel Space Observatory will take over from Spitzer as the prime facility for observations of debris discs. This poster presents an insight into the data characteristics expected from the planned observations of debris discs. It focuses specifically on the quality and depth of the data. We analyse and compare the influence of the scanned and chopped observing modes on confusion noise and data quality, and present the optimal mode for the both the PACS and SPIRE instruments.

Herschel

The Herschel Space Observatory is due to be launched by ESA in early 2009. It contains a 3.5 metre telescope with a pay-load of three instruments, the PACS, the SPIRE, and HIFI. PACS and SPIRE are both dual instruments, comprising three band imaging photometers, and mid resolution spectrometers, while HIFI is a high resolution spectrometer. Herschel has a total wavelength coverage of 60 – 670 μm, thereby sampling the peak of the cold dust spectrum, and breaking the temperature / density degeneracy. Herschel will take over where Spitzer left off, by pushing out to longer wavelengths with high sensitivity and angular resolution.

Fig. 1: A computer model of the Herschel Space Observatory

SPIRE

SPIRE is the long-wavelength instrument on-board Herschel. The three bands of the imaging photometer are centred at 250, 350, and 500 μm, and contain 139, 88, and 43 feedhorn coupled bolometric detectors respectively.

Observing Modes: The feedhorn coupled design of SPIRE means that it does not sample the entire field of view in a single pointing. A fully sampled map can be produced by scanning, or by jiggling. The scanning mode scans the telescope field of view across the sky at a specific angle, chosen such that fully samples the sky with a single crossing. The jiggle map uses both chopping and nod operations while jiggling through a 64-point pattern to fill in the missing regions, and return a fully sampled image. Since the jiggle map has the higher mapping speed, at twice that of the scan map, jiggle mapping is the standard mode for small (4'x4') fields. Both scan and jiggle map observing patterns are shown in Fig. X.

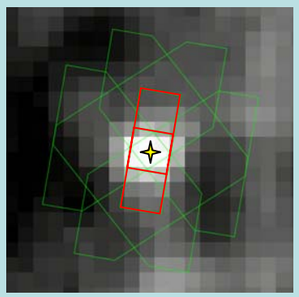

Fig. 2. Scanning (green) and jiggle map (red) patterns shown an IRAS 100 μm image of a typical star.

Planned Surveys

At present there are three programmes that have been awarded time on Herschel to observe debris discs – one guaranteed, and two open time programmes.

The guaranteed time programme will image the 6 large debris discs *Vega*, *βPic*, *Fomalhout*, *εEri*, *AU Mic and τCeti*, using both SPIRE and PACS. These observations will go beyond the confusion limit, with the aim of getting an accurate measurement of the background sources. With these data background galaxies will be modelled and removed from the field, thereby decreasing the effective confusion noise.

The open time programmes, titled DUNES and DEBRIS (see poster by Neil Phillips), focus on statistical analyses of disc observations. These programmes will study many different, and generally unresolved discs, to build up a picture of the characteristics of these sources.

Simulations of Debris Disc Observations

We used the SPIRE photometer software simulator to simulate the two regimes of the planned debris disc observation: *resolved* and *unresolved* discs. Simulated observations were performed for all SPIRE bands in both the jiggle-map and scan-map modes, with the aim of comparing their relative outputs. Of particular interest was the impact of the observing mode on the final confusion seen in the map. In order to assess the effect of the observing mode only, the simulations were performed without instrumental noise. Both maps were designed to produce a 4'x4' map.

Input Maps: The input maps to the simulations comprised of two layers, an extra-galactic background and a disc model. Realistic catalogues of extragalactic sources, scaled to the SPIRE wavelengths, were used to create the extra-galactic confusion background.

Two different models were used for the resolved and unresolved cases. For the unresolved sources a 5-σ point source was placed in the 250 μm band. The point source placed in the 350 and 500 μm bands was then scaled as λ^{-3}. For the resolved source simulations a simple torus model was placed in the map. The model parameters were based on the flux and dimensions of the εEri disc.

Results and Conclusions

The confusion noise was found to be ~20% higher in the jiggle maps than in the scan maps. This can clearly be seen in Fig. 3. In addition, the scan maps replicate the input confusion background with higher fidelity than the jiggle maps, where the background sources have been confused with those in the reference chop/nod position. This means that modelling and subtraction of the background galaxies will be far easier in the scan map case than the jiggle map case. In addition, the larger size of the scan map will make is easier to characterise and remove any foreground structure.

From this study we conclude that, for observations wishing to reach the confusion limit, the scan map observing mode will always be the optimal SPIRE mode for disc observations. Observations which are not required to reach the confusion limit, however, would be better observed with the higher mapping speed of the jiggle map mode. This will produce a lower noise map in less observing time, but will never be able to achieve the low noise levels seen in the scan map mode.

Since the PACS camera on Herschel will also implement similar chopped and scanned observing modes, these results should in principle also be true of PACS observations.

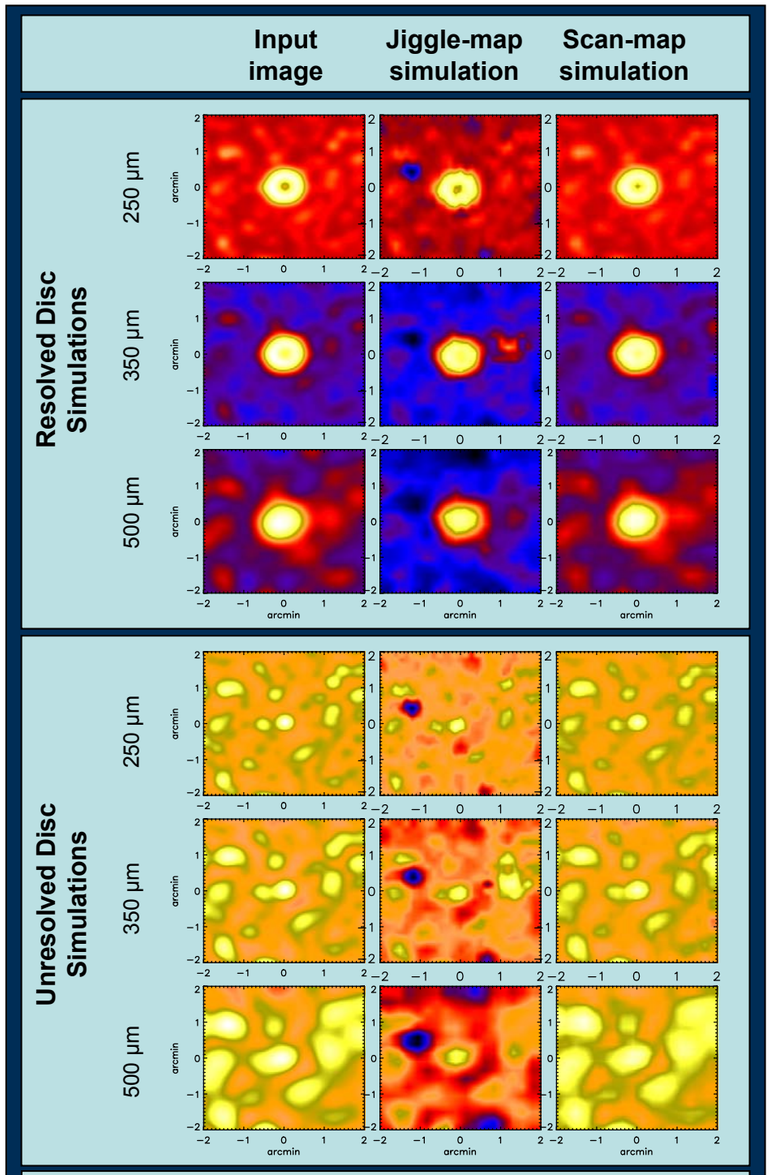

Fig. 3. Simulated observations of resolved (top) and unresolved (bottom) debris discs

Implications for Planned Surveys

The guaranteed time programme would benefit from performing scan map observations, as it will allow a lower confusion limit to be reached. It will also make removal of confusing background sources easier. The open time programmes however are not as concerned with reaching the confusion limit, but instead require the ability to observe many different sources. Therefore the jiggle map option is best suited to these programmes.