

ANALYSES OF THE ISO/ISOPHOT DATABASE IN PREPARATION TO THE HERSCHEL MISSION

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ABSTRACT

We report on our on-going work at Konkoly Observatory dedicated to the refinement of the calibration of ISOPHOT, the photometer on-board the *Infrared Space Observatory*, and to the generation of easy-to-use photometric catalogues and atlases from the ISO data. We present two examples (prediction of cirrus confusion noise; infrared variability) where ISOPHOT data can contribute to the preparation of the Herschel mission.

Key words: ISOPHOT; sky confusion noise; infrared variability.

1. INTRODUCTION

ISOPHOT, the photometer on-board the *Infrared Space Observatory*, was in many ways the predecessor of Herschel/PACS. It performed several thousand observations in the 3.6-200 micron range during its active period of 1995-98. Consulting the ISOPHOT Archive will probably be an obvious step during the preparation of Herschel proposals. Our group at Konkoly Observatory is contracted to ESA for interactive reprocessing and recalibration of selected ISOPHOT observing modes (for more details see <http://kisag.konkoly.hu>). We also contribute to the preparation of the Herschel mission, mainly focusing on the ground-based calibration of PACS.

2. ISOPHOT CALIBRATION WORK AT KONKOLY OBSERVATORY

All ISOPHOT observations have been processed by a pipeline, in order to produce calibrated data which are now publicly available from the ISO Data Archive (www.iso.vilspa.esa.es/IDA). The quality of the calibrated products, however, can further be improved via interactive processing; and the output can be presented in the form of photometric catalogues and spectral atlases, which are easier to use than the original format of the ISO Data Archive. With these aims, at Konkoly Observatory we have already finalised the recalibration of 3 ISOPHOT observing modes: (1) Far-infrared minimaps (C100 & C200 camera). This was the best mode of ISOPHOT

for point source photometry. We introduced transient correction, improved beam profile information, used a more efficient flux extracting method than the pipeline, and checked each observation interactively for any possible quality problem. (2) Far-infrared sparse maps (C100 & C200 camera). Similar technical improvements were introduced as for the minimaps. In many cases local background estimate, derived after flat-fielding from the border pixels of the C100 camera, was better than the "official" off-source position. (3) Mid-infrared spectrophotometry with ISOPHOT-S. By correcting for memory effects from preceding bright source, subtracting zodiacal background, and correcting for off-centre position of the source, we could improve the quality of many spectra significantly. Our on-going investigations include the re-calibration of the far-infrared chopped mode, and of point source photometry performed with the mid-infrared P1 detector. Our catalogues are available as Highly Processed Data Products (HPDPs) in the ISO Data Archive, as well as at <http://kisag.konkoly.hu>.

3. CIRRUS CONFUSION NOISE

Sky confusion noise is the ultimate limit of the achievable accuracy for point source photometry. At far-infrared wavelengths there are two major components: fluctuations due to the cosmic far-infrared background (accumulated light of unresolved galaxies), and small-scale structure of the Galactic cirrus emission. Though its strength is believed to decrease with the increasing resolving power of the telescope, confusion noise will not be negligible even for Herschel/PACS, especially longwards of 100 μ m. Therefore it is an important preparatory task to characterize this phenomenon and provide the community with a prediction tool.

At the moment ISOPHOT far-infrared maps form the most extended database which can be utilized for a confusion noise study. We evaluated about 200 large ISOPHOT raster maps (typically 0.5 deg in size) and calculated the confusion noise from pixel-to-pixel fluctuations (Kiss et al. 2001) for various measurement configurations. Then we determined the relationship between the computed values and the average surface brightness of the ISOPHOT

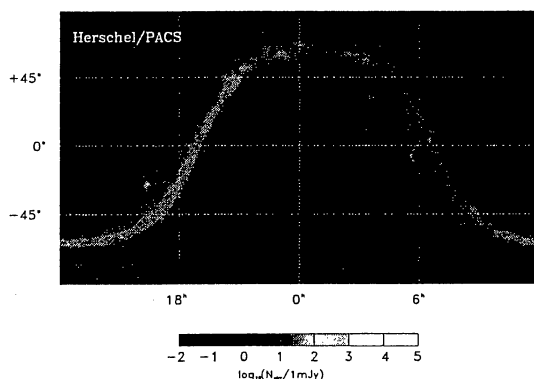


Figure 1. Prediction of point source sensitivity limits for Herschel/PACS at $175\mu\text{m}$ (Kiss et al. 2004).

maps (zodiacal component removed). The cirrus component of the confusion noise was extrapolated to the higher spatial resolution of the Herschel/PACS instrument, by looking at the power spectra of the maps, and characterizing the pixel size effect on simulated maps whose fractal dimension was derived from the power spectra (for more details see Kiss et al. 2004).

The results are summarized in the form of all-sky maps, which predict the sensitivity limits due to cirrus confusion noise for point sources (in mJy). Figure 1 shows the Herschel/PACS $175\mu\text{m}$ estimates as an example. The maps are available in electronic form at <http://kisag.konkoly.hu/>, under "IR Astronomy Tools". As next step we make predictions of the density of false sources "imitated" by the cirrus emission, as function of surface brightness, spatial resolution, and resolving power. We also plan to prepare a prediction tool which will help the preparation of the Herschel observing proposals.

4. INFRARED VARIABILITY STUDIES

It is expected that many types of objects, which are variable in the optical, show variability also at infrared wavelengths, though the physical reasons can be very different. Due to its long lifetime and high precision, Herschel will be able to monitor and document variability in the far-infrared. In the following, mainly based on ISOPHOT photometry, we propose several possible classes of targets for PACS variability studies.

FU Orionis objects. These young stellar objects are characterised by an optical brightening of 3-6 magnitudes, followed by a fading phase, lasting of or many years or decades. We compared IRAS (1983) and ISOPHOT (1995-98) infrared photometry looking for long-term flux evolution. In the case of V1057 Cyg the fading at $\lambda < 25\mu\text{m}$ is synchronised with the optical decay of the central source, indicating an optically thin circumstellar emitting medium (probably an envelope). The constant far-infrared flux, however, is in contradiction with the existing models

(Ábrahám et al. 2004). OO Ser showed an outburst in 1995, and ISO could monitor the fast fading of the source after the outburst. The wavelength dependence of the decay places strong constraints on models of the structure and energetics of the circumstellar medium. New Herschel observations will be essential to increase the temporal baseline and document the wavelength-dependent fading.

EX Lupi-type young stars. These objects produce sporadic 1-4 mag optical outbursts which last several months. Parts of the infrared spectrum follow the outburst, and the wavelength-dependence of the variability carries information on which regions of the circumstellar environment are directly illuminated by the central source. In the case of DR Tau ISOPHOT observations showed that only the $\lambda < 10\mu\text{m}$ part of the SED is changing.

Herbig Ae/Be stars. Many intermediate-mass young Herbig Ae/Be stars show infrared variability, which might be caused either by varying intrinsic luminosity of the star or by changes in the circumstellar dust configuration. The latter case may involve dust formation in a clumpy stellar wind or the appearance of cometary dust clouds revolving around the star on highly eccentric orbits. The ISOPHOT observations of SV Cep exhibit correlated flux variations at different infrared wavelengths, whose quantitative analysis may help to discriminate among the different possibilities.

Mira stars. The AGB star R Scl (spectral type C6.5nep) is a semi-regular variable with a period of 378 days. This type of giant stars has strong stellar wind and an envelope is formed around the star. The light of the giant star heats the envelope, hence we can observe it in the far-infrared. The 60 micron light curve of R Scl follows the optical light variation; the same is true for the 100 micron light curve. Assuming black-body radiation, the temperature of the envelope varies in phase with the central source between $\sim 200\text{ K}$ and 245 K during one light variation cycle.

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REFERENCES

- Ábrahám, P., Kóspál, Á., Csizmadia, Sz., Kun, M., Moór, A., Prusti, T., 2004, A&A accepted, astro-ph/0408048
- Kiss, Cs., Ábrahám, P., Klaas, U., Juvela, M., Lemke, D., 2001, A&A 379, 1161
- Kiss, Cs., Klaas, U., Lemke, D., 2004, A&A accepted, astro-ph/0409336