EPSC Abstracts
Vol. 5, EPSC2010-668, 2010
European Planetary Science Congress 2010

TNOs are Cool: A survey of the Transneptunian region with Herschel Space Observatory

Th. G. Müller, PI (1), E. Lellouch, Co-PI (2), H. Böhnhardt, Co-PI (3), J. Stansberry, NASA-PI (4), C. Kiss (5), P. Santos-Sanz (2), E. Vilenius (1), S. Protopapa (3), R. Moreno (2), M. Mueller (6), A. Delsanti (2,7), R. Duffard (8), S. Fornasier (2), O. Groussin (7), A. W. Harris (9), F. Henry (2), J. Horner (10), P. Lacerda (11), T. Lim (12), M. Mommert (9), J. L. Ortiz (8), M. Rengel (3), A. Thirouin (8), D. Trilling (13), A. Barucci (2), J. Crovisier (2), A. Doressoundiram (2), E. Dotto (14), P. J. Gutiérrez Buenestado (8), O. R. Hainaut (15), P. Hartogh (3), D. Hestroffer (2), M. Kidger (16), L. Lara (8), B. Swinyard (12), N. Thomas (17), A. Pal (5), D. Jewitt (18), A. Guilbert (18)

(1) Max Planck Institute for Extraterrestrial Physics, Germany, (2) Observatoire de Paris, France, (3) Max Planck Institute for Solar System Research, Germany, (4) The University of Arizona, USA, (5) Konkoly Observatory of the Hungarian Academy of Sciences, Hungary, (6) Observatoire de la Cote d'Azur, France, (7) Laboratoire d'Astrophysique de Marseille, CNRS Universite de Provence, France, (8) Instituto de Astrofisica de Andalucia (CSIC), Spain, (9) Deutsches Zentrum für Luft- und Raumfahrt, Germany, (10) Department of Physics and Astronomy, Science Laboratories, University of Durham, United Kingdom, (11) Newton Fellow of the Royal Society, Astrophysics Research Centre, Queen's University, Belfast, United Kingdom, (12) Space Science and Technology Department, Rutherford Appleton Laboratory, United Kingdom, (13) Northern Arizona University, Department of Physics & Astronomy, USA, (14) INAF-Osservatorio Astronomico di Roma, Italy, (15) ESO, Germany, (16) Herschel Science Centre (HSC), European Space Agency (ESA), European Space Astronomy Centre (ESAC), Spain, (17) Universität Bern, Switzerland, (18) Dept. Earth Space Sciences, UCLA, California, USA. (tmueller@mpe.mpg.de / Fax: +49-89-300003490)

Abstract

About 400 hours of observing time have been granted to the *Herschel* Open Time Key Programme "TNOs are Cool: A survey of the Transneptunian region" [1]. In this programme we are using photometric observing modes of the PACS [2] and SPIRE [3] instruments to obtain the fluxes of 139 objects representing different dynamical classes (resonant, classical, scattered disk and detached TNOs as well as Centaurs); half of the known binary TNOs are included in this sample. The four prime scientific goals of this programme are: (i) to determine sizes and albedos, (ii) to measure the density of binary TNOs, (iii) to constrain surface properties, and (iv) to determine light curves of six objects by continuously observing them throughout an entire rotational period.

1. Introduction

More than one thousand Transneptunian objects (TNO) have so far been discovered in our solar system. They are remnants of the planetesimal disk; the size distribution of large TNOs is assumed to have remained unchanged although the surface material on TNOs has changed its composition over time due to collisions and space weathering. Thermal emission of an airless body depends primarily on its size and albedo. Surface emissivity, roughness and porosity also influence the shape of the SED. The fluxes of TNOs, with temperatures in the range 20-50 K, have their maxima in the PACS wavelengths. Thermal models (STM [4], FRM/ILM [5], NEATM [6], TPM [7]) provide sizes and albedos, and they also give indications on the surface properties. The magnitude in visible wavelengths is required as an additional input to these models; they are obtained from our ground-based support observations.

2. Observations and data reduction

All of the 139 targets, whose fluxes are expected to range from a few mJy to $400\,\mathrm{mJy}$, will be observed with the three PACS channels (55 to $210\,\mu\mathrm{m}$) while only the brightest ones are detectable by the three SPIRE channels (194 to $672\,\mu\mathrm{m}$). During the Science Demonstration Phase of *Herschel* PACS observations were carried out in two modes: the point-source mode with chopping and nodding as well as the scan-map mode without chopping. The latter was selected for the Routine Science Phase due to its better overall performance. All SPIRE observations were done in the scan map mode. A follow-on observation is made for each target after it has moved to a different sky background position so that the follow-on observation can be used to characterise the target's background at the time of the first observation. This is a useful observing strategy for solar system targets at PACS and SPIRE wavelengths higher than $100\,\mu\mathrm{m}$ in order to distinguish the target from the background.

The data reduction of the point source chopping-nodding mode was done in a standard way [2]. The scan maps were processed using a modified way: two scan maps taken in different scan angles (non-orthogonal) were joined before executing high pass filtering with empirically chosen widths. The final PACS maps were resampled to pixel sizes of 1 arcsec or 2 arcsec for the PACS 70/100 $\mu\mathrm{m}$ and $160\,\mu\mathrm{m}$ channels, respectively.

In SPIRE maps the two orthogonal scans were first combined, and then the follow-on map was subtracted from the combined map of the first observation.

3. Results and outlook

By the end of the Science Demonstration Phase 17 objects (an example is shown in Figure 1) were observed [8]. One third of them are fainter than predicted and one sixth are brighter. The target sizes range from below 100 km to nearly 1000 km. The albedos of these objects were typically below 10% and thermal inertias below $25\,\mathrm{Jm^{-2}s^{-0.5}K^{-1}}$. The flux values and their error bars used so far as inputs to the thermophysical models may still experience some modifications due to refinements in the data reduction process that we are developing.

The light curve of Haumea at $100\,\mu\mathrm{m}$ shows a factor of 2 amplitude and positive correlation with the optical light curve [9]. Results of model fits are shown by P. Lacerda et al. [this issue, EPSC2010-505].

Orcus has higher albedo (0.27) than the average (0.08 [10]) and a size estimate of $850\,\mathrm{km}$ diameter was obtained using a single terrain model. Makemake also has a high albedo, which has been modeled with a two-terrain bright/dark surface with two albedos: >0.78 and <0.12 [11].

Within our "TNOs are Cool" programme we will observe about 140 TNOs and the results are expected to provide a benchmark for understanding the solar system debris disk, and extra-solar ones as well. We will observe 25 binary TNOs as well as the light curves of Varuna, Haumea, 2003 VS2, 2000 GN171, 2004 TY364, and 2003 AZ84 for over a rotational period. In this work we will present the status of our programme; in September 2010 we will have *Herschel* observations for about 80 targets, including detailed studies of the most prominent dwarf planets Pluto, Eris, Haumea and Makemake.

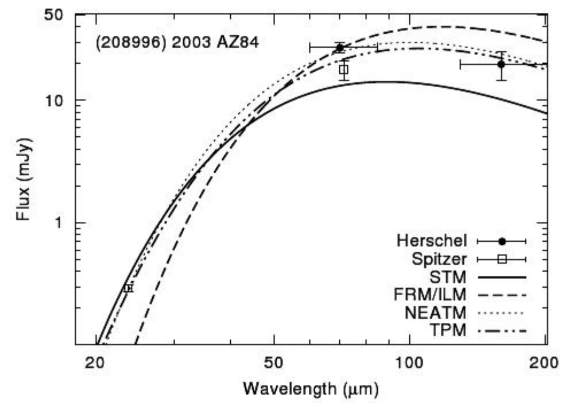

Figure 1: Herschel and Spitzer observations of the Plutino 2003 AZ84. Models STM and FRM/ILM with fixed beaming parameters fail while in NEATM also the beaming parameter is fitted. (Adopted from [8])

Acknowledgements

Herschel is an ESA space observatory with science instruments provided by European-led Principal Investigator consortia and with important participation from NASA.

Part of this work was supported by the German Deutsche Forschungsgemeinschaft, DFG, project number Ts 17/2-1, and by the German Deutsches Zentrum für Luft und Raumfahrt, DLR, project numbers 50 OR 0903 and 50 OR 0904.

References

[1] Müller, Th. G. et al., Earth, Moon, Planets, 105:209-219, 2009.

[2] Poglitsch, A. et al., A&A, accepted, 2010.

[3] Griffin et al., A&A, accepted, 2010.

[4] Lebofsky, L. A. et al., Icarus, Vol. 68, 239, 1986.

[5] Veeder, G. J. et al., AJ, Vol, 97, pp. 1211-1219, 1989

[6] Harris, A. W., Icarus, Vol. 131, pp. 291-301, 1998.

[7] Lagerros, J. S. V., A&A, Vol. 310, 1011, 1996.

[8] Müller, Th. G. et al., A&A, accepted, 2010.

[9] Lellouch, E. et al., A&A, accepted, 2010.

[10] Stansberry et al. in The Solar System Beyond Neptune (eds. Barucci et al.), Univ. Arizona Press, 2008.

[11] Lim, T. et al., A&A, accepted, 2010.