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TNOs are Cool: A survey of the trans-Neptunian region – Herschel observations and thermal modeling of large samples of Kuiper belt objects

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Abstract

We present sample results of 60 TNOs (classical, Plutinos, SDOs, detached objects) derived from Herschel ("TNOs are Cool"-project) and Spitzer observations: sizes, albedos, densities, and correlations.

1. Introduction

Trans-Neptunian objects (TNO) represent the leftovers of the formation of the Solar System [1] and they are analogues to the parent bodies of dust in debris disks around other stars [2, 3]. In addition to Pluto more than 1500 TNOs/Centaurs have been discovered since the first Kuiper belt object in 1992 [4]. Their physical properties provide constraints to the models of formation and evolution of the various dynamical classes of objects in the outer Solar System. The knowledge of albedo is also important in constraining surface composition via spectroscopy (see [5] for an example).

2. Observations

Almost 10% of the known TNOs/Centaurs are included in our Herschel Open Time Key Programm (OT KP) "TNOs are Cool: A survey of the Transneptunian region" [6]. About 130 TNOs have been observed in PACS photometry mode and part of the sample also in SPIRE photometry mode. The results presented here are based on three-band, multi-epoch photometric observations with Herschel/PACS. We use a consistent method for data reduction, background elimination, calibration and aperture photometry for the entire sample to obtain monochromatic flux densities at 70.0, 100.0 and 160.0 μm for each source. Additionally, we use Spitzer/MIPS flux densities at 23.68 and 71.42 μm when available [7]. The observations taken either in the Science Demonstration Phase and/or routine phase of Herschel have been presented in a series of papers [8, 9, 10, 11, 12, 13, 14] and the interpretation of the remaining targets is currently ongoing.

3. Results

The samples we present here are composed of dynamically hot and cold classicals, Plutinos, Scattered-disk objects and Detached objects. We use the Gladman-classification [15], based on 10 Myr time-scale orbit calculations.

We derived diameters and albedos via radiometric modeling techniques which have already been used in previous work [7, 8, 9, 10]. Thermal emission of an airless body depends primarily on its size and albedo but also surface emissivity, roughness and porosity influence the shape of the spectral energy distribution. As auxiliary data we use reexamined absolute visual magnitudes from the literature and data bases, part of which have been obtained by ground based programmes in support of our Herschel key programme.

Classicals

We have determined for the first time radiometric sizes and albedos of eight classical TNOs, and refined previous size and albedo estimates or limits of 11 other classicals [11]. The new size estimates of 2002 MS4 (diameter=934 km) and Salacia (901 km) indicate that they are among the 10 largest TNOs known. Our new results confirm the recent findings that there are very diverse albedos among the classical TNOs and that cold classicals possess a high average albedo (17% $\pm$ 4%). The cumulative size distribution of all hot classicals with radiometric sizes/albedos has a slope of 1.4 in the size range 100-600 km. We also determine the bulk densities of six binary TNOs (see Table 1).

Scattered disk/Detached

Diameters obtained for our sample of 15 targets range from 100 to 2400 km, and the geometric albedos vary from 3.8% to 84.5% [12]. The geometric albedo for the whole sample is 11.2% (excluding Eris); 6.9% for the SDOs, and 17.0% for the detached objects (excluding Eris). We obtain new bulk densities for three binary systems (see Table 1). We find significant correlations between albedo and diameter (more reflective objects being bigger), and between albedo, diameter and perihelion distance (brighter and bigger objects having larger perihelia).

Plutinos

We find the sizes of 18 Plutinos to range from 150 to 730 km and geometric albedos to vary between 4% and 28% [13]. We were able to calibrate the Plutino size scale for the first time and find the cumulative Plutino size distribution to be best fit using a cumulative power law with $q = 2$ at sizes ranging from 120–400 km and $q = 3$ at larger sizes. We revise the bulk density of 1999 TC36 (see Table 1). There is qualitative evidence that icy Plutinos have higher albedos than the average of the sample.

Sedna

Sedna is a detached object and often speculated to be an inner Oort cloud object. Previously, there was only an upper limit of $D < 1670$ km [6], but with Herschel we were able to determine its size to be 995 ± 80 km and its geometric albedo to be $32\% \pm 6\%$ [14]. Furthermore, the surface of Sedna might be covered with ices in a larger fraction than previously thought.

4 Outlook

We are in the process of analysing the remaining 70 targets. We will extend our correlation analysis, currently limited by small sample sizes within the dynamical classes, and will be able to give more definite answers to the existence of correlations.

Table 1: Bulk densities of binary systems. D: effective radiometric diameter, C: classical TNO, SDO: scattered disc object, DO: detached object.

Ref.	Target	Class	Density (g/cm^3)
[11]	Teharonhiawako	C / cold	1.14
[12]	Typhon	SDO	0.36
[11]	2001 XR_{254}	C / cold	1.4
[11]	2001 QY_{297}	C / cold	1.4
[11]	Altjira	C / hot	0.63
[12]	Ceto	SDO	0.64
[11]	Sila	C / cold	0.73 (see also [16])
[13]	1999 TC_{36}	Plutino	0.64
[11]	Salacia	C / hot	1.38
[12]	Eris	DO	2.40

References

[1] Morbidelli, A. et al. in *The Solar System Beyond Neptune (SSBN), eds. Barucci, M.A. et al.*, 2008

[2] Wyatt, M.C., ARA&A, 46, 339, 2008

[3] Moro-Martin, A. et al. in *SSBN*, 2008

[4] Jewitt & Luu, Nature, 362, 730, 1993

[5] Barucci, A.M., Merlin, F., Perna, D. et al. 2012, A&A, 539, 2012

[6] Müller, T.G., Lellouch, E., Böhnhardt, H. et al., Earth, Moon, and Planets, 109, 209, 2009

[7] Stansberry, J. et al. in *SSBN*, 2008

[8] Müller, T.G., Lellouch, E., Stansberry, J. et al., A&A, 518, 146L, 2010

[9] Lellouch, E., Kiss, C., Santos-Sanz, P. et al., A&A, 518, 147L, 2010

[10] Lim, T., Stansberry, J., Müller, T.G. et al., A&A, 518, 148L, 2010

[11] Vilenius, E., Kiss, C., Mommert, M. et al., A&A, 541, A94, 2012

[12] Santos-Sanz, P., Lellouch, E., Fornasier, S. et al., A&A, 541, A92, 2012

[13] Mommert, M., Harris, A., Kiss, C. et al., A&A, 541, A93, 2012

[14] Pal, A., Kiss, C., Müller, T.G. et al., A&A, 541, L6, 2012

[15] Gladman, B. et al. in *SSBN*, 2008

[16] Grundy, W.M. et al., Icarus, *accepted*, 2012