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Thermal properties of Trans-Neptunian objects and Centaurs from combined Herschel and Spitzer observations

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Abstract

We present a study of the thermal properties of about 70 trans-Neptunian objects (TNOs) and Centaurs observed with Herschel Space Observatory [8] (either PACS or PACS and SPIRE) and Spitzer Space Telescope [12] (MIPS). We apply radiometric modeling techniques (NEATM [2]) to the measured fluxes to derive diameter, albedo and the beaming factor (η). The latter parameter is a proxy for the combined effects of surface thermal properties (thermal inertia), surface roughness, and rotation properties. We will examine the results and search for trends in the inferred η values with several parameters, including heliocentric distance, albedo, and rotational properties.

1. Observations

About 130 TNOs and Centaurs have been observed by Herschel in the framework of the open time key programme called "TNOs are Cool: a survey of the Transneptunian region" [5], the prime goal of which is to determine diameters and albedos in this population. For most objects, the observations consist of three-band photometry with Herschel/PACS (centred at 70.0, 100.0 and 160.0 μm), while a small subset (11 objects) is also observed with Herschel/SPIRE at 250.0, 350.0 and 500.0 μm. These observations expand and complement earlier observations by Spitzer/MIPS at 23.68 and 71.42 μm. The latter covered altogether about 100 objects, 60 of which have been published [1,10].

The Herschel data are reduced using consistent and validated methods [4,9,11] of background elimination, aperture photometry and calibration to determine monochromatic flux densities. These are combined with the Spitzer flux densities, when available (60 objects in common).

2. Model

We use the so-called NEATM [2] (or hybrid Standard Thermal Model [6,10]), used in previous asteroid and TNO studies. In this model local temperatures resulting from instantaneous equilibrium with insolation are modified by a so-called beaming factor η so as to match the spectral energy distribution (SED). The beaming factor includes semi-empirically the combined effect of surface thermal inertia, rotation period and pole orientation, and surface roughness. In this manner, by combining the thermal measurements with the optical H magnitude, we determine the diameter, albedo and η factor for each object. Our results are much more accurate when combined Herschel and Spitzer data are available, since η is then much better constrained due to the larger wavelength range being covered.

3. Results

We obtain beaming factors for about 70 TNOs/Centaurs. Most η -values span the 0.6-2.5

range, with a mean of about 1.2. Examination of the distribution of η as a function of heliocentric distance reveals a huge dispersion of the η values, but also shows that there are no objects with large beaming factors at low distances. This is an expected ensemble behaviour for a population of objects with low thermal inertia (probably less than range 0-20 J m^{-2} $s^{-1/2}$ K^{-1}, unless surfaces are extremely rough), consistent with thermo-physical modeling of a few selected objects [3,6,7]. This suggests that these objects are covered with low-conductivity porous surfaces.

We will further examine possible relations of η with other quantities: diameter, geometric albedo, rotation period, light-curve amplitude, surface composition, and density.

Finally, we note that most objects for which SPIRE observations are available indicate a decrease of the spectral emissivity longwards of 200 μm.

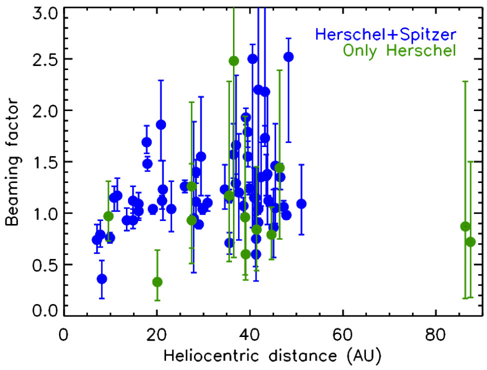

Figure 1: Beaming factor vs. heliocentric distance at the time of observation.

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