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Thermal short-time variability of Kuiper Belt Objects observed with Herschel

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Abstract

Kuiper Belt Objects (KBOs) are leftovers of the Solar System formation and likely the most pristine and less physically-chemically altered bodies we know in our planetary system. Centaurs are related to KBOs and it is believed that they are the link between the latter and the Jupiter Family Comets. Around 1300 KBOs and 200 Centaurs have been discovered as of today. Thermal fluxes of KBOs, with typical temperatures ~20-50 K, have their maxima in the Herschel-PACS wavelengths (60-210 microns). Herschel-PACS observations, covering sufficient time to resolve the thermal light curves (i.e. thermal flux variations versus time), have been obtained for eight KBOs/Centaurs. Results from these observations are presented here.

1. Introduction

Thermal light curves observations with Herschel-PACS have been done for eight objects. Four of them have been observed within the "TNOs are Cool" Herschel key project [2],[4]: 136108 Haumea, 20000 Varuna, 2003 AZ84 and 2003 VS2. The other four have been observed out of this program: 136199 Eris and 50000 Quaoar -OT1-, 134340 Pluto -OT2-, and 2060 Chiron -must do observations-.

All these bodies have been observed during enough time to obtain temporal variations on flux due to object rotation. We have used Herschel-PACS (either at 70/160 or 100/160 microns) to observe all these light curves, except for Pluto, which was observed at all the Herschel-PACS and Herschel-SPIRE bands (70, 100, 160, 250, 350 and 500 microns).

2. Results

Thermal light curves are clearly detected for Haumea, Varuna and Pluto. Thermal light curves of 2003 VS2, Quaoar and Chiron are marginally detected and an incomplete Eris light curve implies rotational variability. No thermal light curves were detected for 2003 AZ84.

Apart from the estimation of diameters and albedos, we can obtain thermal inertias for these objects and derive some surface properties using thermal and thermo-physical models, together with thermal and optical light curves.

3. Summary and Conclusions

Varuna and Haumea thermal light curves are clearly correlated with the optical ones, which means a light curve due primarily to a shape effect (an elongated rotating object). Tentative 2003 VS2 and Quaoar's thermal light curves are also correlating with the optical ones.

The presence of a dark spot on Haumea's surface was noticed from optical light curves [1]. We tentatively detect the effect of this surface dark-spot in the final Haumea thermal light curve, but this effect was not detected in the first observations carried out with Herschel-PACS within the Science Demonstration Phase.

Pluto thermal light curve is detected at all wavelengths, but only marginally at 500 microns. The previously observed anti-correlation between the thermal and optical light curves is confirmed, which means these light curves are mainly due to different albedo terrains in the Pluto surface. We can obtain the thermal inertia and surface emmissivities from these Pluto multi-wavelength light curves, and we see preliminary evidence that the trend of decreasing brightness temperatures with increasing wavelengths continues over 70-500 microns and that the light curves do not confirm the cooling of the Pluto system observed in 2007 by Spitzer [3].

We apply standard radiometric techniques for 2003 AZ84 –the only one with no detected thermal light curve– in order to obtain diameters, albedos and thermal properties. For some of the light curve targets we do have enough information to also apply full thermo-physical model techniques.

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