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Thermal light curve of 20000 Varuna with Herschel-PACS

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Abstract

Classical trans-neptunian object (TNO) 20000 Varuna was observed in 2011 with Herschel-PACS within the "TNOs are Cool" key programme [1] in order to obtain its thermal light curve. Because of the large amplitude of the optical rotational light curve it was expected that the thermal light curve would be detectable from Herschel Space Observatory. Varuna's thermal lightcurve is clearly detected in the Herschel-PACS observations at 100 µm. The comparison of the thermal light curve with the optical one allow us to conclude that the light curve is mainly due to the elongated shape of the object, with perhaps some contributions of terrain with special features that cause some modulation to the light curve. Thermal and thermo-physical models are applied to the thermal light curve to derive equivalent radiometric diameter, albedo, thermal and thermo-physical properties of this trans-neptunian object.

1. Introduction

Trans-neptunian objects are remains of the Solar System formation [2] and probably the more pristine and less physical-chemical altered bodies we known in our planetary system. Their physical characteristics are very useful to constraint the formation and evolution models of the Solar System. Around 1260 TNOs have been discovered until now (April 2013) since the first trans-neptunian object (apart from Pluto itself) discovered in 1992 [3]. Thermal fluxes of trans-neptunian objects, with typical temperatures among 20-50 K, have their maxima in the Herschel-PACS wavelengths (60-210 µm). 130 TNOS/centaurs (and 2 satellites of the giant planets) have been observed within our Herschel Space Observatory open time key programme called "TNOs are Cool: a survey of the Transneptunian region" [1]. Four of them have been observed during sufficient time to obtain temporal variations on flux due to object rotation (i.e. the thermal LC). One of these objects is 20000 Varuna, a dynamically classical trans-neptunian object with no known satellites. Its optical light curve presents a high amplitude (0.43 ± 0.01 mag [4]) which indicates we are probably seeing Varuna in a close pole-up geometry. From Spitzer data we known that Varuna has a moderate albedo ~9 % and an equivalent diameter ~710 km [5].

20000 Varuna was observed on April 17 and 19, 2011 with Herschel-PACS in mini scan map mode at 100 and 160 µm. The observations cover the 121% of the optically measured rotational period.

2. Results and discussion

Varuna thermal light curve is clearly detected (figure 1) at 100 and also at 160 µm - but with larger error bars -. We phased the thermal observations using a very accurate rotational period (P= 6.34358 ± 0.00002 h) derived from optical observations taken on 2009-2011 in order to compare the optical and the thermal light curves. Optical and thermal light curves are correlated, which means that the light curve is primarily due to an elongated-shape object in rotation. A small shift between optical and thermal light curve is also observed. We tentatively interpret this shift in terms of different thermal properties on the surface of Varuna.

Thermo-physical models assuming different shape models and different pole orientations for Varuna were also applied to the thermal data and will be discussed in this work. In figure 2 we show a preliminary thermal light curve of Varuna together with the one in the optical. As can be seen in this figure the amplitude of the thermal flux variation is much larger than that in the optical.

As a preliminary by-product of the Varuna thermal light curve we get an equivalent radiometric diameter of 668 km and a geometric albedo in V-band of 10.7 % for this object by means of the application of the so-called hybrid Standard Thermal Model [6,7].

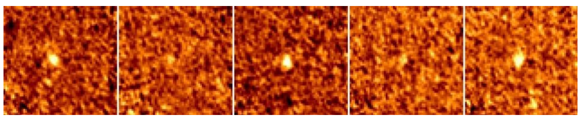

Figure 1: Three consecutive maxima and two minima on the Varuna thermal light curve are clearly visible on these Herschel-PACS mini scan maps images at 100 µm.

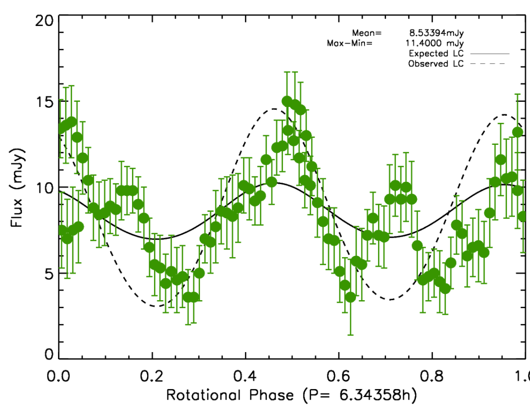

Figure 2: Preliminary Varuna thermal light curve (green symbols) from Herschel-PACS observations at 100 µm. The data have been phased using the optical rotational period 6.34358 h. Superimposed are the optical light curve (black curve) and the same one but scaled to the amplitude observed in the thermal light curve (dashed black curve). Optical and thermal light curves are correlated.

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