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Photometry of TNOs and Centaurs in support of a Herschel Key Programme

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Abstract

Trans-Neptunian Objects (TNOs) and Centaurs represent the remnants of the leftover planetesimals from the early accretional phases of the outer pre-planetary disk, hence the study of their physical properties is fundamental to constrain the formation and evolution of the outer Solar System. In particular, the measure of TNOs' albedos and sizes requires combined visible and thermal observations. In support of the "TNOs are Cool" programme, currently ongoing at the Herschel space telescope, we performed at the TNG telescope visible photometry of 23 TNOs and Centaurs. We derive the absolute magnitude H_V of the targets, a fundamental information to interpret the Herschel data. Moreover, the B-V, V-R, V-I colors give us a first indication about the targets' surface composition. Finally, we combine our results with the available literature, looking for correlations between colors and dynamical properties of TNOs and Centaurs.

1. Introduction

The radiometric technique can be used to derive the albedo and the diameter of the distant and icy Centaurs and TNOs, combining information from the thermal infrared emission and the visible magnitude. The "TNOs are cool" Key Programme at the Herschel Space Telescope [1] will give a significant contribution to our understanding of TNO science, observing ~140 objects in the thermal infrared. These data have to be combined with visible observations (specifically, the visible absolute magnitude H_V) to derive the size and albedo of the investigated objects. We hence carried out visible photometric observations of 23 TNOs and Centaurs which are targets of the "TNOs are cool" programme, at the TNG (Telescopio Nazionale Galileo, La Palma, Spain) telescope (P.I.: E. Dotto). We used the DOLORES instrument and the B,V,R,I filters.

2. Results and discussion

The obtained absolute magnitudes H_V will be used in combination with the thermal modeling of the Herschel data to derive the size and albedo of the 23 observed bodies. The "TNOs are cool" target list is composed by the brightest TNOs, with typical diameters > 200 km. These larger bodies are supposed to be almost unchanged from the accretion phases [2], hence the obtained present time size distribution will reflect the primordial distribution of the outer planetesimals. Further information on the early evolution of the Solar System could be retrieved from possible correlations between the size, the albedo, and other physical and orbital parameters of the targets.

The obtained B-V, V-R, V-I colors give a first hint on the surface composition of the targets, and on the presence of heterogeneities on them (almost all the targets have been observed multiple times in different nights). From comparison with literature data [3], we find some differences in the color values, which could be attributed to inhomogeneous surface compositions. The obtained colors will also result fundamental for the correct interpretation of the Herschel albedo data.

Based on their color indices, we derive the taxonomic classification of our targets via the G-mode method presented in [4], using the taxonomy for TNOs and Centaurs introduced by [5]. This taxonomy identifies four classes, that reasonably indicate different composition and/or evolutional history, with increasingly red colors: BB (neutral colors with respect to the Sun), BR, IR, RR (very red colors).

We combine our results with the literature [3, and references therein], for a total of 158 objects taxonomically classified thus far, looking for correlations between colors and dynamical properties of TNOs and Centaurs.

From the distribution of the taxa within the different dynamical classes (Fig. 1), we find that RR objects dominate the classical TNOs. Moreover, Centaurs and detached TNOs lack of IR-types. Considering that the IR class is the only whose members do not present water ice features in their spectra [6], this could suggest that the different TNO taxa would represent different evolutionary stages rather than differences in the original compositions. Nevertheless, it is still difficult to draw a "safe" scenario for the TNO formation and evolution, because of the lack of fundamental data as reliable albedo, size and mass distributions. Results from the Herschel TNO observations will help in this sense.

Fig. 2 reports the distribution of the taxa with respect to the orbital inclination of the classical TNOs. Inclinations of RR-types are low, in agreement with the previous finding of a red dynamically "cold" population. BB-types are instead concentrated at high inclinations, confirming the suggested association of these objects with the "hot" population (e.g., [7]). If this RR-BB dichotomy is interpreted in terms of evolution, this could mean that the former are objects with "old" (red) surfaces, the latter are objects with "fresh" (blue) surfaces. This could be supported by the results by [6], who find that CH_3OH ice seems to be present only on very red surface objects, while all of the investigated BB-types have high content of H_2O ice. Again, albedos determined from the Herschel data will help to characterize the surface properties of these outer minor bodies.

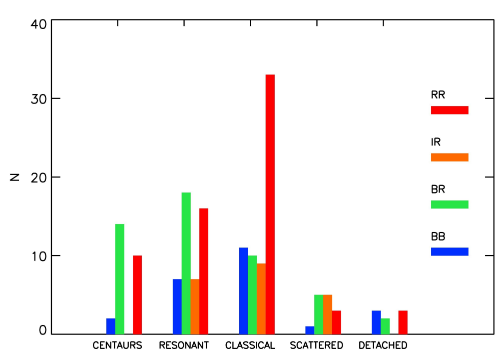

Figure 1: Distribution of the taxa within each dynamical class.

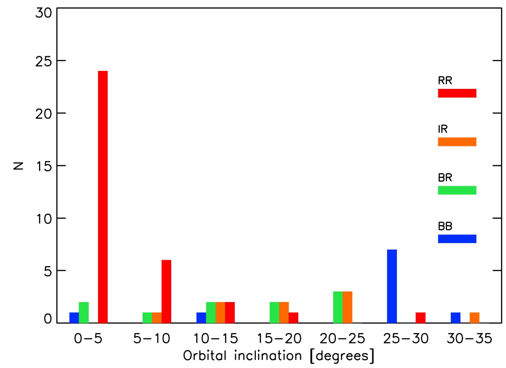

Figure 2: Distribution of the taxa with respect to the orbital inclination of classical TNOs.

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