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Taxonomy and densities of Trans-Neptunian Objects

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Abstract

A Large Programme at ESO has been devoted to the investigation of Centaurs and Trans-Neptunian Objects. In this framework the photometric colors and the light curves of selected targets have been acquired. Here we present and discuss all the results obtained from the photometric technique.

1. Introduction

The investigation of Centaurs and Trans-Neptunian Objects (TNOs) is considered as one of the most important topics in modern planetary science, since these distant and icy bodies represent the remnants of the leftover planetesimals in the outer Solar System, and they retain the most pristine material observable in present times. Hence, from their study we can learn about the origin and early evolution of the Solar System at large distances from the Sun.

A Large Programme on Centaurs and TNOs (P.I. M.A. Barucci) has been performed at the European Southern Observatory, using different observing techniques. The results obtained via spectroscopy and polarimetry will be presented by [1] and [2], respectively. Here we present and discuss all the photometric results obtained as part of the ESO Large Programme.

Visible and near-infrared colors allowed us to derive the taxonomic classification of the observed objects. Looking for correlations between taxonomy and dynamical properties, a statistical analysis has been performed adding our dataset to literature data. Light curves of 12 TNOs and Centaurs have also been acquired to retrieve information about their rotation, shape, and density. Combining our new results with literature data, we investigated the density statistics of the small bodies of the outer Solar System.

2. Colors and taxonomy

Within the ESO Large Programme we obtained visible and near-infrared photometric measurements (at VLT) for 45 objects, 15 of them have their colors reported for the first time. Based on the obtained color indices, the taxonomic classification of the targets was derived via the G-mode statistical method presented in [3], using the taxonomy for TNOs and Centaurs introduced by [4]. Four classes are identified within this taxonomy, with increasingly red colors: BB (neutral colors with respect to the Sun), BR, IR, RR (very red colors).

We combined the objects taxonomically classified in the framework of our programme with previously classified TNOs and Centaurs, for a total sample of 151 objects, looking for correlations between taxonomy and dynamics. As an example of the obtained results, Fig. 1 shows the distribution of the taxa with respect to the orbital inclination of the objects: inclinations of RR-types are quite low, while BB-types seem to be concentrated at high inclinations, which associates these objects with the dynamically “cold” and “hot” populations, respectively. Since the cold population is supposed to to be dynamically primordial while the hot population has most likely formed closer to the Sun and successively scattered outwards (e.g., [5]), this result constitutes an interesting example of the correlations between physical and dynamical properties that are starting to emerge for TNOs. In the long run these correlations could allow us to prove or disprove outer Solar System formation/evolution scenarios.

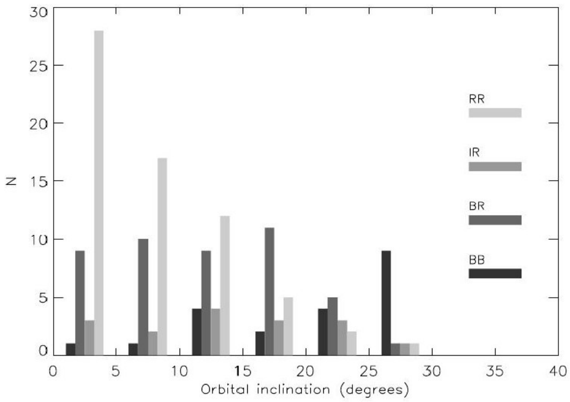

Figure 1: Distribution of the TNO taxa with respect to the orbital inclination.

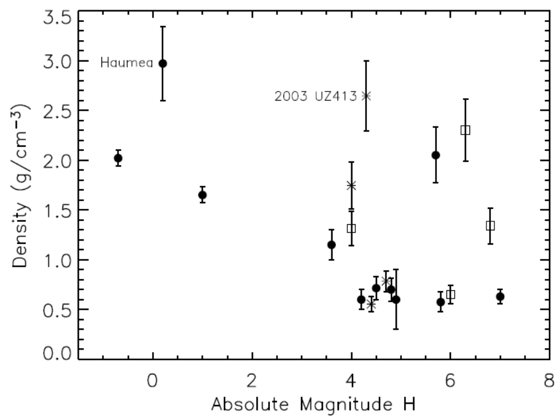

Figure 2: Estimated density ranges of TNOs as a function of their absolute magnitude H.

3. Light curves and densities

To increase the still rather limited sample of TNOs and Centaurs with known rotational properties, we carried out observing runs at ESO-NTT and TNG, acquiring new light curves and performing a Fourier analysis of the data to compute the synodic rotational periods.

Assuming the objects as homogeneous, cohesionless and strengthless bodies, we estimated a lower limit to their axis ratio *a*/*b* and derived a possible density range using the table for rotationally stable Jacobi ellipsoids by [6].

We investigated the density/size correlation for TNOs suggested by [7], by adding our new results to literature data (Fig. 2). Although the trend could be considered statistically significant, the limited sample and the presence of objects of similar absolute magnitude with completely different estimated densities prevent us from assessing its validity. In order to investigate the existence of such a relationship it seems necessary to increase the available sample of density estimations. These latter, although reasonable given the current knowledge and understanding of the physical nature of these bodies, should be improved including internal stresses (i.e., strength). We are currently working in these directions.

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