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A TNO Survey Project with the 2.2m Telescope at ESO La Silla

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Abstract. We propose a wide-shallow TNO search to be done with the Wide Field Imager (WFI) instrument at the 2.2m MPG/ESO telescope in La Silla/Chile. The WFI is a half-deg camera equipped with an 8kx8k CCD (0.24 arcsec/pixel). It was used in 1999 to run a pilot project for a TNO search. Using the images of typically 24mag limiting brightness and an automatic detection software (developed at ESO Chile) it was possible to discover 6 TNOs in a small search area of 1.5 sdeg. The project is now continued on a somewhat larger scale in order to discover more TNOs in a systematic way and to reach operational status for a full on-line detection of the objects as well as astrometric and photometric reduction at the telescope. The final goal is to perform a survey of a major part of the sky (typically 2000 sdeg in and out of the ecliptic) down to 24mag. Follow-up astrometry and photometry of the expected more than 3000 discovered objects will secure their orbital and physical characterisation for synoptic dynamical and taxonomic studies of the transneptunian population.

1. Introduction

With the discovery and exploration of the icy objects in the region beyond the orbit of Neptune the global picture of the Outer Solar System underwent a major revision. Pluto is no longer considered a planet, but the largest (moreover very peculiar, since double) representative of a new whole object class in the Solar System, the transneptunian objects (TNOs). The TNOs are believed to be members of another large-scale structure in the Outer Solar System, previously speculated on by Edgeworth and Kuiper, since 1992 getting confirmed by the discovery of more than 300 objects at distances of 30-50 AU from the Sun. The newly discovered entity formed by the TNOs and called Edgeworth-Kuiper Belt (EKB) seems to be a relic of the origin of our own Solar System. As such it may represent the most pristine objects and may reflect the most original characteristics of the formation disk of the Sun and its planets.

The past years of TNO research revealed that the answers to key questions of the Solar System formation are related to the understanding of the structure, dynamics and taxonomy of the EKB and its objects. On the other side: all the research efforts on the EKB of the past years, although very important in itself and for the progress achieved so far, were devoted to studies which a posteriori can only be considered as "looking for trees, but not seeing the forest as a whole". The observations and knowledge presently available on TNOs and the EKB is

far too little to build a realistic scenario of the Solar System formation on safe scientific grounds.

2. Key Questions

Key questions to be answered are:

- What were the dimensions of the original formation disk of our Solar System?
- Was there a cold (or warm) state during the accretion of planetesimals in the planetary formation disk?
- What was the number and size distribution, i.e. the mass distribution, in the formation disk?
- Is there a "wall", a much larger number, of TNOs somewhere between 50-100 AU which could reflect the decreasing influence of gravitation by the major planets and may thus indicate the original nature of the formation disk of the Solar System?
- How large could the planetesimals far from the Sun grow in mass or in other words: are Pluto and Charon (and Triton) unique among objects in the transneptunian region or do other large TNOs exist?
- Is the Outer Solar System in dynamical (quasi-)equilibrium state, i.e. how populated are the regions of orbital resonances with the outer planets in respect to the non-resonant orbits and how important are collisions for the body environment of the EKB?

3. Tasks of the TNO Search Projects

A systematic and coordinated research project is proposed which will address the "forest" of the EKB by measuring a large number of its "trees". The project has three tasks:

1. the search for TNOs in an about 10 deg wide band along the ecliptic (except for the Milky Way intersections) down to a limiting magnitude of at least 24 mag
2. the orbit determination of the discovered objects by securing astrometric positions of the TNOs
3. the taxonomic classification of a large sample of the discovered objects

Task 1 will be performed with the 2.2m telescope plus Wide-Field Imager instrument WFI at ESO La Silla within 3-4 years (using dark time only). Tasks 2 and 3 require in total about 100 observing nights each with narrow-field cameras at 4m class telescopes almost equally distributed over 5 and 3 years, respectively. Suitable telescopes for these two tasks are the ESO NTT and 3.6m telescopes

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and any other 3-4m class telescope around the world (assuming similar instrumentation exists). It is therefore anticipated to include more observatories in the follow-up astrometry and photometry part of our proposal.

The search area to be covered with the WFI amounts to 2400 sdeg of the ecliptic sky. It is estimated that at least 3000-4000 TNOs of the classical EKB (i.e. closer than 50 AU from the Sun) will be discovered and their orbit will be determined. About 1000 of them (i.e. the brighter ones) will be measured with photometric colours (4 filters). All classical TNOs (50 AU and closer) in the search area with radii above about 100km will be detected as well as 150km size bodies at 60AU and the largest TNOs (apart from Pluto) at about 80 AU from the Sun. Pluto-type bodies will not escape detection to a distance of 150 AU from the Sun. As spin-off results of this search a number of Centaurs (a detection limit of 15km radius at 15 AU can be taken as a reference), short and long-period comets and thousands of 100m size objects of the main asteroid belt will be measured.

For the studies of the EKB structure and population, for physical studies of taxonomic and collision properties of the EKB, the follow-up observations of the TNOs discovered with the 2.2m WFI search is crucial. Only with the orbit determined and the colours measured a global physical picture of the EKB will evolve.

4. Expected Science Return

The combined study using the data from all three tasks of this project will allow to study: the orbit distribution and the dynamics in the EKB, the resonance and non-resonance populations, their long-term stability and migration, the size and distance distribution of TNOs and Centaurs in the ecliptic, the mass density profile for the outer Solar System, the collision environment in the EKB and the presence of collision families, the questions of cold vs warm disk for the Solar System formation scenario, the taxonomic population of the EKB and whether it is of pristine or an evolutionary nature and the presence of exceptional objects like other Plutos or taxonomic outlyers.

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