FINAL REPORT

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"A search for 23rd magnitude Kuiper Belt comets"

P. I.: Jane Luu, Astronomy Dept., Harvard University

The goal of the project was to identify a statistically significant sample of large (200 km-sized) Kuiper Belt objects (KBOs), by covering 10 sq. degrees of the sky to a red limiting magnitude m_R = 23. This work differs from, but builds on, previous surveys of the outer solar system in that it will cover a large area to a limiting magnitude that is deep enough to guarantee positive results. The proposed work should provide us with a significant number of 200 km-size KBOs (~ 20 are expected) for subsequent studies. Such a sample is crucial if we are to investigate the statistical properties of the Belt and its members.

During the duration of this grant, in collaboration with Dr. David Jewitt of the University of Hawaii, we have found several dozens of new KBOs, most of them brighter than 22nd magnitude, with estimated diameters 300 km - 500 km. These objects form ideal targets for more detailed physical studies (we have already started our own program to carry out detailed photometric and spectroscopic studies). By now it has now become clear to us that the task of obtaining follow-up observations of KBOs is just as important as discovering them. The main problem is that most known KBOs are at the edge of the capability of most ground-based telescopes -- few observers have the resources or are willing devote considerable time and effort into such difficult observations. We have worked out a search strategy where most of the discoveries were made on the University of Hawaii 2.2m telescope on Mauna Kea, and the follow-up observations were carried out at Harvard's Fred L. Whipple Observatory 48-inch telescope at Mt. Hopkins, AZ. After each new discovery, follow-up observations were obtained at 2 different epochs within the subsequent 2-3 months. Thanks to this kind of monitoring, nearly all of the new Kuiper Belt objects discovered in the last 3 yrs now have secure orbits.

Probably the most spectacular result in recent years is the discovery of a new dynamical class in the Kuiper Belt represented by the object 1996 TL_{66} (semimajor axis a = 84 AU, eccentricity e = 0.58; see Luu *et al.* 1997). At red magnitude m_R ~ 21, it is the brightest trans-Neptunian found since Pluto and Charon. With an assumed red geometric albedo of 4%, the estimated diameter is 500 km. Previously discovered KBOs have orbits clustered inside ~ 50 AU. In contrast, the large, eccentric orbit of 1996 TL_{66} carries it to more than 130 AU at aphelion. Evidently, 1996 TL_{66} represents a new type of trans-Neptunian dynamics, and

provides the first direct evidence that the trans-Neptunian population extends much further than the 30-50 AU region sampled by previous surveys.

The origin of 1996 TL_{66} is as yet unknown but it most likely represents the long-hypothesized scattered component of the Kuiper Belt (Ip 1989, Torbett 1989, Ip and Fernandez 1991). In contrast with the KBOs on primordial near-circular orbits (which we identify with the "Classical" Kuiper Belt), the scattered objects (which we call Scattered Kuiper Belt Objects, or SKBOs for short) may be Uranus-Neptune region planetesimals that have been scattered in to large eccentric orbits, perhaps by Neptune or by planetary embryos. The SKBO population is likely to be large. Very roughly, the discovery statistics suggest that there must be ~ 6400 objects like TL_{66}. If we assume that this population follows an inverse cube size distribution, the Scattered Kuiper Belt contains ~ 0.5 M_E between ~ 40 and 200 AU -- larger than the 0.1 - 0.2 M_E estimated for the classical Kuiper Belt (Jewitt, Luu, and Chen 1996). Here we have the first evidence that the trans-Neptunian population is likely to be more massive than previously suspected, and might merge smoothly with the Oort cloud at larger distances (Torbett 1989).

In short, although we modified the original research strategy to accommodate unanticipated problems such as the urgent need for follow-up observations, the original goal was still reached: we have substantially increased the number of Kuiper Belt objects brighter than 23rd mag (see URL http://cfa-www.harvard.edu/cfa/ps/lists/TNOs.html). They present ideal targets for more detailed studies.

References

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