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SOME INTERRELATIONS OF ASTEROIDS, TROJANS AND SATELLITES

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The Trojans of Jupiter have the same magnitude-frequency distribution as the asteroids, but there is a puzzling asymmetry of the densities in Preceding and Following Lagrangian points. The outer satellites of Jupiter have a peculiar magnitude-frequency distribution, with large and also small ones missing; they therefore cannot be captured asteroids or Trojans unless during the capture a resisting medium was present out to ~400 R_J for proto-Jupiter.

In Sec. 1 of this paper I shall give an overview and references for our surveying, of various populations in the solar system, with the 122-cm Schmidt Telescope on Palomar Mountain. Section 2 will discuss in more detail the findings for the Trojans, while Sec. 3 will give possible interrelations of both the Trojans and the Main Belt Asteroids with the outer satellites of Jupiter.

1. PALOMAR SURVEYS

As guest investigator of the Hale Observatories I have been working occasionally with the Palomar Big Schmidt. The observations are primarily for a cooperative program with C. J. and I. van Houten and J. Degewij of the Leiden Observatory, and with P. Herget of the Cincinnati Observatory. Telescope time has also been available for additional search programs in cooperation with B. G. Marsden of the Smithsonian Astrophysical Observatory and C. D. Vesely and R. E. Sather of the University of Arizona. The goals and results of various programs can be summarized under three headings:

1) A general survey of populations and their completion. New Apollo and Amor asteroids have been found, as well as five comets, but thus far no Trojans of Earth, Saturn or Neptune, or objects beyond Neptune. In none of our blinking have we found an asteroid between Jupiter and Saturn; Hidalgo (944) therefore is a unique object. The details of the search areas, etc. are described in Gehrels (1977).

2) Systematic statistical surveys of faint asteroids and Jovian Trojans. The primary article on the "Palomar-Leiden Survey of Faint Asteroids" has been published (van Houten *et al.* 1970a), and so is a preliminary report on the density of the Trojans near the Preceding Lagrangian Point (van Houten *et al.* 1970b). Incidentally, we use the words Preceding (L_5) and Following (L_4) with respect to Jupiter in the sense of its orbital motion.

3) Photographic lightcurve photometry of the faintest asteroids and outer satellites of Jupiter. This is to be the major part of a dissertation at

Leiden University by J. Degewij, and he has prepared a preliminary report (Degewij 1977).

2. TROJANS OF JUPITER

The detailed study of Jovian Trojans is still going on. An additional observing run at Palomar is planned for October 1977, with particular attention to the distribution within Lagrangian regions. However, already now it appears established that there are about 700 Trojans brighter than B ~ 20.9 in the Preceding Lagrangian Point L_5 and only ~300 in the Following Point L_4. It is noted that the larger ones of the Trojans occur in the Preceding Point. Apparently L_5 had a denser cloud of material, from which the Trojans formed, than L_4. This, however, brings up the question of the stability in these Lagrangian regions; presently are there originally accreted objects, or merely transients? An analytical study of early accretion into and stability within these regions would be of great interest.

Alternately, the Trojans in the Following Point could be darker by a factor ~2.3, which also would have to be explained. It is noted that the ones in the Preceding Point are already known to be very dark (Cruikshank 1977), and the following Trojans would then have to be exceptionally dark.

The magnitude-frequency distribution of the Trojans is about the same as that of the Main-Belt Asteroids. Whatever process caused the frequency distribution of the asteroids apparently was also at work in the Trojan regions. At present, the density in these regions seems an order of magnitude lower than that in the Asteroid Belt, and it therefore probably is not great enough for collisions to build up such a frequency relation. Was this relation then established at an earlier time, during the formation of the solar system?

Van Houten *et al.* (1970a,b) have noted that the Trojans show two groups of orbital inclination alike the faint Palomar-Leiden asteroids in the Main Belt do, while the numbered, large, asteroids show only a single peak of the inclinations. It would appear from these observations that the Trojans, and also some of the faint asteroids, have a mixture of two populations, and possibly "asteroidal" and cometary, with the cometary population causing the higher inclinations.

3. OUTER SATELLITES OF JUPITER

The magnitude-frequency relation of the outer satellites is totally unlike that of Trojans and Main-Belt Asteroids. This simple observation seems to invalidate all proposed theories that the outer satellites are captured Trojans or asteroids, unless more complicating conditions might have an appreciable effect as for instance that of a resisting medium, out to ~400 R_J for proto-Jupiter. I have made the argument before (Gehrels 1976) based on the peculiar lack of smaller fragments. I have since then searched further with the Big Schmidt for satellites down to 21.2 photographic magnitude (Gehrels 1977); it appears unlikely that there are anymore objects to that detection limit. The lack of larger objects is also noted. Morrison and Burns (1976) give approximate radii in the direct group: ~4 km for J13, 85 km for J6, 10 km for J10, 40 km for J7; and in the retrograde group: 9 km for J12, 12 km for J11, 14 km for J8, and 11 km for J9.

Capture and breakup by a resisting medium would indeed bring about a narrow size distribution. Smaller masses would spiral into Jupiter, while very large masses would not be sufficiently affected by the medium. As the medium becomes less dense, away from Jupiter, only smaller masses could be affected; we see that in the diminishing of the above upper limits within the direct and retrograde groups (85 → 14 km). Perhaps only the less dense medium would have allowed the retrograde irregular orbits of the outer group. An analysis of the

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drag and breakup has been made by Pollack *et al.* (1977) who indeed derive that the two clusters may have originated in this manner.

No light variation - having amplitudes greater than 0.3 mag and periods between 10 mins and 10 hrs - is found for the outer satellites, except perhaps for J6 (Zellner *et al.* 1977). These objects therefore do not appear to be irregular fragments that are spinning rapidly. This somewhat speaks against their being break-up fragments, unless it could be established that they have elongated shapes but very slow spin, retarded by the medium.

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