DESCRIPTIVE SURVEY OF FAMILIES, TROJANS, AND JETSTREAMS

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The word "group" is so general that I would like to suggest that here it is used in its most general way: a group of asteroids is a collection of minor planets that have some feature in common. If we agree on this use of the word "group," then we can discern the following asteroidal groups:

(1) Groups that have a dynamical cause:
  (*a*) Trojans
  (*b*) Commensurability groups:
    (i) Hungaria group
    (ii) Hilda group
    (iii) Thule
(2) Groups that probably have no dynamical cause:
  (*a*) Hirayama families
  (*b*) Brouwer groups
  (*c*) Jetstreams

Because the topic of this colloquium is the physical studies of the asteroids, I shall here briefly review the physical studies made on these groups.

TROJANS

These are asteroids moving near the lagrangian points L_4 and L_5 of the Sun-Jupiter system. There are 15 numbered Trojans, but at fainter magnitudes than the limit of the ephemeris they are very numerous; it was shown that around L_5 there are 700 Trojans brighter than $B(a, 0) = 21.0$ (van Houten, van Houten-Groeneveld, and Gehrels, 1970). Their distribution as a function of absolute magnitude is similar to the normal asteroids. Rotation lightcurves of three Trojans were obtained (Gehrels, 1970) and they show relatively large amplitudes. The color measurements indicate a small ultraviolet excess (Gehrels, 1970), but the number of Trojans observed (2) is too small to be certain on this point. ($\overline{U - B} = 0.22$ of two Trojans against ≈ 0.40 of field asteroids.) The phase function of the Trojans will be discussed in my next paper;[1] it looks as if the Trojan phase function is flatter than that of normal asteroids.

COMMENSURABILITY GROUPS

The members of these groups have values of semimajor axes that make their revolution period commensurate with that of Jupiter. The Hungaria group is found at the commensurability 2:9, the Hilda group at 2:3, and Thule at 3:4.

The Hungaria group has 15 numbered members, and the Palomar-Leiden survey (PLS) added nine more. No physical studies have been made on members of this group as yet.

The Hilda group has 23 numbered members and 10 additional members in the PLS. No physical studies have been made on members of this group as yet.

Thule is the only numbered asteroid found at this commensurability, and the PLS contributed no new members. A further remarkable fact about Thule is that both the eccentricity and inclination of its orbit are small (0.032 and 2°.3). It would be worthwhile to obtain a rotational lightcurve of this object because its amplitude may be small as well.

HIRAYAMA FAMILIES

If the numbered asteroids are plotted in a three-dimensional space using as coordinates the semimajor axis a, the proper inclination i', and the proper eccentricity e' (for the definition of the proper elements, see Brouwer and Clemence, 1961), then concentrations of asteroids are found that were called families by Hirayama. They are thought to be the remnants of a larger body after collision with a second body. Brouwer (1951) reinvestigated the families and adopted the following as definite: (1) Themis family; (2) Eos family; (3) Coronis family; (4) Maria family; (5) Phocaea family; and (6) Flora family, which Brouwer divided into four subfamilies. Except for the Phocaea family, all these families were recognized in the PLS. Moreover, five new families were found in the PLS, which were named the Nysa, Medea, Michela, Vesta, and Io families.

BROUWER GROUPS

The proper elements, as defined by Brouwer, still contain the secular terms, but in the sum of the longitudes of proper node λ_n' and proper perihelion λ_p' the first-order secular term cancels out. Brouwer, therefore, expected this sum to be approximately constant in the families, which turned out not to be the case. Nevertheless, he succeeded in finding small concentrations in the (a, i', e') space, for which this constancy of $\lambda_p' + \lambda_n'$ was more or less realized. They were named "groups" by Brouwer (1951). Kiang (1966) showed that in several cases Brouwer had selected the wrong quadrant for $\lambda_p' + \lambda_n'$, which makes Brouwer's criterion less convincing. Moreover, seven Brouwer groups were also

[1]See p. 184.

found in the PLS, three of them belonging to the new families. In none of these groups was the criterion of $\lambda_p' + \lambda_n' =$ constant fulfilled. It seems, therefore, better to regard the "Brouwer groups" as families, and disregard the criterion that Brouwer used for finding them. The average amplitude of the rotational lightcurves of family members is practically equal to those of the field asteroids. Also, no clear difference could be found between the colors of family members and field asteroids, although the fact that the four bluest asteroids observed thus far are all family members (see table I, taken from Gehrels, 1970) suggests that it may be fruitful to investigate this matter further.

TABLE I.–*Colors of the 4 Bluest Known Asteroids*

Asteroid no.	$B-V$, mag	$U-B$, mag	Family
2	0.65	0.26	Brouwer 28
16	.70	.24	Brouwer 13
44	.67	.22	Nysa family
268	.69	.29	Themis family

JETSTREAMS

These were introduced by Alfvén (1969) as concentrations in the (λ_p', λ_n') plane for family members. Alfvén found three in the Flora family and Arnold (1969) found several more. Moreover, one was found in the PLS, in the Nysa family. Kresák (this colloquium[2]) showed that the latter was caused by selection effects in the PLS material and suggested that the jetstreams found by Alfvén could be explained in a similar way. This matter should be investigated more closely.

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[2]See p. 206.