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ON SEARCHING FOR ASTEROID FAMILIES
I. HIRAYAMA FAMILIES

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RESUMEN. Una nueva técnica de agrupamiento de asteroides es estudiada, basada en ideas de la taxonomía numérica. Con un software especialmente diseñado se reproducen las familias de Hirayama.

ABSTRACT: A new clustering technique based upon numerical taxonomic analysis is studied. It is shown that it faithfully reproduces Hirayama's families.

Key words: ASTEROIDS

ITRODUCTION

Hirayama (1918) was the first to determine the existence of families, i.e., groups : asteroids whose osculating elements (semi-major axis a, eccentricity e, and inclination i) ıve similar values.

Later on, Hirayama and other authors added new asteroids to the exiting families, ith the use of proper elements. Further, they determined some new families. However, the ethods adopted in the search for asteroid families differ from author to author.

In the following, we show preliminary results which were obtained using methods ssociated with well-known numeric taxonomy procedures.

[. METHOD

Standard taxonomic techniques have been implemented (Sneath, 1978). An ad-hoc pecialized software was designed to this effect. The main idea is to work within an -dimensional "character" space. Three characters have been utilized here, namely, semimejor xis, eccentricity and inclination.

The corresponding data (associated to each asteroid), after a standard normalization ocedure (Crisci and Armengol, 1983), were correlated by means of an appropriately defined imilitude coefficient (distance in 3-character space (Sokal, 1961)).

Cluster analysis (Hartigan, 1975) is then invoked in order to produce the special oupings of related objects that constitute the basis of taxonomic classification schemes.

These schemes are conveniently visualized by recourse to special diagrams called henograms" (Willey, 1981), which in the present work describe a sample of 166 asteroids.

[I. RESULTS

In order to reproduce the families found by Hyrayama, we select twenty asteroids elonging to each of his original families. The pertinent orbital elements were obtained om the Ephemerides of Minor Planets (1988) and from these values, the proper elements were alculated with the tables of Brouwer and van Woerkom (1950).

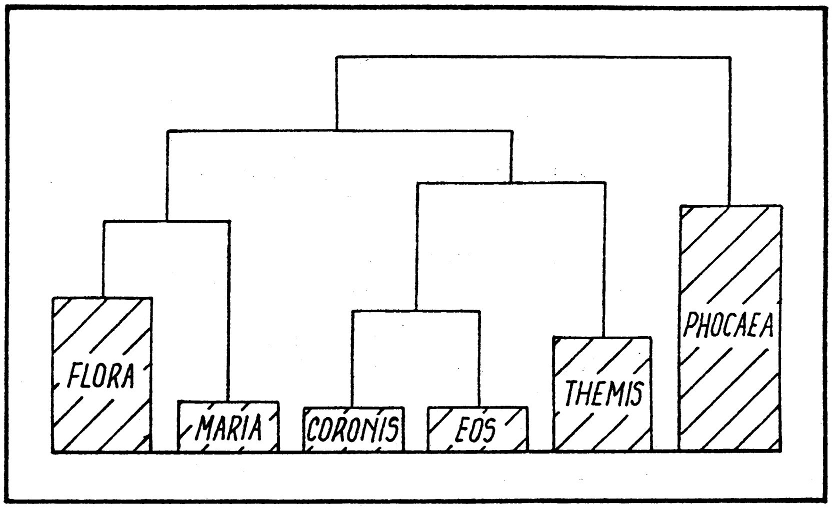

Fig. 1: Reduced phenogram of 166 asteroids.

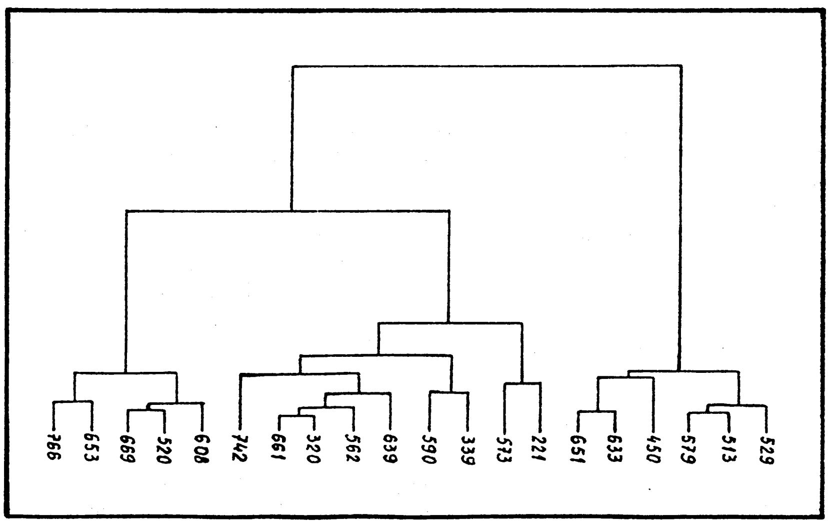

Fig. 2: Eos Family (portion of the global phenogram, fig. 1)

We applied numeric taxonomy to 166 selected asteroids. The corresponding results are arranged in the accompanying diagrams, (phenograms). Phenogram 1 is a reduced version of the full computer output, in which microstructures have been eliminated in order to provide the reader with a clear overall picture. Phenogram 2 is the section corresponding to the "Eos" family, taken as produced by our computer software. Standard numbers identifying the asteroids are given and the way in which the different groups are formed is clearly exhibited.

On the basis of the taxonomic selection criteria here employed, the original families of Hirayama are confirmed. The appropriate families are shown in the reduced phenogram ordered according to increasing values of a. Table 1, list the members of these families and give ranges of the elements. A division of the asteroids belt into three rings: inner ring (Flora), central ring (Maria), outer ring (Themis, Eos, Coronis) becomes apparent. The Phocaea separation is due to its large inclination.

TABLE 1. Hirayama Families.

Family	Members	Range
Themis	24- 62- 90-104-171-184-222-223- 268-316-379-363-431-461-468-492- 515-526-555-621	a 3.08- 3.17 e 0.12- 0.19 i 0.80- 2.37
Eos	221-320-339-450-513-520-529-562- 573-579-590-608-633-639-651-653- 661-669-742-766	a 3.00- 3.03 e 0.06- 0.08 i 9.74-10.55
Coronis	158-167-208-243-263-277-311-321- 452-462-534-658-720-761-811-832 962-975-993-1029	a 2.83- 2.91 e 0.04- 0.06 i 2.04- 2.27
María	170-472-575-616-652-660-695-714- 727-751-787-875-879-897-994-1158- 1160-1215-1379-1677	a 2.53- 2.57 e 0.08- 0.12 i 14.26-15.42
Phocaea	25-105-265-273-290-323-326-391- 502-587-654-852-914-950-1090-1108 1164-1170-1192-1316	a 2.30- 2.46 e 0.15- 0.29 i 18.83-26.31
Flora	8- 43-244-254-270-281-291-296- 315-341-352-364-367-376-422-428- 440-453-525-540-553-641-685-700- 703-711-736-763-770-782-800-802- 809-810-819-823-825-831-836-841- 851-913-939-956-960-963-1016-1037 1055-1060-1078-1088-1089-1123- 1130-1150-1153-1216-1225-1270- 1365-1377-1387-1399-1451-1619-	a 2.17- 2.31 e 0.10- 0.18 i 1.11- 7.34

IV. CONCLUSIONS

Our results suggest that automatic taxonomic techniques (where the computer does not knows wether it working with asteroids or with, say apples) may provide the astronomer with a powerful tool for classification purposes. Indeed, we have been able in this paper to reproduce the original families of Hirayama with such an objetive technique.

One is thus encouraged to process additional asteroids with these techniques, on the one hand, and to work within a larger space (that is, with other character), on the other, in the hope of establishing new classification criteria or validating pre-existing tentatives ones.

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