

Pre-Encounter Observations of 951 Gaspra

D. J. Tholen, *Institute for Astronomy, University of Hawaii*
J. D. Goldader, *Institute for Astronomy, University of Hawaii*
D. P. Cruikshank, *NASA Ames Research Center*
W. K. Hartmann, *Planetary Science Institute*

We obtained photometry and colorimetry of 951 Gaspra on nine nights during the 1990 opposition. A composite lightcurve constructed using data from eight of those nights yielded a synodic rotational period of 7.04246 ± 0.00006 hours, a mean absolute V magnitude of 11.8026 ± 0.0025, and a slope parameter of 0.285 ± 0.005. Barucci *et al.* (1990, BAAS **22**, 1113) found a comparable rotational period, but their slope parameter of 0.217 is significantly less than the value we determined from our data. The apparent discrepancy can be easily resolved by realizing that their determination is based primarily on data obtained prior to opposition, whereas our determination is based primarily on data obtained after opposition. Different phase functions pre- and post-opposition are a natural consequence of a changing aspect during an opposition. If the sub-Earth latitude on Gaspra is at a less equatorial aspect after opposition than it was before opposition, then we would expect to see a shallower phase function (corresponding to a larger numerical value of the slope parameter). Adding weight to this hypothesis is our last observation of the opposition, made in May after Gaspra had passed postopposition quadrature, which is displaced toward brighter absolute magnitudes relative to the rest of our data, indicating an even more poleward sub-Earth latitude than earlier in the opposition. Because the orbits of Earth and Gaspra are nearly coplanar, a substantial change in sub-Earth latitude during the opposition would not have been possible unless the obliquity of the asteroid's rotational axis is not small.

Rotationally resolved colorimetry of Gaspra shows a very slight variation in color with rotation, perhaps as much as 5 percent, but the precision of our data makes this variation significant at only the one standard deviation level.

To supplement the 0.3 to 1.1 micron reflectance spectrum of Gaspra obtained during the course of the Eight-Color Asteroid Survey by Zellner *et al.* (1985, Icarus **61**, 355), we obtained a spectrum of Gaspra from 0.8 to 2.5 microns using the double CVF at the Infrared Telescope Facility. A shallow absorption feature at 1 micron is obvious in the data. Although the data are noisier than we had expected, the band center appears to be slightly longward of 1 micron, which suggests than olivine dominates over pyroxene. An independent estimate of the pyroxene content can be obtained by examining the 2 micron region of the spectrum. The data hint at a slight depression in signal level relative to the continuum near 1.6 microns, but the noise level also allows the possibility of no absorption feature. It is worth noting that the redder than average visible colors are more reminiscent of the A-type asteroids, whose spectra are dominated by olivine, than the V-type asteroids, whose spectra are dominated by pyroxene. Gaspra would appear to be have a fairly high olivine to pyroxene ratio.

A comparison of our composite spectrum of Gaspra with one for 8 Flora obtained by Gaffey (1984, Icarus **60**, 83) shows reasonable agreement. According to Williams (1979, Asteroids, 1040), both 8 Flora and 951 Gaspra are members of his dynamical family 189, thus such spectral agreement hints at the compositional homogeneity of the parent body, if indeed these objects are fragments of the same parent body.

DETERMINATION OF ORBITS OF COMETS: P/KEARNS-KWEE, P/GUNN, INCLUDING NONGRAVITATIONAL EFFECTS IN THE COMETS' MOTION; B. Todorovic-Juchniewicz, G. Sitarski, Space Research Centre, Bartycka 18, 00-716 Warszawa, Poland

To improve the cometary orbits, 252 positional observations made in the period 1963-1991 for comet P/Kearns-Kwee and 200 positional observations made in the period 1954-1990 for comet P/Gunn were used. The correction of orbital elements were determined in two ways: - Model I - together with Marsden's nongravitational parameters A1, A2, A3; - Model II- together with angular parameters of a rotating cometary nucleus: the lag angle, the equatorial obliquity and the cometocentric solar longitude at perihelion , and with the parameter A. It was found that for comet P/Kearns-Kwee Model I with the constant values of the nongravitational parameters became incorrect and inconsistent with the real motion of the comet. On the contrary, the solution with Model II was very good, however, taking into account the time dependence of the nongravitational parameter A=A0*exp(-B*t). In the case of comet P/Kearns-Kwee, a parameter D of a displacement of the photometric center from the center of mass of the comet was also determined along with the parameters of motion. For the comet P/Gunn, the mathematical Model I may be acceptable whereas Model II taking into consideration the change of the nongravitational parameter A with time represent very well the real motion of this comet.

MINOR SATELLITES AND THE GASPRA ENCOUNTER; T.C. Van Flandern, Meta Research

On October 29, 1991, the Galileo spacecraft will encounter the minor planet 951 Gaspra. Pictures of the object and its environment will reveal immediately whether or not the minor planet has numerous moons ("minor satellites") in stable, bound orbits.

In 1977 predictions of occultations of stars by minor planets became widely available through the efforts of D.W. Dunham. At about the same time occultations of the same stars by secondary bodies, apparently in the vicinity of the associated minor planet, also started to be reported. To date there are a few dozen reports of secondary occultation events, two of which have been confirmed by a second, independent observer. In the best case to date, the Herculina occultation event in 1978, a secondary occultation of four seconds duration reported by a visual observer in California was confirmed in a photoelectric record made at the Lowell Observatory. Additional evidence for secondary bodies in the vicinity of minor planets was found by Binzel[1], and by Tedesco[2]. For example, lightcurves of some minor planets show multiple-body phenomena, such as eclipses and transits. Also, radar ranging to minor planets which approach the Earth quite closely have shown similar phenomena. Ostro et al.[3] report that 1989 PB had at least a double-peaked radar echo which appeared to be separated at certain elongation angles, with possible additional echoes present.

Since the target asteroids were essentially randomly selected, and minor satellite evidence occurs relatively frequently, it would appear that the presence of minor satellites is commonplace for asteroids smaller than the largest four. Moreover, given how few observers were involved, and how large the volume of space within a minor planet's own sphere of influence is, yet how often one or more secondary events were seen, it would seem that such minor satellites are numerous. This would lead to the expectation that at the upcoming encounter, Gaspra will also be found to have minor satellites. The only qualifier is that Gaspra is a "peculiar S-type" asteroid. S-types are believed to have been involved in collisions, which would tend to remove most of their satellites. And a peculiar asteroid is not a good basis for establishing that any particular phenomenon is normal for most asteroids.

Nonetheless, because of the apparent generality of this phenomenon, we predict that Gaspra will exhibit minor satellites during the encounter. Even if Gaspra was involved in a collision, tidally-decayed satellites should be found on its surface.

1. R.P. Binzel and T.C. Van Flandern, Science **203**, 903 (1979).

2. T. C. Van Flandern, E. F. Tedesco, R. P. Binzel, Asteroids, T. Gehrels, Ed. (U. of Ariz. Press, Tucson, 1979) pp. 443-465.

3. S. J. Ostro et al., Science **248**, 1523 (1990).

The role of organic polymers in structure and fragmentation of the cometary dust

V. Vanysek, Department of Astronomy and Astrophysics, Charles University
150 00 Prague 5 Czechoslovakia

In situ obtained data concerning the size and composition of the dust in Comet Halley indicate that a high percentage of the dust particles are composite grains containing organic species among the may be also polymerized molecules. One of the very first proposed candidate for polymers in cometary material was formaldehyde in form of polyoxymethylene or POM (Vanysek and Wickramasinghe 1975). After the discovery of repeating mass spectral pattern at 45, 61, 75, 91 and 105 *amu* in inner coma of comet Halley, the possible presence of POM or similar compounds in comets was widely discussed (see for instance Huebner 1987, Huebner *et al.* 1989, Moore and Tanabé 1990). Also within the frame of the model of agglomerated grains for cometary dust the possible role of organic polymers as gluing material between the individual building blocks of submicron size was outlined (Boehnhardt *et al.* 1990, Vanysek 1989). In he preset study this problem is newly reviewed and confronted with new laboratory results. For fragile dust aggregates, where are only few bridges between individual particles the tensile strength should be in range 10^4 to 10^5 dyn cm^{-1}. Such a relatively stable "bridges" may be formed by polymerized formaldehyde as a natural "cosmic glue". It is shown that formation of such structures is possible even in dense interstellar molecular clouds.

References

Boehnhardt H. Fechtig H. and Vanysek V. 1990: Astron. Astrophys., 231, 543

Huebner W.F. 1987: *Science* 237, 628

Huebner W.F.Boice D.C. and Korth A. 1989: *Adv. Space Res.* 9(2), 29

Moore M.H. and Tanabé T. 1990: *Astrophys. J.* 365, L39

Vanysek V. and Wickramasinghe N.C. 1975: *Ap. Space Sci.* 33. L19

Vanysek V. 1989: in *Fluffy Structures II*, eds. P.M.M. Jenniskens and J.I. Hage , Leiden, p.18.

QUALITATIVE AND NUMERICAL-ANALYTIC METHODS FOR INVESTIGATION OF THE EVOLUTION OF ASTEROID ORBITS; M. A. Vaschkov'yak.

The present paper contains the short survay of the works, executed by author at the Keldysh Institute of Applied Mathematics, the USSR Academy of Sciences in 80-th years.

The qualitative investigation of the orbit evolution in restricted circular three-body problem [1a,b] is founded on the integrability of twice-averaged scheme or Gauss problem. In these works the analysis of the orbit crossing conditions is carried out, the typical families of the integral curves are constructed for different values of the parameters, the extreme characteristics of the evaluating orbits are calculated. The generalization of the method on the concentric coplanar system of N perturbing bodies has permited to reveal the same qualitative pecularities of the orbit evolution of the asteroids not belonging to the main belt [1c].

More exact numerical-analytic method for investigation of the asteroid orbits evolution [2] was created taking into account eccentricities, inclinations and the secular perturbations of the planet orbits. By use this method, in particular, the posibility of qualitative change of the evolution of perihelion argument for the orbit of asteroid 2335 (James) was discovered [3]. It reduses to the transition from libration regime in circulation one and back over interval of $\sim 10^5$-10^6 years and gives the clear example of the motion in the vicinity of the secular resonance.

REFERENCES.

1. Vashkov'yak M. A. Cosmic Research, 1981, Vol. 19;
a) No 1, pp. 1-10; b) No 2, pp. 99-109; c) No 4, pp. 357-365;
(Translated from Kosmicheskie Issledovaniya).
2. Vashkov'yak M. A. Cosmic Research, 1985, Vol. 23, No 3, pp. 277-287
(Translated from Kosmicheskie Issledovaniya).
3. Vashkov'yak M. A. Cosmic research, 1986, Vol. 24, No 3. pp. 255-267
(Translated from Kosmicheskie Issledovaniya).