DUST PARTICLES FROM COMETS AND ASTEROIDS: PARENT-DAUGHTER RELATIONSHIPS

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Much progress has been made in laboratory analyses of cosmic dust grains collected from the stratosphere, the arctic and antarctic ices, and from the ocean floor (1), and on material identified as meteoritic in impact craters on Earth-orbiting spacecraft (2). Zook (3) noted that the scientific value of laboratory dust grain research would be greatly enhanced if one knew from which parent body each dust grain derived. It was thought possible that such correlations could be made if dust grain trajectories were measured before catching them into some suitable capture medium; indeed, trajectory measurement (and the resulting orbital determination) has been made a major goal of the CDCF (Cosmic Dust Capture Facility) that is proposed for flight on the Freedom Space Station (4).

We report here on numerical analyses of the expected orbital evolution of three sizes of dust grains (of radii 10, 30, and 100 microns; mass density 1g/cm3) released from the 33 different asteroids and comets listed in Table 1. All grains were assumed to be released at the perihelion points of their parent bodies, and the orbits were followed using the numerical procedure described in Jackson and Zook (5). Forces assumed acting on the particles are those of the gravitational fields of the sun and planets, radiation pressure, Poynting-Robertson drag, and solar wind drag. In figures 1 through 6 are plotted the dust grain orbital eccentricities as ordinates and their velocities with respect to a gravitationless Earth as abscissas at the points where their ascending and descending nodes coincide with the ecliptic plane near 1 A.U. (and where they have the potential to impact the Earth).

One sees in these figures that, even though the particles followed very complicated orbital evolutionary histories, orbital eccectricities of the asteroidal dust grain population, are lower than those of nearly all cometary dust grains (except for an occasional cometary dust grain that lands in the asteroidal dust grain field). Thus it appears that one may generally differentiate asteroidal grains from cometary grains on the basis of the measured orbital eccentricities alone. Both asteroidal and cometary grains pass through interior orbital period resonances with Jupiter and are often scattered and are occasionally trapped for some interval of time at those locations. Cometary grains are also often trapped in resonances exterior to the orbit of Jupiter. Most asteroidal, and some cometary, grains in the 10 to 100 micron size range are trapped into resonances exterior to Earth. Because large grains are more likely to be trapped into such resonances than are small grains, and because orbital eccentricity increases during such trapping, the eccentricities of large asteroidal grains are seen in figures 1-6 to to be generally greater than those of small grains.

The average values of eccentricity and magnitude of relative velocity for asteroids are, respectively, for grains of 10, 30 and 100 microns radius .1, .1,. 2, and 6, 7, 7 (km/sec). The respective numbers for the comets with $q > 1$ AU are .4, .4, .5 and 14, 12, 11 (km/sec). For comets $q < 1$ AU these numbers are .6, .7, .7 and 15, 16, 17(km/sec). We see, therefore, that even after many tens of thousands of years of orbital evolution, that cometary and asteroidal dust grains do not, on the whole, resemble one another. Thus, broad parent-daughter associations can be made from measurements of their trajectories in earth orbit.

Table 1. List of Source Bodies with orbital elements (a,e,i)
(a = semimajor axis (AU), e = eccentricity, i = inclination (deg.))

Asteroids	Comets ($q>1$ AU)	Comets ($q<1$ AU)
Budrosa (2.92,.022,.046)	Brooks2 (3.63,.490,5.5)	Biela (3.53,.861,12.6)
Ceres (2.76,.077,10.6)	Clark (3.12,.502,9.5)	Brorsen (3.1,.81,29.4)
Concordia (2.70,.045,5.06)	Du Toit-Hartley (3.36,.602,2.9)	Encke (2.22,.846,11.9)
Eos (3.01,.102,10.9)	Gunn (3.60,.316,10.4)	Grigg-Skillerup(2.96,.666,21.1)
Eunomia (2.64,.188,11.8)	Johnson (3.64,.367,13.7)	Honda-Mrkos-Pajduskova(2.61,.822,4.2)
Flora (2.20,.156,5.89)	Kopff (3.46,.545,4.7)	
Hertha (2.43,.151,3.71)	Longmore (3.65,.343,24.4)	
Hungaria (1.95,.074,22.5)	Neujmin 2 (3.03,.567,10.6)	
Koronis (2.87,.056,1.00)	Russell 1 (3.34,.517,22.7)	
Leto (2.78,.187,7.95)	Schwassman - Wachmann 2 (3.48,.387,3.7)	
Maria (2.55,.065,14.4)	Temple 2 (3.40,.638,5.4)	
Nyasa (2.42,.151,3.7)	Temple - Swift (3.11,.521,10.6)	
Phocaea (2.42,.204,2.30)	Tuttle-Giacobini-Kresak (3.15,.502,9.9)	
Themis (3.13,.133,.761)	Whipple (3.8,.356,10.2)	
Undina (3.21,.082,9.88)	Wolf (4.15,.396,27.3)	

REFERENCES: (1) Brownlee D.E. (1985) Ann. Rev Earth Planet. Sci. 13, 147-173.(2) Laurance M.R. and Brownlee D.E. (1986) Nature 323, 136-138. (3) Zook H.A.(1986) In LPI Tech. Rep. No. 86-05, 97-99. (4) Horz F. (1990) NASA TM-102160. (5) Jackson A.A. and Zook H.A. (1989) Nature 337, 629-631.

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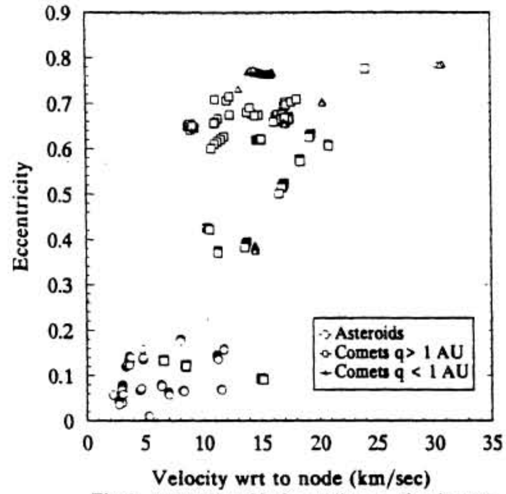

Fig 1. Ascending Node, radius = 10 microns

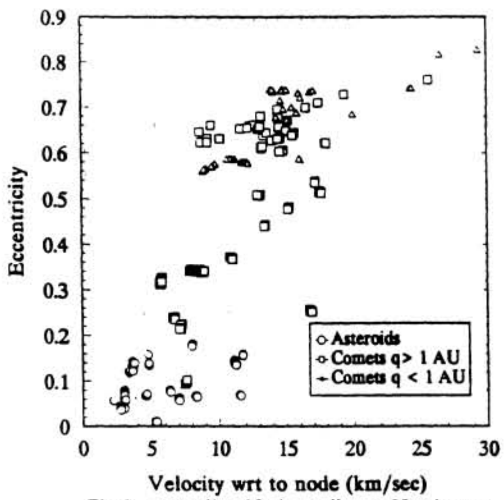

Fig 2. Ascending Node, radius = 30 microns

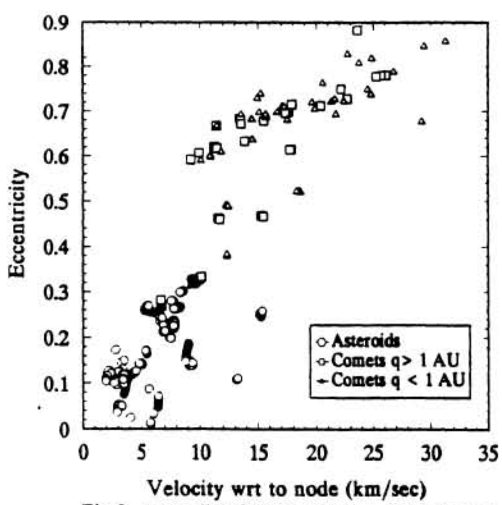

Fig 3. Ascending Node, radius = 100 microns

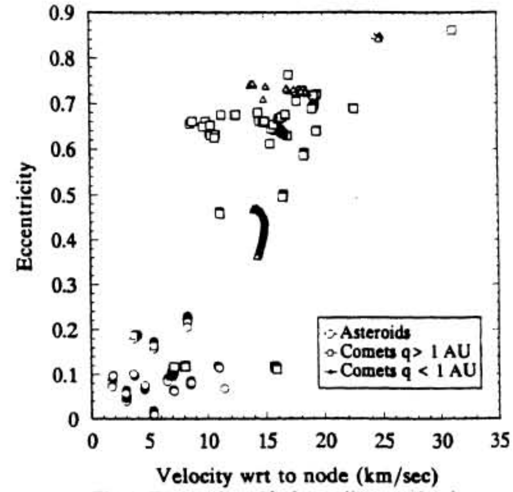

Fig 4. Descending Node, radius = 10 microns

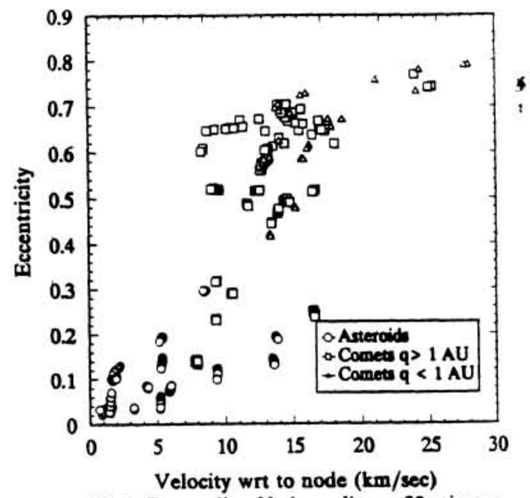

Fig 5. Descending Node, radius = 30 microns

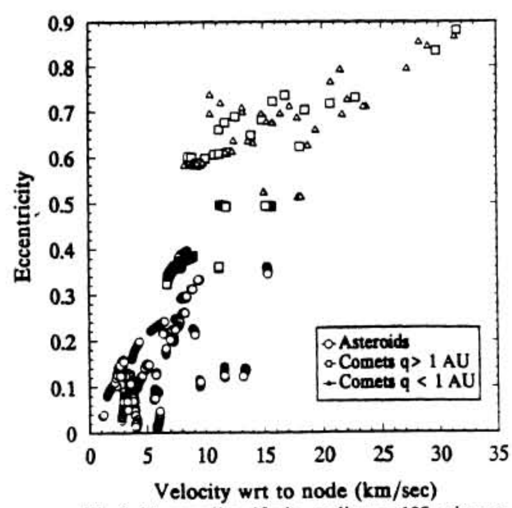

Fig 6. Descending Node, radius = 100 microns