DUST PARTICLES IN THE JOVIAN SYSTEM. Herbert A. Zook, NASA Johnson Space Center, Houston, TX 77058 and Shin-Yi Su, Lockheed-EMSCO, Houston, TX 77058

The rate of penetration of the meteoroid detector panels on the Pioneer 10 and Pioneer 11 (P-10, P-11) spacecraft increased by a factor of nearly 10^3 over the nearby interplanetary background rate when these spacecraft flew by Jupiter (1,2,3). A difficulty arises when one attempts to solely ascribe this increase in penetration rate to a near-Jupiter gravitational enhancement of the flux of interplanetary meteoroids. That is, to match a near-Jovian gravitational enhancement with the observed flux, interplanetary meteoroids must either be in near-circular, low inclination orbits, or the size distribution of meteoroids must be very steep (with numerous small meteoroids) at 5 AU. The experimental evidence (2,3) indicates that neither condition can be strictly true. An alternative is to postulate that a cloud of meteoritic particles are in orbit about Jupiter and that they caused the observed increase in penetration rate. We have studied this latter possibility in some detail and now summarize some of our results here.

The orbital and size distribution of the eight outer moons of Jupiter (4 in prograde and 4 in retrograde orbits) are consistent with them being the largest remaining fragments of a previous collision history (e.g., 4). It is also reasonable to assume that this collision history produced a large but unobserved population of smaller objects in both prograde and retrograde Jovian orbits. Under interplanetary meteoritic erosion and under mutual collisions with each other, a cloud of micrometer to millimeter sized particles is postulated to be continuously created from the suggested population of larger particles. The small particles then drift, under Poynting-Robertson drag, toward Jupiter. When particles from this cloud reach the Jovian magnetosphere at about 100 R_J (Jovian radii), we find that the plasma ion density (5) and average plasma atomic weight (6) are such that the co-rotating magnetospheric plasma drag will dominate P-R drag. Particles in prograde Jovian orbits will drift no closer to Jupiter but, instead, will increase their apojoves until it is probable that they escape the Jovian system. Particles in retrograde orbits will have their inward drift velocities increased. Figure 1 shows the drift velocities, under both P-R and plasma drag, of particles of radius 5 μm whose initial orbits are circular but whose semi-major axes and inclinations are those of the 4 retrograde Jovian moons. The inward drift velocity is given in km/s. Plasma drag also acts to lower the orbit inclination with time. This effect is shown in Figure 2 where orbital inclination is plotted versus Jovicentric distance for particles in retrograde orbit. The particle trajectories progress to the left with time. If the initial inclination is less than about 150° the particles will evolve into prograde orbits and then expand orbital dimensions. They then progress away from, rather than toward, Jupiter.

We find that under reasonable assumptions that the 4 retrograde moons and associated fragments are able to produce enough small particles to account for the magnitude of the P-10 and P-11 results. This expectation includes an analysis of the rate of destruction of these particles by collisions with the Galilean moons while the particles drift toward Jupiter. However, our theoretical results also show that P-10 spacecraft should be penetrated at a rate 5 to 10 times higher on the approaching leg of the Jupiter swingby than on the receding leg. This appears to be contrary to the actual observation that there was little difference between the number of penetrations during each leg of the swingby. Thus we have the dilemma that neither the interplanetary meteoroid population nor debris from the outer Jovian moons can be clearly demonstrated to be resposible for the P-10 pene-

tration data. The data are too limited to provide good statistics, however. There remains the possibility that particles from Amalthea, 1979J2, and possible associated debris could be responsible. The latter possibility would seem to require electromagnetic scattering of the particles out of the Jovian equatorial plane.

References:

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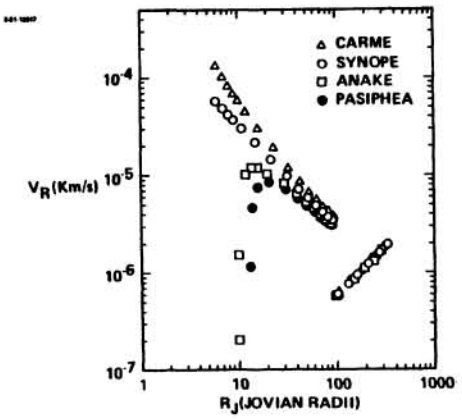

Fig. 1: Inward drift velocity vs. Jovicentric distance for particles of radius = 5 μm (ρ = 3 g/cm^3)

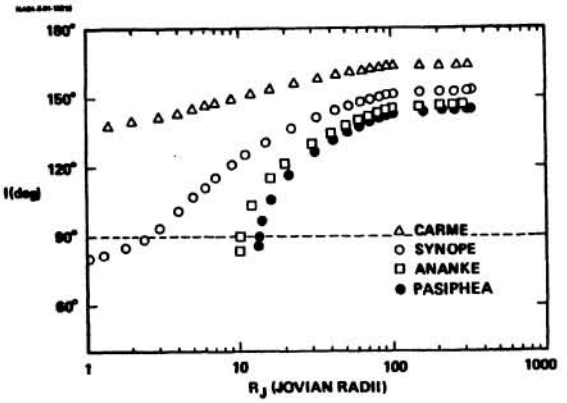

Fig. 2: Jovicentric orbit inclination vs. Jovicentric distance. Particles evolve to lower left from upper right with time.