PARTICLE/PLANETESIMAL ORBITAL BEHAVIOR NEAR PROTO-JUPITER

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It has been suggested that the accumulation time for Mars is dependent upon both the presence as well as development of proto-Jupiter [1]. It has also been suggested that the formation of both the inner and outer planets are directly limited by the developmental time scale of proto-Jupiter [2]. This paper examines the affect a developing proto-Jupiter would have on the orbital trajectories of particles and planetesimals ranging in size from 0.1 m to 100 m.

The current work models a gaseous proto-Jupiter taking into account the size, mass, composition, viscosity, rotation and orbital parameters of both the proto-planet (core) and its cloud (gaseous envelope). The proto-planet has an assumed core mass of 15 $M_\oplus$, a cloud mass of 302 $M_\oplus$ and a tidal radius of approximately 782 Jupiter radii. A cloud radius of 500 Jupiter radii (based on the tidal radius given above) yields a cloud density of 9.5×10^{-6} kg/m^3. Assuming a nearly pure hydrogen composition for the cloud (to simplify the calculations involved) and an overall temperature of 750° C, a viscosity of approximately 200 μpoise (2×10^{-5} kg/m s) is obtained. Given the above, a calculation for the gas drag force can be obtained using the Stokes drag law equation for various drag coefficients and particle sizes [3]. This expression for the gas drag force then allows for a proper calculation of the particle's total acceleration while within the proto-Jupiter cloud. The orbital trajectories of the particles/planetesimals are calculated taking into account the usual gravitational forces (including the J_2 component of the Martian gravity) as well as the gas drag force mentioned above. Particles of varying radii and densities are injected into the system and their orbital trajectories then tracked. Several different numerical methods (3rd, 4th & 5th order Runga-Kutta) have been employed in an attempt to optimize CPU time constraints with numerical accuracy. The acceleration to the particle due to gravitational forces (excluding the J_2 component of the Martian gravity for the moment) is given by

$$\ddot{x}_i = \sum_{\substack{k=1 \\ k\neq i}}^{n-1} Gm_k\left(\frac{x_k - x_i}{|x_k - x_i|^3} - \frac{x_k}{|x_k|^3}\right) - G(m_n + m_i)\frac{x_i}{|x_i|^3}$$

where G is the gravitational constant and M represents the mass of the Sun [4]. Calculations were made for varying radii and densities.

Several interesting results using the above model have been obtained and are illustrated below in Figure 1. It appears that although proto-Jupiter places many of the particles into a Lagrangian resonance, it also accretes particles from within the L_1 or L_2 resonance zones through gas drag. Additional results (as well as a detailed analysis) will be presented in a forthcoming publication.

References: [1] Zharkov, V.N. (1993) Geop. Mono. 74, IUGG 14, 7-17.

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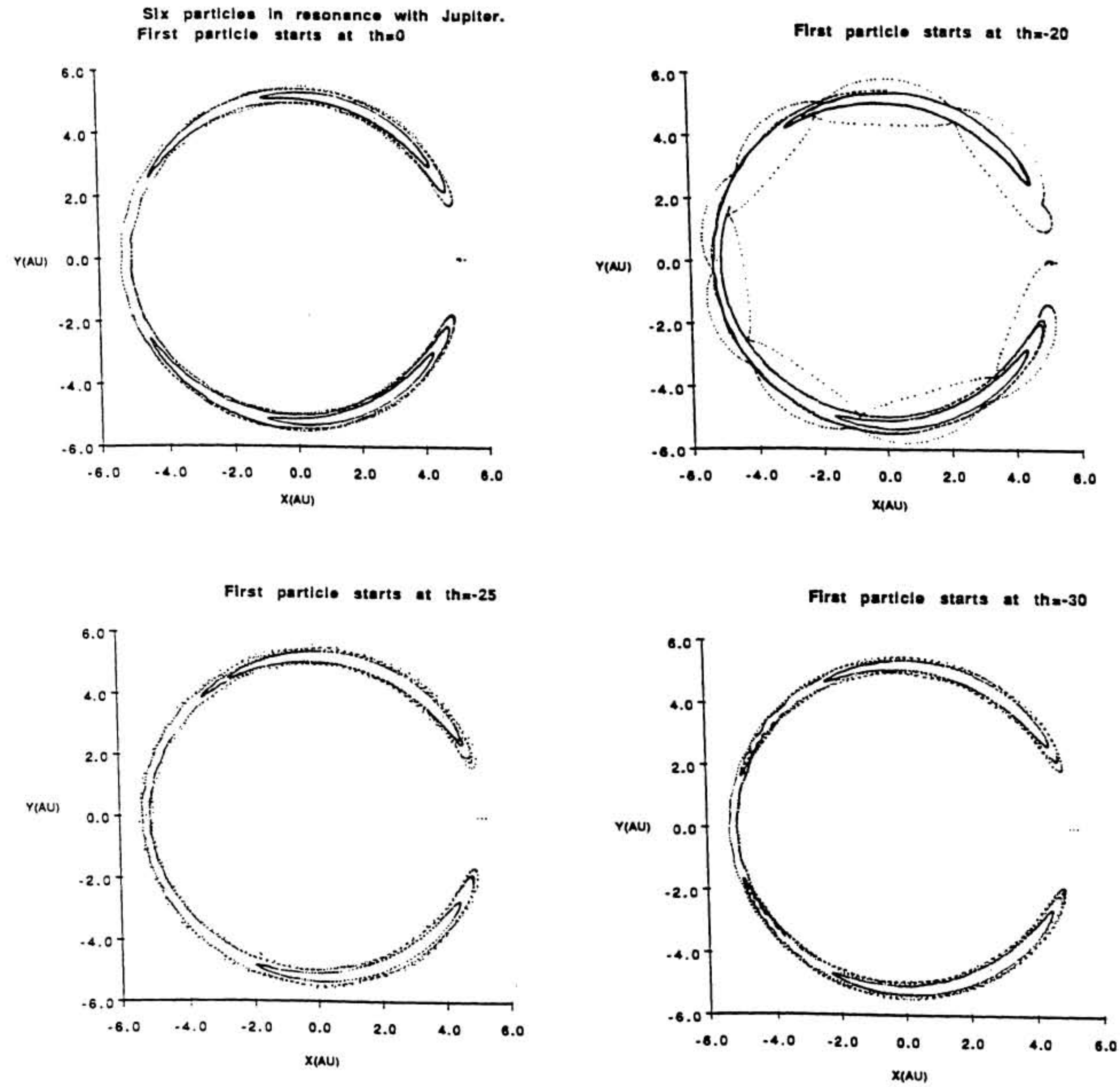

Figure 1. Plot positions of six particles released from positions located 60° apart along Jupiter's orbit. The upper left hand figure has the first particle located at the position of Jupiter (located at 0° in the figures). The upper right hand figure has the particles rotated by 20° clockwise for their initial positions. The lower left hand figure has the particles rotated by 25° clockwise. The lower right hand figure has the particles rotated by 30° clockwise.