Cover: The solar system in many ways resembles a complex clockwork, in which subtle interactions produce unexpected results. The rational understanding and mathematical description of the physical processes involved is the gist of our book and is well illustrated in the cover. On March 5, 1979 the Voyager 1 space probe imaged volcanic plumes on Io, one of the four Galilean satellites of Jupiter (discovered by G. Galilei in 1611); the picture we show, with only one, but impressive plume, has been obtained by the Galileo spacecraft in 1995 (and is available at NASA's node http://www.jpl.nasa.gov/galileo/images/io). Io's volcanism provides direct evidence that the satellite interior is extremely hot, and raises the question of the energy source of this surprising activity. On January 26, 1979 S.J. Peale of the University of Santa Barbara (California), P. Cassen and R.T. Reynolds (both of the NASA Ames Research Center, California) submitted to *Science* a paper, "Melting of Io by Tidal Dissipation", in which they specifically predicted this volcanic activity. A special refereeing process was requested, and obtained from the editor, so that the paper could appear before the Voyager encounter; the paper was in fact accepted, and published on March 2, just three days before. A sample of the preparatory notes was kindly provided by S.J. Peale and are shown in the cover. We thank him very much for his help.

Io is tidally deformed by Jupiter's gravitational field into an oblate shape aligned with the direction of the planet; this deformation locks the satellite in a synchronous state, in which the rotation and the orbital periods are the same. But since the orbit is eccentric the tidal deformation changes periodically and the ensuing friction heats its interior. The striking prediction by Peale and his collaborators is based on three conditions: (i) the rate of tidal energy dissipation induced by the orbital eccentricity can be calculated, (ii) the orbital eccentricity is maintained in spite of the dissipation, and (iii) the tidally deposited heat could not escape fast enough to keep Io cool. The dissipated heat, proportional to the square of the eccentricity, can be established in order of magnitude, as discussed at the end of Sec. 15.3; in the bottom of the cover Peale gives a rigorous formula. The triplet of Jupiter's satellites Io, Europa and Ganymede (in the cover indicated with the suffixes $_1$, $_2$ and $_3$) are locked in a peculiar three-body resonance first understood and studied by P.S. Laplace in 1805. The eccentricities of Io and Europa are maintained by the resonance at the particular values shown in the first two formulas below the plot. In our book this resonance is briefly described in Sec. 14.2, while the mechanism of resonant enhancement of eccentricity (and inclination in some cases) is introduced in Sec. 15.2. The rate of heat loss from a solid Io by solid state convection was shown to be less than the rate of deposition by tidal friction, so Io had to get hot and form a molten core. The formation of a fluid core increases the tidal dissipation in the remaining solid shell so the fluid core would grow in a runaway fashion. As shown in Peale's plots on the cover, the fluid core becomes a substantial part of the body of the satellite in a time much shorter than the satellite lifetime.

Physics of the Solar System

PHYSICS OF THE SOLAR SYSTEM
Dynamics and Evolution, Space Physics, and Spacetime Structure

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Kluwer Academic Publishers
Boston/Dordrecht/London

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