

## The Orbits of the Minor Saturnian Satellites

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I have determined new orbits for the nine minor Saturnian satellites, Janus, Epimetheus, Helene, Telesto, Calypso, Atlas, Prometheus, Pandora, and Pan. All but Pan's orbit are based on fits to the currently available set of Earthbased astrometric and Voyager imaging data. Orbits for the co-orbiters (Janus, Epimetheus) and the Lagrangian satellites of Tethys and Dione (Helene, Telesto, Calypso) are represented by numerical integrations. Orbits for the F Ring Shepherds (Prometheus, Pandora) and Atlas are represented by processing ellipse theory with semi-major axes and periapsis rates computed from the analytical expressions of Null, *et al.* (1981, AJ 86, 456) using the dynamical constants of Campbell and Anderson (1989, AJ 97, 1485). The orbit of Pan is also represented by the processing ellipse theory with elements from Showalter (1991, Nature 351, 709) but with a revised epoch time (22-Aug-1981 19:03:48.7141ET). The revision of the epoch is the result of a joint analysis by Showalter and myself.

The new orbits for the co-orbiters are consistent with those of Yoder, *et al.* (1989, AJ 98, 1875) and confirm his values of the satellite masses. Revised masses of Tethys and Dione, however, were required in order to produce acceptable orbits for the Lagrangian satellites. The new values ( $\text{km}^3/\text{sec}^2$ ) are, respectively,  $41.62 \pm 0.55$  and  $73.12 \pm 0.25$ . The Tethys mass is remarkably close to Kozai's original value (Ann. Tokyo Obs. Ser. 25, 73). The minimum and maximum libration amplitudes for Helene, Telesto, and Calypso are, respectively,  $(44^\circ 3, 74^\circ 0)$ ,  $(58^\circ 8, 61^\circ 2)$ ,  $(-56^\circ 0, -63^\circ 9)$ , and the associated libration periods (days) are 767.8, 692.0, and 693.4.

This work was performed to support observations planned for the upcoming Saturn Ring Plane Crossing time period. Satellite ephemerides are available through World Wide Web at NASA's Planetary Data System Rings Node.

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