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Saturn's Gravity Field and Interior Structure

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The orbiting Cassini spacecraft can be used as a probe of Saturn's gravity field. We use the most recent Cassini gravity results, along with the Zharkov-Trubitsyn theory of figures, to infer properties of Saturn's interior, similar to the inferences drawn from the gravity fields of the Galilean satellites during the Galileo mission at Jupiter. A solid-body rotation period from Cassini magnetic-field data is used for the effective potential and for the calculation of the level surfaces. The first-order differential equations for hydrostatic equilibrium are numerically integrated with a polytropic interpolation function for the equation of state. We find that the measured gravity coefficient J4 requires a substantial core in Saturn of about 3.2 Earth masses, and with a core radius about 18% of the total radius. Similar calculations for Jupiter demonstrate that unlike Saturn, the measured zonal gravity harmonics can be fit with a single polytrope of index one, as pointed out by W. B. Hubbard over 30 years ago. The derived empirical equations of state for both planets are shown for a depth of 10 bar to 2 Mbar, just short of where the phase transition from molecular to metallic hydrogen occurs.