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The determination of Iapetus mass from Doppler tracking of the Cassini spacecraft

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On October 17 and December 31, 2004 the Cassini spacecraft came at about10^6 and 10^5 Km from the Saturn's moon Iapetus. Although the closest approach distance was large and the encounters barely deserve the name of flybys, they provided the first opportunity for an accurate determination Iapetus mass and density. Previous estimates of the satellite's gravitational parameter GM were indeed affected by a large uncertainty. Using Voyager data, Campbell and Anderson (2003) obtained a value of 106 +/- 15 km^3/s^2, while a recent estimate by Jacobson (2004) put the GM at 129.6647 +/- 17 km^3/s^2. The good quality of the Cassini X-band Doppler data (about 3.9×10^{-3} and 1.4×10^{-3} cm/s at 300 s integration times, respectively for the first and second flyby) allowed a substantial reduction of the experimental uncertainty. The orbital fit of the spacecraft trajectory was carried out over arcs of 15 days about closest approach using a limited set of solve-for parameters (the spacecraft state vector and Iapetus GM, with Saturn GM as a consider parameter). Our best estimate of the satellite's gravitational parameter comes from the first and more distant flyby, which yielded the value GM =$120.20 \pm 6.306 \times 10^{-2}$ km^3/s^2. Assuming a radius of 730$\pm$6 km (based upon recent Cassini images), the corresponding density of Iapetus is $1.106\times10^3\pm2.5\times10^1$kg/m^3. The second flyby, occurring at a much closer distance, gave a smaller formal error and a rather consistent estimate (GM=$120.51 \pm 2.903 \times 10^{-3}$ km^3/s^2), but the orbital solution was much more affected by the uncertainties in Iapetus ephemerides. and likely to be biased.