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An Angular Momentum Approach to the study of the Cassini States of large triaxial icy satellites in synchronous rotation

Alexis Coyette[1], Rose-Marie Baland[2], and Van Hoolst Tim[2]
[1]University of Namur, Naxys Institute, Department of mathematics, Namur, Belgium (alexis.coyette@unamur.be)
[2]Royal Observatory of Belgium, Brussels, Belgium

The large icy satellites are thought to be in a Cassini State, an equilibrium rotation state characterized by a synchronous rotation rate and a precession rate of the rotation axis equal to the precession rate of the normal to the orbit. In such states, the spin axis of the satellite, the normal to its orbit and the normal to the inertial plane remain coplanar and the angle between the spin axis and the normal to its orbit, also called the obliquity. For a rigid body, up to 4 Cassini States exist, characterized by an obliquity close to 0 (Cassini State I), π/2 (Cassini State II), π (Cassini State III) and -π/2 (Cassini State IV). However, only the Cassini States I and IV are stable.

In the Cassini State, the obliquity remains almost constant over time. As the gravitational torque exerted on the satellite shows small periodic variations, the orientation of the rotation axis also varies with time, resulting in periodic nutations in obliquity.

Even if the Galilean Moons are thought to be characterized by an obliquity close to 0, it is possible that other satellites in synchronous rotation (in our Solar System or elsewhere in the Universe) occupy another Cassini State. We investigate the influence of the triaxiality and of the presence of a subsurface ocean on the obliquity (close to 0 or close to π) of the Galilean Moons and of Titan.

In the early 30s, the ESA JUICE (Jupiter Icy moons Explorer) mission will measure the rotation of Ganymede and Callisto. We therefore focus on this period of time to determine if future observations of the obliquity of these satellites, and of their nutations, could constrain their interior structure.