EPSC Abstracts
Vol. 10, EPSC2015-825, 2015
European Planetary Science Congress 2015

Simulating the librational behaviour of propeller moons in Saturn's rings

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Abstract

Since its arrival at Saturn in 2004 the observations by the spacecraft Cassini have revolutionised the understanding of the dynamics in planetary rings. One of the tremendous discoveries of the Cassini space mission has been the detection of small disk-embedded moons in the dense rings of the Saturnian system. These small disk-embedded objects (*moonlets*) are not directly observable by the cameras aboard the spacecraft Cassini and cause S-shaped density variations in the surrounding ring material and therefore are called *propellers*.

Recurrent observations of the same propeller structures in Saturn's A ring allowed the reconstruction of their orbital motion from the Cassini ISS images and revealed a systematic sinusoidal excess motion from the expected Keplerian orbit of several 100 km in azimuthal direction [1]. Many attempts have been started to explain this librational behaviour, but none of them has been able to successfully explain all of the observed features [4, 2, 3, 6].

Resonant moon-moon interactions are well known phenomena in the Saturnian system and result in the same systematic librational behaviour as observed for the propellers [5, 1].

Therefore, here, we discuss the possibility that the observed periodical excess motion of the propellers is caused by the gravitational interaction with the moons of Saturn. We present results of N-body simulations where we integrate the orbital evolution of a moonlet - treated as a test particle - under the gravitaional influence of one or more perturbing moons. We examine the resulting librational excess motion of the moonlet and identify a set of moons, which explains the observed libration frequencies and amplitudes. In our simulations we account for interactions between all relevant moons of the Saturnian system which automatically allows the consideration of many-body resonances.

Acknowledgements

This work was supported by the Deutsche Forschungsgemeinschaft (Sp 384/28-1, Sp 384/24-2) and the Deutsches Zentrum für Luft- und Raumfahrt (OH 1401).

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