EPSC Abstracts
Vol. 9, EPSC2014-152, 2014
European Planetary Science Congress 2014

Vertical structures induced by propeller moonlets: Comparison of hydrodynamical model and N-body box simulations

H. Hoffmann (1), M. Seiß (1), H. Salo (2) and F. Spahn (1)
(1) Institute of Physics and Astronomy, University of Potsdam, Germany (hohoff@uni-potsdam.de),
(2) Division of Astronomy, Department of Physics, University of Oulu, Finland

Abstract

Small moonlets in Saturn's rings induce *propeller* called structures into the surrounding ring material. Images of Saturn's rings, taken by the Cassini spacecraft near Saturn's equinox in 2009, show shadows cast by these propellers [1], offering the opportunity to study their vertical structure.

We compare results from an extended hydrodynamical propeller model with results from local N-body box simulations of propeller structures. In the hydrodynamical model, maximal propeller heights are determined from the gravitational scattering of the ring particles by the moonlet. Afterwards the disturbed balance of viscous heating and collisional cooling is considered as main mechanism of the propeller height relaxation [2]. For the N-body box simulations we use the code by Salo [3], which was also applied in the propeller simulations of [4] and [5].

We find that the exponential height relaxation predicted by the hydrodynamical modelling is confirmed by N-body simulations of non-self gravitating ring particles. By projecting the propeller height evolution of the hydrodynamical model into observations of the shadows cast by the Earhart propeller, we determine the exponential cooling constant of the height relaxation. With this cooling constant we estimate collision frequencies of about 6 collisions per particle per orbit in the propeller gap region or about 11 collisions per particle per orbit in the propeller wake region of the Earhart propeller.

The N-body simulations lead to maximal propeller heights between 60 to 70 percent of the Hill radius of the corresponding moonlet. Moonlet sizes estimated by this relation are in fair agreement with size estimates from radial propeller scalings [5, 6] for propeller structures with observed shadows.

Acknowledgements

This work was supported by Deutsche Forschungsgemeinschaft (Sp 384/24-2), by Deutsches Zentrum für Luft- und Raumfahrt (OH 0003) and by the Academy of Finland.

References

[1] Tiscareno M. S. et al.: Physical Characteristics and Non-Keplerian Orbital Motion of "Propeller" Moons Embedded in Saturn's Rings, ApJL, Vol. 718, pp. L92-L96, 2010.

[2] Hoffmann, H., Seiß, M., and Spahn, F.: Vertical relaxation of a moonlet propeller in Saturn's A ring, ApJL, vol. 754, L4, 2013.

[3] Salo, H., Schmidt, J., Spahn, F.: Viscous Overstability in Saturn's B Ring. I. Direct Simulations and Measurement of Transport Coefficients, Icarus, Vol. 153, pp. 295-315, 2001.

[4] Seiß, M., Spahn, F., Sremčević, M., Salo, H.: Structures induced by small moonlets in Satrun's rings: Implications for the Cassini mission, Geophys. Res. Lett., vol. 32, doi:10.1029/2005GL022506, 2005.

[5] Sremčević, M., Schmidt, J., Salo, H., Seiß, M., Spahn, F., Albers, N.: A belt of moonlets in Saturn's A ring, Nature, Vol. 449, pp. 1019-1021, 2007.

[6] Sremčević, M., Spahn, F. and Duschl, W. J.: Density structures in perturbed thin cold discs, MNRAS, Vol. 337, pp. 1139-1152, 2002.