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Thickness and mass of Saturn's B ring as derived from its seasonal temperature variations

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Abstract

Structural and thermal properties of Saturn's B ring and its particles are derived from orbital and seasonal temperatures variations observed by the CIRS infrared spectrometer between 2004 and 2009. Our multi-scale thermal model [1], best suited to model heat transfer in dense rings, is adjusted to data.

Most observations were focused on the center B ring, at 105,000 km from Saturn. At this distance, a very good fit is obtained for conductive particles embedded in a moderately conductive ring medium. Assuming a bulk composition of water ice, the thermal inertia of particles is found to be of the order of $\Gamma_1 = 160 - 200$ J/m^2/K/s$^{1/2}$. It varies with seasons because part of the heat transfer through the particle happens via radiation. For the same reason, the ring thermal inertia also varies with seasons. Its value, around 30-40 J/m^2/K/s$^{1/2}$, is very comparable to the thermal inertia of icy satellites regoliths. The ring filling factor is found to be relatively high, D=0.34, typical of a compact medium and compatible with output of numerical simulations of their dynamics. The thickness of the B ring at this distance of Saturn is estimated at 2.2 ± 0.2 m.

The correlation of the vertical thermal gradient between lit and unlit sides with the optical depth is easily reproduced if the variations in optical depth of the B ring are due to varying thickness. Its vertical thickness H is found to range between 1 and 3 meters across the B2, B3 and B4 rings (Figure 1). It is thinner than the neighbouring C ring and Cassini Division. This can be understood as a consequence of self-gravity which acts at reducing the vertical excursion of ring particles within self-gravity wakes.

Radial variation of the surface mass density is deduced from the thickness using aspect-ratios H/λ of self-gravity wakes detected there. It ranges between 300 and about 2000 kg/m^2. The inferred B ring mass is $M_B = 8.7 \pm 1.7\ 10^{18}$ kg and the total ring mass is $M_R = 1.4 \pm 0.17\ 10^{19}$ kg. This mass is expected for a viscously disk evolving over the age of the Solar System, whatever its initial mass [2].

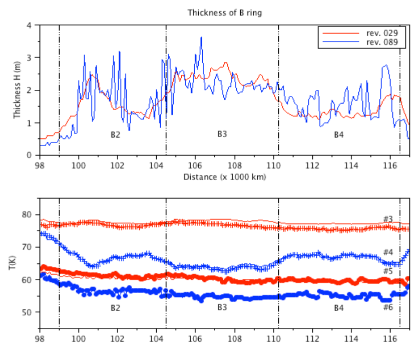

Figure 1 - Vertical thickness of the B ring versus saturnocentric distance. (**Top**) Two radial profiles derived from vertical thermal gradient at solar elevation B_0=-15.7° (red) and B_0=-4.5° (blue). (**Bottom**) Radial profiles of lit (red) and unlit (blue) sides temperatures of the B ring as observed (crosses at epoch of B_0=-15.7°, dots at epoch of B_0=-4.5°) or modeled (full lines).

Acknowledgements

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References

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[2] Salmon, J., Charnoz, S., Crida, A., Brahic, A., 2010. Long-term and large- scale viscous evolution of dense planetary rings. *Icarus* **209**, 771-785.