

## **Dynamical and photometric modeling of dense planetary rings**

**H. Salo** (1), J. Schmidt (2)

(1) Univ. of Oulu, Finland (heikki.salo@oulu.fi/Fax:+358-8-5531934) (2) Univ. Potsdam, Germany

Planetary rings, with their extremely rich multi-scale structure, offer an ideal laboratory for studies of gravitational dynamics and collective viscous behavior in non-linear systems. In addition, their observable photometric characteristics provide stringent constraints for the physical properties of individual, unseen particles. To facilitate such studies, we use a combination of dynamical N-body simulations and photometric Monte Carlo ray tracing.

In local scales the ring's energy balance is governed by the collisional dissipation and the viscous gain of energy from systematic orbital rotation. Details of the resulting steady-state (velocity dispersion, geometric thickness, viscosity) depend on the elastic properties and the internal density of particles, as well as on their size distribution. Depending on the implied viscosity versus surface density behavior, the ring can be either stable or unstable against the growth of local perturbations. In particular, if the particles are rather inelastic, as indicated by the Bridges et al. (1984, *Nature* 309,333) laboratory measurements, then dense rings can be viscously overstable (Salo et al. 2001, *Icarus* 153, 295, Schmidt et al. 2001, *Icarus* 153, 316; see also Schmit and Tscharnuter 1995, *Icarus* 115, 304, Spahn et al. 2000, *Icarus* 145, 657): this might relate to the axisymmetric structures observed in Saturn's A and B rings (see Schmidt et al. and Marouf, Abstracts presented in this conference; Porco et al. 2005, *Science* 307, 1226).

Another important diagnostic for the local velocity dispersion is provided by the long-studied azimuthal brightness variations in both the A and the inner B ring (French et al. 2007, *Icarus* in press). The non-axisymmetric gravity wakes (Salo 1992, *Nature* 359,

619; see also Julian and Toomre 1966, ApJ 146, 810) provide a natural explanation for these observations (Salo et al. 2004, Icarus 170, 70), indicating that the ring is close to threshold of gravitational instability. Such wakes also imply longitude-dependence of ring optical depth, as verified by recent Cassini RSS (Marouf et al. 2005, Eos Trans. AGU, 86, P31D-04), UVIS (Colwell et al. 2006, GRL 33, 7201, Colwell et al. 2007, Icarus in press), and VIMS (Hedman et al. 2007, AJ 133, 2624) occultations. Even in the uniform regions not displaying wakes, the overall photometric properties (dependence of ring brightness on elevation and phase angle) can constrain the local volume filling factor and the relative vertical distributions of different sized particles (Salo and Karjalainen 2003, Icarus 164, 428; see also Dones et al. 1993, Icarus 105, 184).

This talk will address two specific topics in detail: 1) the correspondence between the simulated N-body gravity wakes and the idealized geometric models which have been used in interpreting the UVIS and VIMS occultations, and 2) the expected photometric characteristics of overstable ring regions.