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What Tell "Propellers" in Saturns Rings About Planet Formation?

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We investigate the action of gravitational perturbers in thin cold astrophysical discs. The model includes viscous diffusion of the disc matter and gravitational scattering by the perturber as counteracting processes. Two types of density structures are found, depending on the mass of the perturbing body and on the amount of momentum transport in the disc. A gap around the whole circumference of the disc is opened if the perturber is more massive than a certain threshold. Alternatively, a local S-shaped density modulation is generated that we call a "propeller". Beyond the perturber's mass, the kinematic viscosity of the disk comprises the second crucial parameter of the model which describes the transport properties of the disc material. Analytical and numerical solutions provide the characteristic spatial extent of the "propeller" to depend on the mass of the perturber and the disk-viscosity.

Firstly, these results are applied to dense planetary rings perturbed by an embedded moonlet where inspections of the Cassini-imaging data revealed 12 "propellers" in the 100-metres size range to reside in Saturn's A ring up to date. From these observations we conclude abouta few million such 100m objects - but none larger than 500 metres - to exist in the outer rings of Saturn. This, in turn, has crucial consequences for the origin of the rings.

The second application concerns gas-dust discs around a protostar perturbed by a protoplanet - practically the "nursery of a planet". Again either gaps or "propeller"-shaped structures can be expected to have formed within the disk. With increasing resolution of modern telescopes the chance might appear in future to be witness of a planetary growth by studying structures in circum-stellar disks.