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Self-gravity wakes in dense planetary rings

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Planetary rings are composed of a number of colliding icy particles. Interplay among collisions, mutual gravitational attraction and the Keplerian shear leads to the formation of spatial structure called as "self-gravity wakes" that are prevalent throughout dense planetary rings. One can observe similar wake-like patterns in collisionless gravitational many-body systems such as galactic disks as well, which demonstrates that self-gravity wakes are a common feature among gravitationally interacting astrophysical disks.

The shapes of self-gravity wakes in diverse types of disks are different, according to the physical characteristics of the disk(disk mass, energy dissipation rate, inter-particle gravity compared with tidal force, etc). However so far no previous studies have focused on the effects of the physical properties of disks on the shape of self-gravity wakes. In order to tackle this subject for the first time, we have developed a numerical code that can deal with a sufficiently large number of self-gravitating particles within realistic CPU time, and have systematically studied the dependence of the shapes of self-gravity wakes on several physical parameters that characterize various types of particulate astrophysical disks. With the aid of a special-purpose computer GRAPE-DR, we can boost up
the computational speed.

In this study, three parameters were adopted to characterize dense planetary rings, namely, (i) the dynamical optical depth, (ii) the coefficient of restitution, and (iii) the ratio between the Hill radius and the physical radius of a ring particle. The shape of self-gravity wakes is analyzed with two-body correlation function, and the inclination (the pitch angle) of self-gravity wakes towards the orbital direction were investigated. We have found that the inclination increases with the optical depth and the ratio between the Hill radius and particle radius, but that the inclination barely depends on the coefficient of restitution. We discuss the physical mechanisms leading to these numerical results.

Keywords: planetary rings, self-gravity, Local N-body simulation