N-Body Simulation of Chariklo's Ring

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Recently, two dense narrow rings around Centaur Chariklo were discovered [1]. The existence of a ring around Centaur Chiron was also proposed [2]. These observations suggest that rings around large Centaurs may not be rare.

Chariklo's ring has the large optical depth which is about 0.3–0.4. In Saturn's ring, the gravitational instability takes place in the region where the ring has the large optical depth and the self-gravity wakes form. The self-gravity wakes are small spiral structures, which cause the efficient angular momentum transfer. Thus, in order to investigate the detailed structure of the ring, we performed the global *N*-body simulations.

We developed the simulation code using the *N*-body simulation library, FDPS [3]. We considered the gravitational interaction, and mutual collisions.

Figure 1 shows the typical result of the simulation. We adopted the particle density $\rho_p/\rho_C = 0.5$ and the radius $r_p = 5$ m, where ρ_p is the particle density, ρ_C is the Chariklo's density, and r_p is the particle radius. The large scale structures are not visible. For the dynamical timescales, the ring keeps its original global shape. However, we find small scale structures, namely, self-gravity wakes in the inner ring.

We performed the simulations with various parameters. If $\rho_p/\rho_C > 0.5$, the rapid large aggregate formation takes place. Thus, this case does not correspond to the real ring. For suppressing the self-gravity wakes, the very low density particles, such as $\rho_p/\rho_C < 0.1$, are necessary.

Next we examined the long term evolution of the ring with the self-gravity wakes. The wakes accelerate the viscous spreading of the ring significantly and it typically occurs on timescales of about 100 years, which is considerably shorter than the timescales suggested in previous studies. Thus, the existence of these narrow rings implies the existence of shepherding satellites.

References

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[3] Michikoshi, S., Kokubo, E.: 2017, *ApJL*, **837**, L13.
[4] Iwasawa, M., et al.: 2016, *PASJ*, **68**, 54.

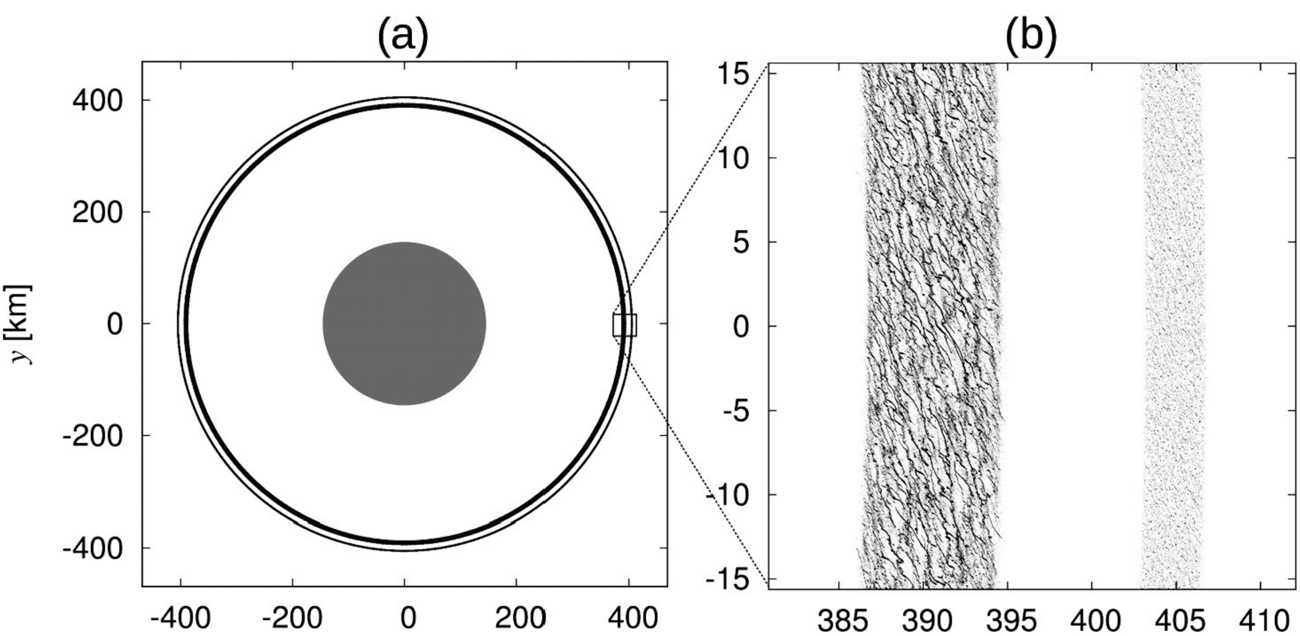

Figure 1: Particle distribution of the simulated ring in the x-y plane where the particle density and radius are $\rho_p/\rho_C = 0.5$ and $r_p = 5$ m, respectively. The panel (a) shows the overall structure of the ring, while the panel (b) shows enlarged view of ring section.