Department of Planetology
Graduate School of Science, Kobe University
1-1 Rokkodai, Nada, Kobe 657-8501, Japan

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To whom it may concern,

I have read the manuscript by Iwasawa et al., which describes their achievement in performing global simulations of planetary rings with up to 10^{12} particles. As is described in the manuscript, almost all previous simulations of planetary rings adopted the so-called local approximation, where orbits of particles in a small rectangular region are followed with periodic boundary conditions. This approximation is reasonable for the study of microphysics in rings such as dynamical steady state, viscosity, small scale structures called gravitational wakes, or impacts between aggregates in the ring. Local simulations for self-gravitating rings have been performed by many researchers in the filed since early 1990's, and significantly advanced our understanding of their dynamical behavior.

However, any global behavior, such as the resonant interaction with shepherding satellites and formation of narrow rings, requires global simulations. NASA's Cassini spacecraft, which arrived at Saturn in 2004 and completed its mission in September 2017, brought us numerous new findings about the rings. However, we remain far from a full understanding of Cassini's observations of the rings, partly because currently we do not have tools to simulate real ring systems. In addition to the four giant planets, rings have been recently discovered around small solar system bodies, such as a Centaur Chariklo, and a trans-Neptunian object Haumea. These findings suggest that rings provide us unique clues to understand the formation and evolution of the solar system. Also, efforts to search for rings around extrasolar planets are continuing. Therefore, the field of ring studies is expected to expand significantly in the coming years.

The work described in the manuscript, for the first time, demonstrates the possibility of such a global simulation of planetary rings with particles of the realistic size. This will definitely be a significantly important breakthrough and timely contribution to the field, and such realistic simulations of planetary rings are expected to advance our understanding of, not only structures and evolution of planetary ring, but also the history of the solar system. Of course, I understand that right now performing one such simulation requires huge amount of computing resource on fastest supercomputers and thus might not be practical, but I do hope such resources will be available in the near future.

Sincerely,

Keiji Ohtsuki

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