N-body simulations of the formation process of Uranian satellites

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There are 27 satellites around Uranus. Five of the major satellites are responsible for 99% of the total mass of Uranian satellites. There are various models of how the satellites around giant planets, not only Uranus, formed (Canup & Ward 2006; Sasaki et al. 2010). However, unlike other planets in our solar system, Uranus has an equatorial tilt of 98 degrees, and its satellites orbit around its rotation axis. Therefore, even if we apply the model in the above paper as it is, we have to consider another mechanism to tilt the axis. As a way to explain this system, the giant impact hypothesis was proposed, in which two protoplanets collide and the collision bends the rotation axis, scattering debris around the rotation axis and forming a debris disk. As a result of SPH calculations based on this hypothesis, it was explained that debris disks, which are the origin of equatorial tilt angles and satellites, are formed around planets (Slattery et al. 1992). The debris disk was used as a basis for N-body calculations to see if the current satellite system could be formed, and it was found that the mass of the outer satellites would be smaller than the actual observation results because the areal density of the initial disk is smaller at the outer side than at the central planet (Ishizawa et al. 2019). In order to solve this problem, an early disk model around Uranus was proposed that takes into account the thermal evolution of the gas disk formed by the giant impact (Ida et al. 2020). This study suggests the possibility of the formation of a debris disk whose areal density increases with increasing radius. This would be a good explanation for the Uranus system with large outer satellites, since the outer part of the disk contains more solid material from which the satellites are derived.
Therefore, we are currently working on the description of the satellite formation process using N-body calculations from the initial disk suggested by Ida et al. 2020 to see if the satellites around Uranus can be reproduced from observations. In this presentation, I will explain the results of the calculations and the physical interpretations of the points of agreement and disagreement with observations.

Keywords: Uranus, satellite formation, N-body simulation

