Scattering and accretion of the planetesimals by a planet

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I investigate the orbital evolution of planetesimals perturbed by a planet as the first step of the study of the formation of the Oort cloud.

Observations of long-period comets suggest existence of a comet reservoir in a region of -10^4 AU from the Sun. Oort (1950) first suggested this huge comet reservoir (the Oort cloud)to explain the spherical distribution of the aphelions of long period comets. The aphelions of the comets are in the Sun's gravitational influence sphere but far from the planetary region. It is said that the number of comets in the Oort cloud is more than 10^12 and their total mass is estimated 10 to 1000 Earth masses. Small bodies such comets and Edgeworth-Kuiper belt objects are now considered as the remnants of planetesimals which did not accumulated into planets. Investigations of the formation of the Oort cloud is important for understanding the formation of the global planetary formation.

The standard scenario of the solar system and the Oort cloud formation proceeds as follows.

Formation of planets:
(1) Planetesimals are formed in the protoplanetary disk.
(2) Planetesimals grow to planets through accretion (formation of the Terrestrial planets).
(3) Planets which grow large enough before the gas disk disappears capture gas(formation of Jovian planets).

Formation of the Oort cloud:
(1) Planetesimals are formed in a protoplanetary disk.
(2) Their semimajor axes and eccentricities increase due to planetary perturbation.
(3) Their eccentricities decrease and their perihelion distances exceed the planetary region and their inclinations are randomized due to the galactic tide and/or stellar encounters.

I perform the orbital integration of planetesimals in the restricted three-body formalism and show the evolution of planetesimals due toscattering by the planet and the gas drag. The dependences of the semimajor axis and the mass of the planet and the eccentricities of the planetesimals on the evolution are
investigated. I find that the eccentricity and inclination of the planetesimals are raised highly by close encounters with the planet. The scattering results can be scaled using the Hill scaling except for the large eccentricity. This means the effect of scattering by the planet with a large semimajor axis and large mass is effective. The gas drag reduces the semimajor axis, the eccentricity, the inclination and thus the Jacobi energy of planetesimals, which makes planetesimals difficult to collide on the planet.