TEMPORARY CAPTURE OF PLANETESIMALS BY A GIANT PLANET  Ryo Suetsugu1, Keiji Ohtsuki1, 2, 3.
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Introduction: Gravitational interaction between planets and planetesimals plays an important role not only in planet formation but also in the origin and dynamical evolution of small bodies in the Solar System. When planetesimals encounter with a planet, in most cases they experience either gravitational scattering by the planet or collision onto it. However, in some cases planetesimals can be captured by the planet's gravity and orbit about the planet for an extended period of time, before they escape from the vicinity of the planet. This phenomenon is called temporary capture, and may have played an important role in the origin of irregular satellites and Kuiper-belt binaries, as well as dynamical evolution of short-period comets.

Recently, we investigated temporary capture of planetesimals initially on eccentric orbits, and found that temporary capture orbits can be classified into four types [1]. Their orbital size and direction of revolution around the planet change depending on planetesimals' initial eccentricity and energy. When initial eccentricity is so small that Kepler shear dominates relative velocity between planetesimals and the planet, temporary capture typically occurs in the retrograde direction in the vicinity of the planet's Hill sphere, while large retrograde capture orbits outside the Hill sphere are predominant for large eccentricities. Long prograde capture occurs in a very narrow range of eccentricity and energy of planetesimals. We obtained rates of temporary capture of planetesimals and found that the rate of long capture increases with increasing eccentricity at low and high eccentricity but in intermediate values of eccentricity decreases with increasing eccentricity.

In the above study [1], we performed three-body orbital integrations under Hill's approximations, where the masses of the planet and planetesimals are assumed to be much smaller than the solar mass. In this case, the effect of the curvature of their guiding-center orbits are neglected. This assumption is valid for the case of low mass planets, but the effect of curvature may be important for temporary capture by a high mass planet, like Jupiter. Previous global orbital integration that investigated temporary capture focused on long-term evolution of small bodies under the influence of multiple giant planets [2, 3].

In the present work, we use a simple three-body system that consists of the Sun, a planet, and a test particle, and perform global orbital integration to examine effects of a high mass planet on temporary capture.

Numerical Method: We examine temporary capture using three-body orbital integration. When the masses of planetesimals are much smaller than the other two bodies' masses and the planet orbits about the Sun in circular orbit, the problem of motion of planetesimal is called restricted three-body problem. We integrate equations of motion for planetesimals with various initial orbital elements, using the forth-order Hermite integrator.

Results: We found four types of capture orbits by our present global integration, as we did in our local three-body integration [1]. The orbital shapes in the case of capture in the vicinity of the planet are consistent with those found in our previous work [1]. However, the shape of temporary capture orbits which revolves outside of the planet's Hill sphere was found to be bent due to the effect of the curvature of the guiding-center orbits. On the other hand, the other three types of capture orbits are located in the vicinity of the planet, thus the effect of the curvature was negligible. The size of the region swept by the planetesimal trajectory during temporary capture increases with increasing mass of the planet; thus the above curvature effect becomes significant when the size of temporary capture orbits is comparable to the planet's orbital radius. Therefore, this curvature effect needs to be taken into account when we examine the source region for planetesimals that undergo temporary capture by a giant planet. We will discuss the rates of temporary capture obtained by our global calculation and compare them with our previous results of local three-body calculation.