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# Duration of temporary capture of asteroids around an eccentric planet

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## Abstract

We have investigated the temporary capture of asteroids by an eccentric planet. We performed numerical orbital integrations and examined the duration of temporary capture. We found that the distributions of the duration of temporary capture for prograde and retrograde captures are different. The distributions can be described by a broken power law. The parameters to characterize the distributions are functions of the type of capture, the incident velocity to the Hill sphere, and the mass and eccentricity of the host planet.

## 1. Introduction

Irregular satellites around giant planets, which are small with elliptical and inclined orbits, are usually thought to be passing asteroids that were captured (e.g., [1]). The objects that are temporarily captured in the Hill sphere of a planet can become permanently captured due to some energy loss (e.g., tidal dissipation, drag force from a circumplanetary disk when it existed, or collisions with other solid bodies in the disk). Higuchi & Ida (2017)[2] derived the conditions for the temporary capture by an eccentric planet in an elliptic orbit as functions of the mass and eccentricity of the host planet. However, they didn't discuss temporary capture time, which could be an important factor in the evolution toward permanent capture. In this paper, we show the results of numerical orbital integrations focusing on the lifetime of the test particles as temporarily captured satellites. This is done in order to discuss the origins of general irregular satellites of planets, especially those of Mars.

## 2. Numerical Calculations

We perform numerical calculations for the temporary capture of bodies by planets with Mars, Jupiter, Earth, and Neptune masses. We compute the orbital evolution of massless bodies—which correspond to asteroids—perturbed by a planet in a circular or eccentric orbit using a fourth-order Hermite integration scheme. The parameters and their ranges are the same as those used in [2]; asteroids are initially uniformly distributed on the $a$-$e$ plane, where $a$ and $e$ are the semimajor axis and eccentricity of the massless bodies, respectively. The other angle variables are uniformly distributed between 0 and $2\pi$. We count bodies as temporary captures if they satisfy two conditions: (1) they must stay within 3 $r_H$ from the host planet longer than one orbital period of the planet and (2) the minimum distance from the host planet is less than 1 $r_H$. If a body collides with the host planet or the Sun, or has $e > 1$ at $r > 30$ AU, it is removed from the calculation. The duration of temporary capture is defined as the time between the two moments when a body enters/exits the Hill sphere. The type of temporary capture is defined by the position and velocity vectors at the moment when the body enters the Hill sphere; via $L_1$ or $L_2$, and prograde or retrograde.

## 3. Results and Discussion

Figure 1 shows the cumulative distributions of temporary capture time of particles by a Martian mass planet with eccentricity = 0.02. For short-time temporary capture, the number of retrograde captures is more than that of the prograde captures. However, for long-time temporary capture longer than ~10 $T_K$ ($T_K$ is the orbital period of the host planet), the slopes for the prograde captures become shallower and the numbers exceed those of the retrograde captures. These long tails seen in prograde long captures is consistent with Suetsugu et al.(2011)[3]. For Martian mass planet cases, no large differences are seen between the $L_1$ and $L_2$ captures. We find that the broken power law fits each distribution nicely. The parameters to characterize the distribution are functions of the type of capture, the incident velocity to the Hill sphere, and the mass and eccentricity of the host planet. The details of these parameters will be discussed on our poster.

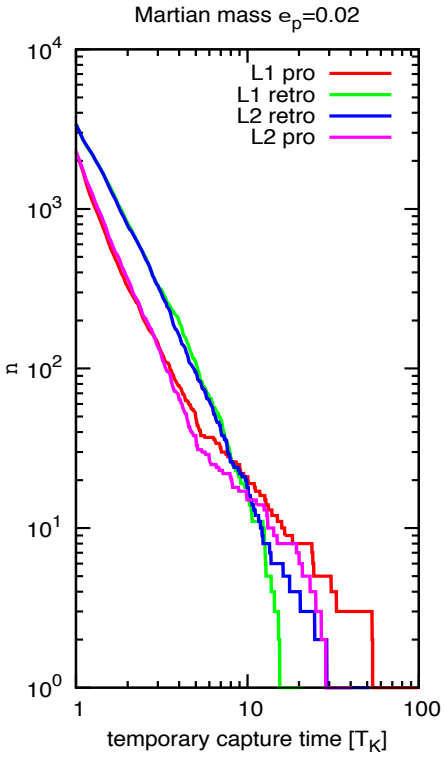


Figure 1: Cumulative number distribution of temporary capture time scaled by the orbital period of the host planet, a Martian mass planet with semimajor axis = 1.52 AU and eccentricity = 0.02. Each color indicates capture type; via $L_1$ or $L_2$, and prograde or retrograde.


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## References


[1] Jewitt, D & Haghighipour, N., ARA&A, 45, 261, 2007.

[2] Higuchi, A. & Ida, S., AJ, 153, 4., 2017

[3] Suetsugu, R., Ohtsuki, K. & Tanigawa, T. (2011) AJ, 142, 6, 2011