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Capture and orbital evolution of irregular satellites by gas drag from circumplanetary disk

Ryo Suetsugu[1*], Tetsuya Fujita[1], Keiji Ohtsuki[1]

[1]Dept. Earth Planet. Sci., Kobe Univ.

Many satellites are orbiting about the giant planets in the Solar System. The number of known satellites has been increasing significantly due to advancement of observation technology, and studies of these small bodies help us understand better not only their origin but also formation processes of giant planets. Satellites are classified into regular satellites and irregular satellites. It is thought that regular satellites formed in circumplanetary disks around giant planets, because their orbits are nearly circular and coplanar. On the other hand, orbits of irregular satellites are highly eccentric and inclined, thus, they are thought to be planetesimals captured by the planets through some energy dissipation.

Although several energy dissipation mechanisms for capturing irregular satellites have been proposed by previous works, most of them seem to have difficultly in explaining capture of the irregular satellites of Jupiter. However, Cuk & Burns (2004) argued that a cluster of prograde irregular satellites of Jupiter may be collisional fragments of a single planetesimal captured by gas drag from the circumjovian disk at the final stage of the formation of Jupiter. They integrated orbits of this parent body backward in time, and found that the parent body experienced a period of temporary capture by Jupiter before it became gravitationally bound by Jupiter. If the gas density of the circumjovian disk was too high, a captured planetesimal would likely spiral into Jupiter rather quickly due to large energy dissipation, but its lifetime within the disk is expected to be longer if a gap in the solar nebula was formed by the gravity of Jupiter and the gas density in the circumjovian disk was lower. Therefore, if planetesimals with low energy are temporarily captured by Jupiter for an extend period of time near the end of Jupiter's formation, they may survive for a long time and even weak energy dissipation may be sufficient for capturing them as irregular satellites or their progenitors. However, temporary capture itself have not been examined in detail. Recently we investigated temporary capture of planetesimals by a planet using three-body orbital integration. As a result, we found that temporary capture orbits could be classified into four types and evaluated the rates of temporary capture (Suetsugu et al. 2011 AJ 142, 200; Suetsugu & Ohtsuki, MNRAS, in press).

Growing giant planets can capture planetesimals by gas drag from circumplanetary disk (Fujita et al, submitted to AJ). In order to reveal origin of irregular satellites, it is also important to examine orbital evolution after the capture. In the present work, we will discuss capture and orbital evolution of irregular satellites due to gas drag from circumplanetary disk.

Keywords: planet, satellite