Accretion Rates of Planetesimals by a Protoplanet Embedded in Nebular Gas

Takayuki Tanigawa[1]; Keiji Ohtsuki[1]; Masahiro Machida[2]

[1] LASP, Univ. of Colorado; [2] Theoretical Astrophysics Group
Department of Physics

One of the serious problems in the planetary formation theory is the long growth time of planets in two senses. One is that the growth timescale of the outer planets is estimated to be much longer than the typical lifetime of proto-planetary disks. It makes difficult for planets to capture disk gas to be gas-giant planets before the disk dissipation. The growth timescale is also longer than the migration of planets, which is widely thought to be occurred through the gravitational interaction with the proto-planetary disk, which results in falling toward the Sun before they grows up. For the both cases, the longer growth timescale makes the planet formation difficult.

However, most of studies that consider planetesimals' accretion do not include gas drag effect, which can play an important role for planetary accumulation in proto-planetary disks. In particular, planets start to have thick atmosphere when their size is larger than the Moon, thus the
gas drag effect near the planets becomes more effective. Pollack et al. 1996 and Inaba and Ikoma 2003 have considered the dissipation energy due to the gas drag with planet atmospheres and obtained effective collision radii, which is enhanced by the gas drag with the atmospheres. But because of their simplicities, the effect of the Sun's gravity or eccentric orbit of planetesimals were not be considered.

In this study, we investigate the effective accretion rate of planetesimals with wide range of eccentricity and inclination onto
protoplanets that have atmospheres using numerical integration of planetesimals' orbits considering solar gravity. We will compare the obtained accretion rate with that of previous studies and discuss the
difference. We also consider the accretion rates of planetesimals onto gas-giant planets that are dynamically capturing disk gas and will report the results as well.