Satellitesimal formation in a circumplanetary disk and pebble accretion

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It has been recently suggested that planetesimals rapidly grow to the cores of gas giants by accreting a number of cm-sized solid particles called pebbles. We investigate how this pebble accretion mechanism affects satellite formation around gas giants. We construct a simple but comprehensive model that treats 1) the growth and radial transport of pebble-sized dust particles in a protoplanetary disk and in a circumplanetary disk around a gas giant, 2) the inflows of the gas and pebbles from protoplanetary to circumplanetary disks, and 3) pebble accretion by satellitesimals in a circumplanetary disk.
We found that most of pebbles flow into a circumplanetary disk not from the high-altitude of the disk but from the mid-plane against gas outflows. We also found that the growth processes of pebbles in a circumplanetary disk are divided into two much different ways; 1) satellitesimal formation by direct collisional growth of pebbles and subsequent satellite formation by direct collisional growth of the satellitesimals in a critical orbit, and 2) pebble accretion by large satellitesimals outside of the critical orbit. The critical orbit is moved by the conditions of the disk and pebbles. We introduce a parameter x, the ratio of the two mass fluxes of pebbles; flowing into the circumplanetary disk and drifted from the outer region of the protoplanetary disk. When x = 1, the critical orbit is in $r \sim 20\ R_J$ in the circumplanetary disk around a Jupiter-like planet with the mass of $0.4\ M_J$. However, when x = 0.1, the critical orbit is in $r \sim 3\ R_J$. Outside of the critical orbit, large satellitesimals accrete pebbles within their accretion radiuses. The radius expands dramatically when the mass of the satellitesimal reaches 10^{23}-10^{24} g, and the satellitesimal grows rapidly after that.
In conclusion, we paved the way for the formation of satellitesimals in a circumplanetary disk and reveal a rough picture of the pebble accretion by the satellitesimals.

Keywords: Satellite, Satellite formation, Pebble accretion , Circumplanetary disk, Satellitesimal, Gas planet

