Accretion of gas and solid materials into the circumplanetary disk of a growing giant planet: Dependence on planetary mass

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Regular satellites such as the Galilean satellites are likely formed by accumulation of solid particles supplied into the circumplanetary disks. Small particles so-called pebbles are considered to be important material of satellite formation (Shibaike et al. 2019). Since small particles are easily affected by gas flow around the planet, we have to take account of the gas flow around the planet obtained by hydrodynamic simulation to examine how they are delivered into the circumplanetary disk to form satellites. Tanigawa et al. (2014) examined accretion of solid particles initially confined within the midplane of the protoplanetary disk into the circumplanetary disk of a growing giant planet whose mass is 0.4 M_J (M_J being Jupiter's mass) using gas flow obtained by hydrodynamic simulation. Homma et al. (in revision) examined supply of vertically stirred solid particles into the circumplanetary disk using the same gas flow. However, current satellite systems were likely formed in the late stage of the formation of the host planet, and different behavior would be expected depending on planetary mass.

In this study, we focus on dependence of mass of the host planet. We examine gas flow in the cases of planetary mass of 1, 0.7, and 0.4 M_J obtained by isothermal, local hydrodynamic simulation, and investigate vertical accretion of pebbles by the circumplanetary disk under the influence of such a gas flow. We found that the width of the radial band for gas accretion into the circumplanetary disk becomes larger with increasing planetary mass. On the other hand, the gas gap formed in the vicinity of the planet's orbit becomes deeper and the surface densities of gas and dust becomes smaller with increasing planetary mass. Also, the size of the planet's Hill sphere becomes larger than the gas scale height of the protoplanetary disk for a sufficiently massive planet. Our result show that the rates of accretion of gas and dust onto the circumplanetary disk are determined by a balance among these effects.

Keywords: planets and satellites: formation –protoplanetary disks

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