Gap formation by a super-Jupiter-mass planet and its effects on the planetary mass accretion rate

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A giant planet embedded in a protoplanetary disk creates a gap structure along with its orbit by disk-planet interaction. Physical properties of the gap depend on several conditions such as mass of the planet and disk structures, and they affect both mass accretion rate onto the planet via the gap and migration rate of the planet. Therefore, the properties of the gap are important to investigate formation and evolution of planetary systems.
Recently, numerical simulations of the disk-planet interaction have been done intensively, and the disk properties such as width and depth of the gap, and mass accretion rate have been studied. However, previous studies mainly focused on planets less massive than Jupiter. In addition, there are a discrepancy between several previous works on the mass accretion rate onto the planet heavier than Jupiter. Since a lot of super-Jupiter-mass planets have been found, formation and evolution of them in the protoplanetary disk should be investigated in more detail.
We performed a set of hydrodynamic simulation of disk-planet interaction and investigated the properties of the gap and their parameter dependence. We varied the planetary mass from 1 to 10 Jupiter masses. We found that the gap becomes deeper as planet's mass increases up to around 3 Jupiter masses, but in more massive cases the outer edge of the gap shows significant eccentricity, which is consistent with several previous works. In this eccentric regime, the gap depth becomes shallower than an empirical relation between the depth and the planetary mass due to non-steady behavior of the gap outer edge. We also estimated the mass accretion rate onto the planet by using our result and found that the accretion rate can increase when the planet's mass is heavier because of the eccentricity of the gap.

Keywords: planet formation, protoplanetary disk, gas giant, disk-planet interaction

