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# タイプ I 惑星移動に対する輻射の影響について
# Radiative effect on the type I migration

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Gravitational interactions between a low-mass planet and a gas disk are one of the most important physical processes in planetary formation. A planet excites density waves in a disk, of which the tidal torque acts on a planet and leads to the migration of the planet. This is known as the type I migration of a planet. A planet migrates toward a central star on a shorter timescale than a lifetime of a disk. Previous studies adopted a disk with the constant temperature distribution and did not take into account the energy transfer in a disk. However, it was shown that density waves can be altered by a thermal structure of a disk. A planet might move away from a central star (i.e., outward migration) if the entropy gradient of a disk is negative.

Yamada and Inaba (2010, MNRAS) studied the type I migration of planets in disks, considering a cooling effect of gas due to radiation. They found that the total torque exerted on a planet by an adiabatic disk decreases with an increase in the power law index of the entropy distribution. The torque changes the sign from positive (outward migration) to negative (inward migration) at $a$= - 0.4, where $a$ is the power law index of the entropy distribution. They also found that the total torque decreases with an increase in opacity of a disk if a cooling effect is taken into account. The type I migration is influenced by opacity of a disk. Yamada and Inaba used a constant opacity in a disk even though it is expected to change in a disk because it depends on the temperature.

We study the type I migration of a planet in disks with various opacities. We find that the total torque acting on a planet by a disk strongly depends on opacity of the disk. We adopt a more realistically opacity model and find that the sign of the total torque could change in a zone of a disk. Planets formed in other regions of a disk migrate toward the zone. Accumulation of planets in the zone might accelerate further growth of planets.

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