Type I Migration in Radiatively Efficient Discs

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We study Type I migration of a planet in a radiatively efficient disk using global two dimensional hydrodynamic simulations. The large positive corotation torque is exerted on a planet by an adiabatic disk at early times when the disk has the steep negative entropy gradient. The gas on the horseshoe orbit of the planet is compressed adiabatically during the change of the orbit from the slow orbit to the fast orbit, increasing its density and exerting the positive torque on the planet. The planet would migrate outward in the adiabatic disk before saturation sets in. We further study the effect of energy dissipation by radiation on Type I migration of the planet. The corotation torque decreases when the energy dissipates effectively because the density of the gas on the horseshoe orbit does not increase by the compression compared with the gas of the adiabatic disk. The total torque is mainly determined by the negative Lindblad torque and becomes negative. The planet migrates inward toward the central star in the radiatively efficient disk. The migration velocity is dependent on the radiative efficiency and greatly reduced if the radiative cooling works inefficiently.

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