GIANT PLANET FORMATION ON WIDE ORBITS BY CORE ACCRETION

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The discovery of giant planets on wide orbits represents a major challenge for the standard core accretion model. In such model, giant planets are expected to form at small or moderate distances from the central star in order to form massive cores able to trigger the gaseous runaway growth before the dissipation of the disk. In this work, we present a new simple mechanism for the formation of giant planets on wide orbits by core accretion considering planet formation, planet migration and disk evolution.

El descubrimiento de planetas gigantes en órbitas lejanas representa un reto para el modelo estándar de acreción del núcleo. En este modelo, se espera que los planetas gigantes se formen a distancias pequeñas o moderadas de la estrella central para poder formar núcleos masivos capaces de desencadenar el crecimiento en fuga de la envoltura gaseosa antes de la disipación del disco. En este trabajo, presentamos un nuevo y simple mecanismo para la formación de planetas gigantes en órbitas lejanas considerando la formación del planeta, la migración del planeta y la evolución del disco.

In this work, we improve our model of planet formation (Guilera et al. 2010, 2014) incorporating a viscous evolution for the gas disk and photoevaporation (D'Angelo & Marzari 2012). We also incorporate type I and type II migration and gas accretion limitation onto the planets. We calculate the formation of a planet by the concurrent accretion of planetesimals, of 100 m of radius, and gas, immersed in a disk of ~ 0.1 $M_\odot$ that evolves in time.

The top panel of Fig. 1 shows the time evolution of the gas surface density radial profiles. After a few Myr of viscous evolution, a gap is opened at a few au due to photoevaporation. This gap not only acts as a barrier for type I migration, but also produces, under certain circumstances, the outward migration of the planet because the edge of the gap moves outward due to photoevaporation. In the bottom panel of Fig. 1, we show the formation of a planet initially located at two different positions, 15 au and 25 au. When the planet starts at 15 au, it grows and migrates to the inner part of the disk before the gap opens, so the planet becomes a hot Jupiter. However, if the planet starts at 25 au, it grows and migrates inward until the gap is reached. Then, the combination between the growth rate of the planet and the change of the edge location of the gap due to photoevaporation makes that the planet migrates outward until ~ 60 au. Thus, if photoevaporation is included, the presence of giant planets at wide orbits could be explained with this particular combination between planet formation and disk evolution. This scenario will be studied in a more accurate way in a future work.

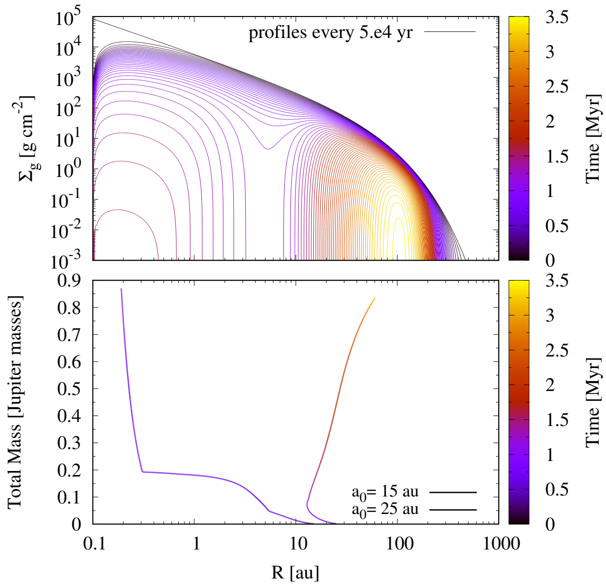

Fig. 1. Top: time evolution of the gas surface density radial profiles. After a few Myr of viscous evolution a gap is opened at a few au due to photoevaporation. Bottom: total mass of the planet as function of the semi-major axis and time for two different initial locations.

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