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Planetary migration in protoplanetary discs and outer Solar System architecture.

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Planets form around stars in gaseous protoplanetary discs. Due to tidal effects, they perturb the gas distribution, which in turn affects their motion. If the planet is massive enough (see for instance Crida et al. 2006 for a criterion), it repels the gas efficiently and opens a gap around its orbit ; then, locked into its gap, the planet follows the disc viscous evolution, which generally consists in accretion onto the central star. This process is called type II migration and leads to the orbital decay of the planet on a timescale shorter than the disc lifetime.

After a review of these processes, we will focus on the Solar System giant planets. Strong constraints suggest that they did not migrate significantly. Masset and Snellgrove (2001) have shown that the evolution of 2 giants planets in mean motion resonance in a common gap differs from the evolution of a single planet. For what concerns Jupiter and Saturn, we found that in some conditions on the disc parameter, they can avoid significant migration (Morbidelli and Crida 2007). Adding Uranus and Neptune to the system, six stable fully resonant configurations for the four giants in the gas disc appear.

Of course, none of them correspond to the present configuration. However, after the gas disc phase, the system was surrounded by a planetesimal disk. Interactions with this debris disk make the planets slowly evolve, until an instability in reached. This destabilises the planetesimal disc and triggers the Late Heavy Bombardment, while the planets reach their actual position, like in the model by Tsiganis et al (2005) and Gomes et al (2005). Our simulations show a very satisfying case, opening the possibility for a dynamically consistent scenario of the outer Solar System evolution, starting from the gas phase.