RevMexAA (Serie de Conferencias), **49**, 69–69 (2017)

XV Latin American Regional IAU Meeting (Cartagena de Indias, Colombia, 3-7 October 2016)
Editors: Mario Armando Higuera Garzón & Santiago Vargas Domínguez

PLANET FORMATION IN DENSITY PERTURBED TRANSITIONAL DISKS: A GRID MODEL APPROACH

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With increasingly sharp sub-millimeter direct imaging of transitional disks captured by ALMA, our understanding of the conditions necessary for debris disks to form planetary systems has drastically improved in recent years. Evidence for particle traps in transitional disks suggests that planet formation could possibly take place within density perturbed regions. For this reason we run a grid of models of planet formation in density perturbed transitional disks, and analyze the impact on giant planet formation.

In many transitional disks warm micron-sized dust grains seem to be decoupled from millimeter-sized dust grains. This has been interpreted as dust traps, possibly caused by pressure bumps in the gas (Dipierro et al. 2015). These dust traps have been proposed as candidates for active planet formation regions in debris disks. However, it is unknown how a perturbation in the disk surface density would impact planet formations processes such as planetesimal growth and accretion, and planet migration.

For this reason, we explore the impact of dust traps in planet formation by introducing a perturbation in the gas/dust surface density in a grid of protoplanetary disk models based on recent observations (Pinilla et al. 2012). We analyze the change in planet formation timescales, distance from the star and final arrangement for different length scales and amplitude of the perturbation in a time dependent analytical planet formation model (Miguel et al. 2011). The density perturbation is modeled as in (Pinilla et al. 2012)

$$\Sigma_p(r) = \Sigma(r)\left(1 + A\cos\left[2\pi\frac{r}{fH(r)}\right]\right). \quad (1)$$

Here Σ_p, Σ are the perturbed and unperturbed surface density of the disk, respectively, r is the radial distance to the star, H is the scale height of the disk, and A and f are the amplitude and scale length perturbation parameters.

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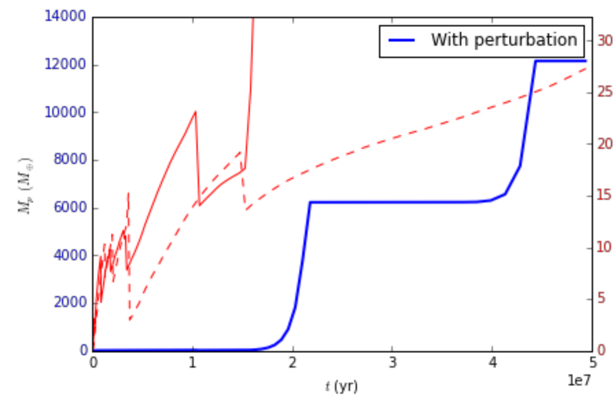

Fig. 1. Time evolution of the total mass of planets formed around a red dwarf when the disk is perturbed according to Eq.1 using $A = 0.5$, $f = 1$. The dashed red line (rhs scale) indicates the unperturbed case.

We conclude that for a single planetary system around a red dwarf, the mass budget for terrestrial planets is not affected by the presence of a perturbation. When the amplitude of the perturbation is large ($A > 0.5$) it is very likely to form giant ($M_p \sim 10^3 M_\oplus$) planets in a timescale of the order of 10 Myr, regardless of the length-scale of the perturbation. However, only when $A \simeq 0.5$ and the length scale is similar to the scale height of the disk $f \gtrsim 0.7$, it is possible to form Super-Jupiters, as shown in Figure 1 ($M_p \sim 10^4 M_\oplus$). This happens after a growth spurt occurring at ~ 40 Myr. In all cases where giant planets were formed, they can be classified as Hot Jupiters, as they end up in orbits with semi-major axes within 1 AU. However, giant planets are sometimes lost to infall toward the star in timescales shorter than 20 Myr, even with a low Type I migration rate. The length scale of the perturbation only seems to affect the formation of Super-Jupiters, but more simulations are required to confirm this.

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