Physics of Planetary Systems — Exercises — Set 5

Problem 5.1 *(2 points)*

Calculate the transit probability, photometric amplitude, transit duration, and (maximum) RV amplitude for

(a) Neptune in a circular orbit at 0.1 au from a solar-type star,
(b) a G2V star in a circular orbit at 2 au from a K0III giant (such as Pollux).

Problem 5.2 *(3 points)*

Briefly describe 3 sources of "false positives" and what observations you can make to prove that these are not really transiting planets.

Problem 5.3 *(1 point)*

It is thought that the dispersal of a protoplanetary disk occurs inside-out, that is, a disk develops an inner hole of growing radius. Which observations to prove this can you imagine?

Bonus problem 5.4 *(1 extra point)*

Show that the following equations for the Toomre parameter are (very roughly) equivalent:

$$Q \equiv \frac{h\Omega_\mathrm{K}^2}{\pi G \Sigma} \qquad \text{and} \qquad Q \equiv \frac{h}{r}\frac{\mathscr{M}_*}{\mathscr{M}_\mathrm{disk}}. \tag{1}$$

Problem 5.5 *(2 points)*

Assume that the disk around the protosun had the mass $\mathscr{M}_\mathrm{disk} \approx 0.01\ \mathscr{M}_\odot$ (the so-called mininum mass solar nebula). How cold had the disk to be to build giant planets directly? Then, estimate the minimum disk mass for which this planet formation scenario becomes thinkable, i. e. for which the critical temperature becomes realistic.
Bonus: consider Gammie's cooling time (1 extra point).

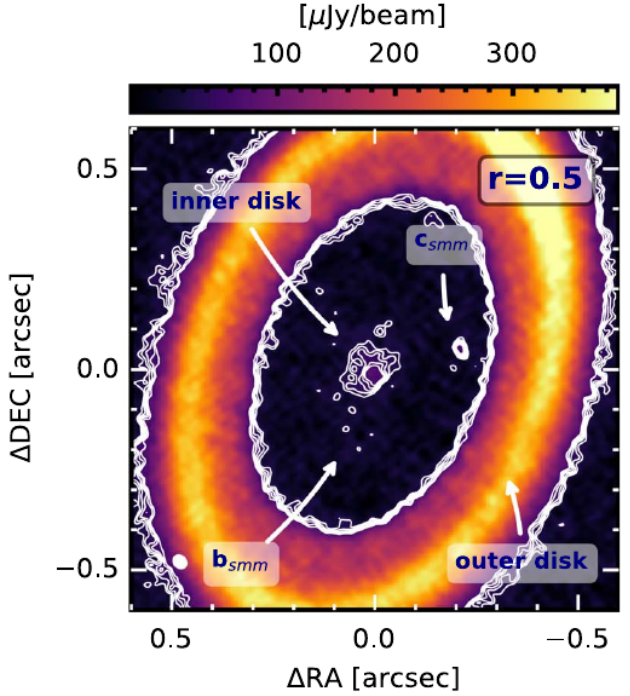

Figure 1: ALMA image of the disk around PDS 70, showing a planet candidate with circumplanetary dust, labelled "c_{smm}" (BENISTY et al. 2021).

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