Physics of Planetary Systems — Exercises — Set 9

Problem 9.1 *(2 points)*

Use the Gaia astrometric solution for “HIP 66074” (mass $\mathscr{M}_* \approx 0.7\ \mathscr{M}_\odot$) to estimate semi-major axis (in au) and mass of the detected planet. *Hints: you can access the Gaia catalog via the VizieR data base. There, first select the validated, non-single-star orbital models (`tbootsvc`), then add the output column for semi-major axis (`amaj`), and finally enter the star's name at the very top.*

Problem 9.2 *(2 points)*

The ELT will have a primary mirror with a diameter of 39 m. Suppose you have a focal reducing instrument with focal ratio = 3 (resulting focal length = 3×39 m) and a CCD camera with 15-μm pixels. If you could measure the centroid position of stars to an accuracy of 1/100 CCD pixels, what is the lowest planet mass (in Jupiter masses) that you could detect astrometrically at 1 au from α Cen (distance = 1.34 pc). Assume a solar mass for the α Cen.

Problem 9.3 *(2 points)*

Instead of a 3-dimensional disk of planetesimals, consider a 2-dimensional one: all planetesimals are still spherical, but their centers all lie in one and the same plane. Show that in such a flat disk the runaway growth is not possible.
Hint: systematically replace all 3D quantities in the formulas of runaway growth by their 2D counterparts.

Problem 9.4 *(2 points)*

Assume the surface density of the planetesimal swarm in the early Solar System to be $\Sigma = 10$ g cm^{-2} at 1 au and 3 g cm^{-2} at 5 au. Estimate the masses and orbital separations of finished oligarchs at these distances.

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