Physics of Planetary Systems — Exercises — Set 6

Problem 6.1 *(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 6.2 *(2 points)*

The ELT (Fig. 1) 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.

Bonus problem 6.3 *(1 extra point)*

What problems would you have in measuring the astrometric displacement discussed in the previous problem?

Problem 6.4 *(2 points)*

Estimate the temperature of a spherical dust grain at a distance r from the star. Assume that the grain absorbs all incoming stellar radiation and then re-emits it at the same rate, thus residing in a thermal equilibrium. Make a numerical estimate for dust particles at 1 au from the Sun. Then, find the radius of the inner dust-free zone around the Sun, assuming that dust sublimates at $T > 1500$ K.

Problem 6.5 *(2 points)*

At which size does the boundary between “small” ($\Gamma \gg 2\Omega_K$) and “big” ($\Gamma \ll 2\Omega_K$) grains lie? Assume solar nebula conditions at 1 au and adopt a gas density of 10^{-9} g cm^{-3}.

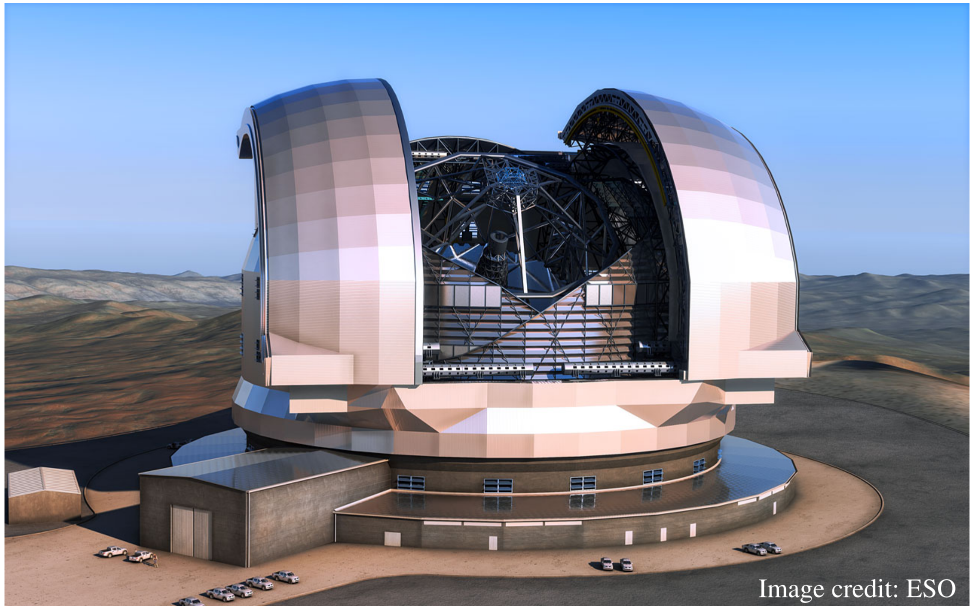

Figure 1: Model rendering of the Extremely Large Telescope on Cerro Armazones, under construction until 2027.