Physics of Planetary Systems — Exercises

Astrophysikalisches Institut und Universitätssternwarte Jena
Thüringer Landessternwarte Tautenburg

Distributed: 2009-04-30; results due: 2009-05-07.

Set 2

Problem 2.1

Figure 1 shows the correlation between period and semi-major axis of known planets as given in the Extrasolar Planet Encyclopaedia (exoplanet.eu). Why is there such a tight correlation? What about the outliers (some are circled)? Do these violate any physical law? What does this figure tell you? *(2 points)*

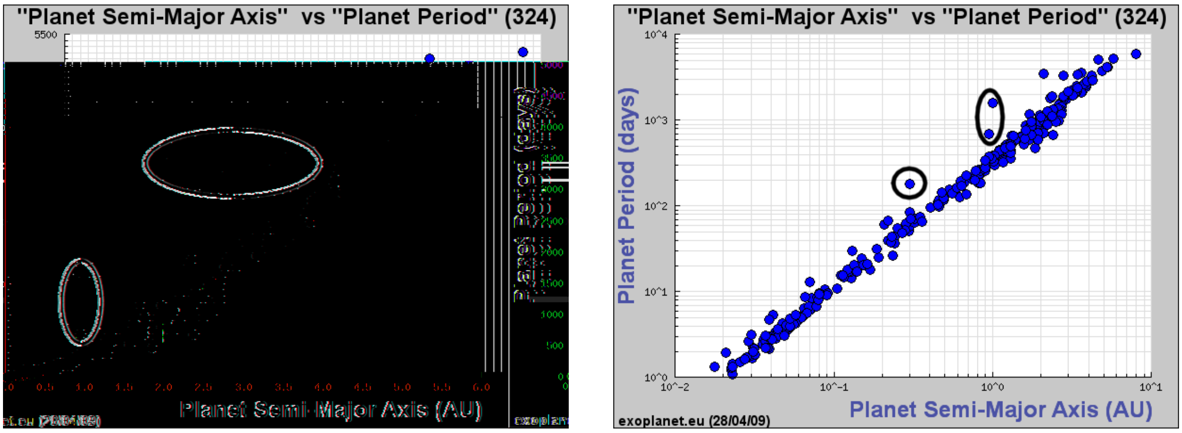

Figure 1: Correlation between period and semi-major axis. The left panel is in linear scale, the right one in log-log scale. (Source: exoplanet.eu)

Problem 2.2

Go to the Exoplanet Encyclopaedia (exoplanet.eu) and find all radial velocity detected extrasolar planets with masses $1\mathscr{M}_{\rm Jup} < \mathscr{M} < 2\mathscr{M}_{\rm Jup}$. (Click on “candidates detected by radial velocity”. Under “planet table” you can sort by mass.) *Estimate* the probability that *all* of these planets are in reality companions with true mass greater or equal to that of a brown dwarf (i.e. $\gtrsim 20\,\mathscr{M}_{\rm Jup}$). *(3 points)*

Problem 2.3

Consider the following naïve model of the Sun’s formation. An “infinitely” large and cold, nonrotating spherical cloud of molecular hydrogen with $\mathscr{M} = \mathscr{M}_\odot$ collapses to the radius $R = R_\odot$, yielding the Sun. Which mechanism has stopped the collapse? Is the total energy conserved during the collapse? Estimate the temperature T of the cloud in its final state, i.e. the temperature of the Sun.
Hint: use the virial theorem. *(3 points)*

Problem 2.4

Do you think planetary systems have better chances to develop around stars of lower or higher mass (or luminosity)? Why? *(2 points)*