Physics of Planetary Systems — Exercises

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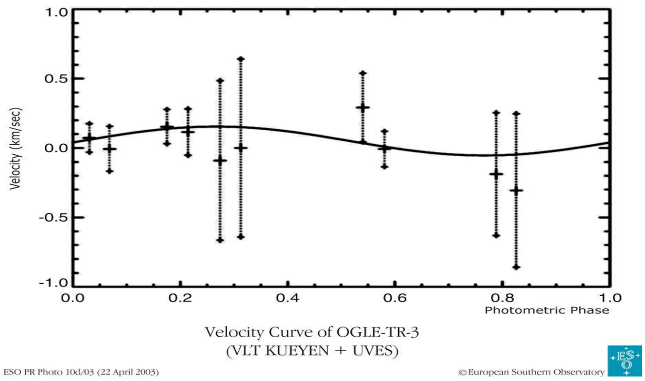
Set 4

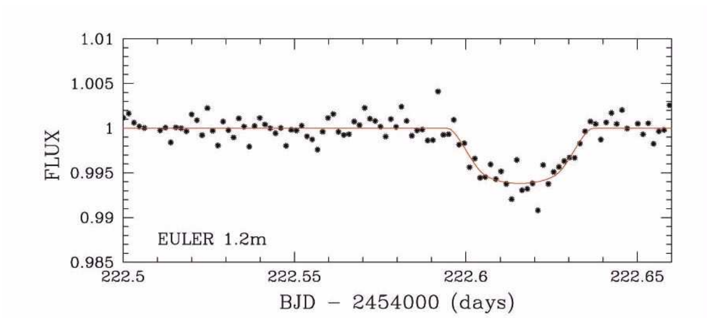
Problem 4.1

The figure below was part of an ESO Press Release announcing the confirmation of the transiting planet around OGLE-TR-3 (the results later appeared as a refereed paper in Astronomy and Astrophysics). It shows the radial velocity measurements of the star as a function of photometric phase (phase = 0 is the mid-time of the planet transit). The solid line is the orbital solution. Explain why the radial velocity measurements, in fact, do not support the planet hypothesis. (From this figure alone the referee should have rejected the paper!) *(3 points)*



Problem 4.2

From the duration of the transit shown below (read off the graph, an approximate value is okay), estimate the radius of the star. Assume that it has the same mass as the Sun and that the orbital inclination is 90 degrees. The orbital period of the planet is 2.6 days. Is this a solar-type star? *(2 points)*
From your estimate of the stellar radius use a more appropriate value for the stellar mass to get a better estimate of the stellar radius. *(1 extra point)*



Problem 4.3

Estimate the young Sun's luminosity and temperature, assuming an accretion rate of $10^{-5}\ \mathscr{M}_\odot\ \mathrm{yr}^{-1}$. *(2 points)*

Problem 4.4

Assume that the disk around the proto-sun had a mass $\mathscr{M}_{\rm disk} = 0.01\ \mathscr{M}_\odot$ (the so-called minimum mass solar nebula, MMSN). How cold had the disk to be to build giant planets directly? Is the temperature you obtain realistic? Estimate the minimum disk mass with which this planet formation scenario becomes thinkable. Hint: use the Toomre parameter. *(2 points)*