Scanning Radial Velocity Planets for Transit/Eclipse Signatures

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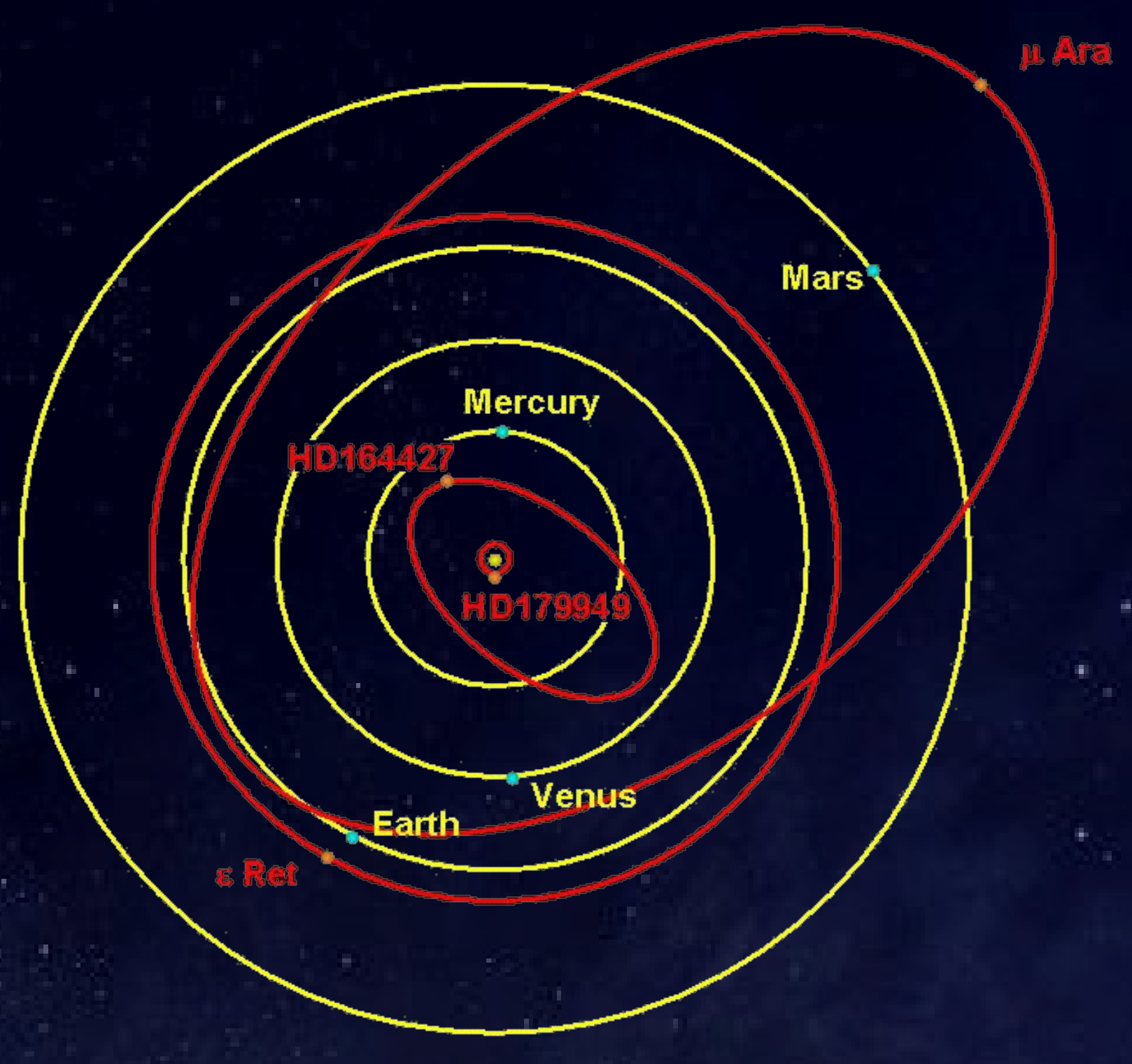
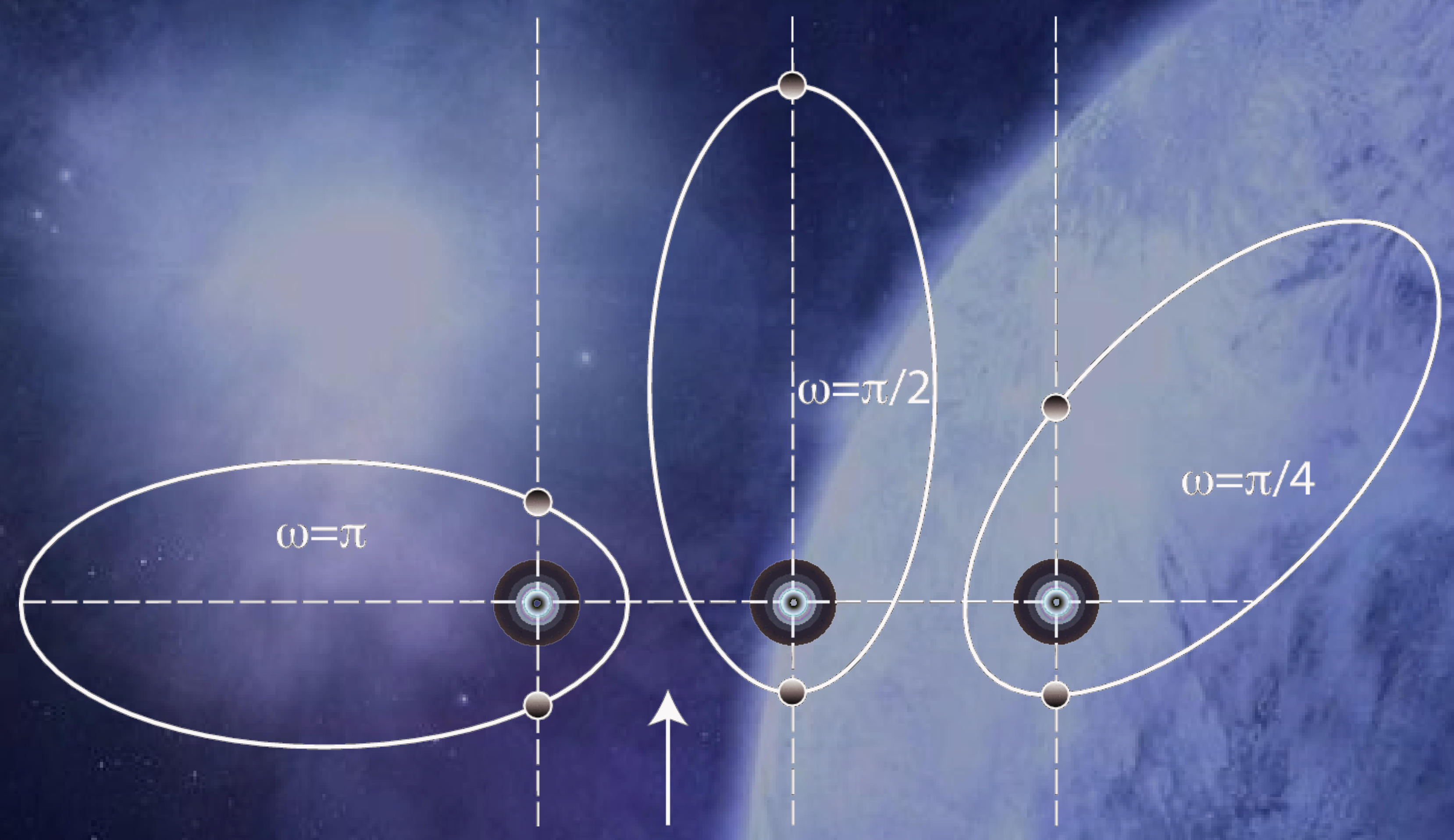
1. Introduction



In addition to the period, the orbital parameters of eccentricity, e, and argument of periastron, ω, have a significant impact on the probability that a planet will undergo a primary transit or secondary eclipse. The radial velocity information can be used to construct an effective photometric follow-up strategy which will provide optimal detection of possible transits. We present the results of studying these effects and apply them to the known radial velocity planets.

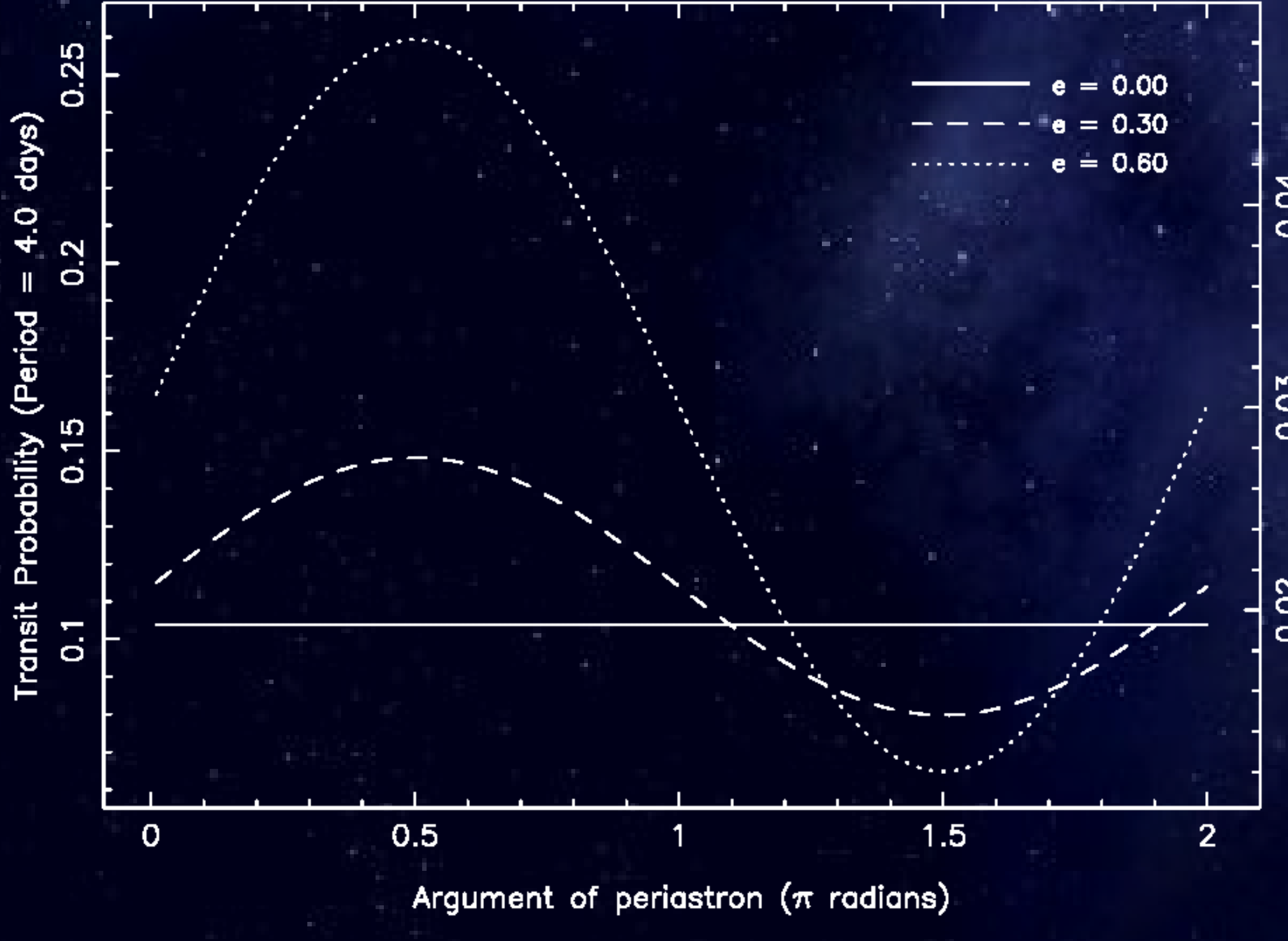
2. Orbital Configuration

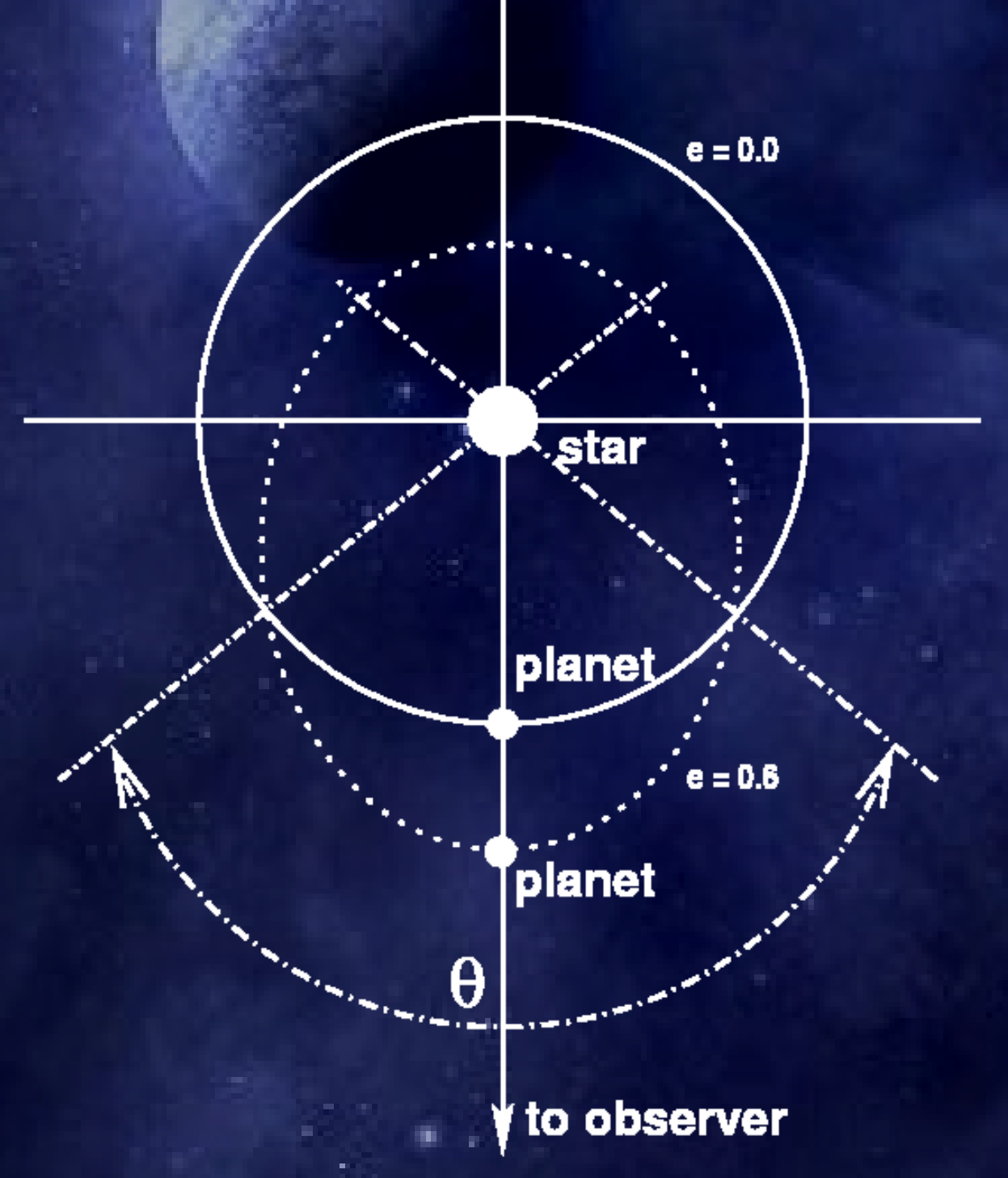


The probability of a transit or eclipse occurring for a particular planet depends upon the star-planet separation both in front of and behind the star. For a circular orbit, this distance is equal to the semi-major axis of the orbit, but for an eccentric orbit can be quite different. The figure above demonstrates how the orientation of the orbit (argument of periastron) for a given eccentricity can influence the likelihood of a primary transit or a secondary eclipse.

3. Argument of Periastron

Recent work by Barnes (2007) and Burke (2008) has shown that analysis of the eccentricity distribution can produce a higher predicted planet yield for transit surveys. Here we show the combined effect of the eccentricity and the argument of periastron on the primary transit probability.

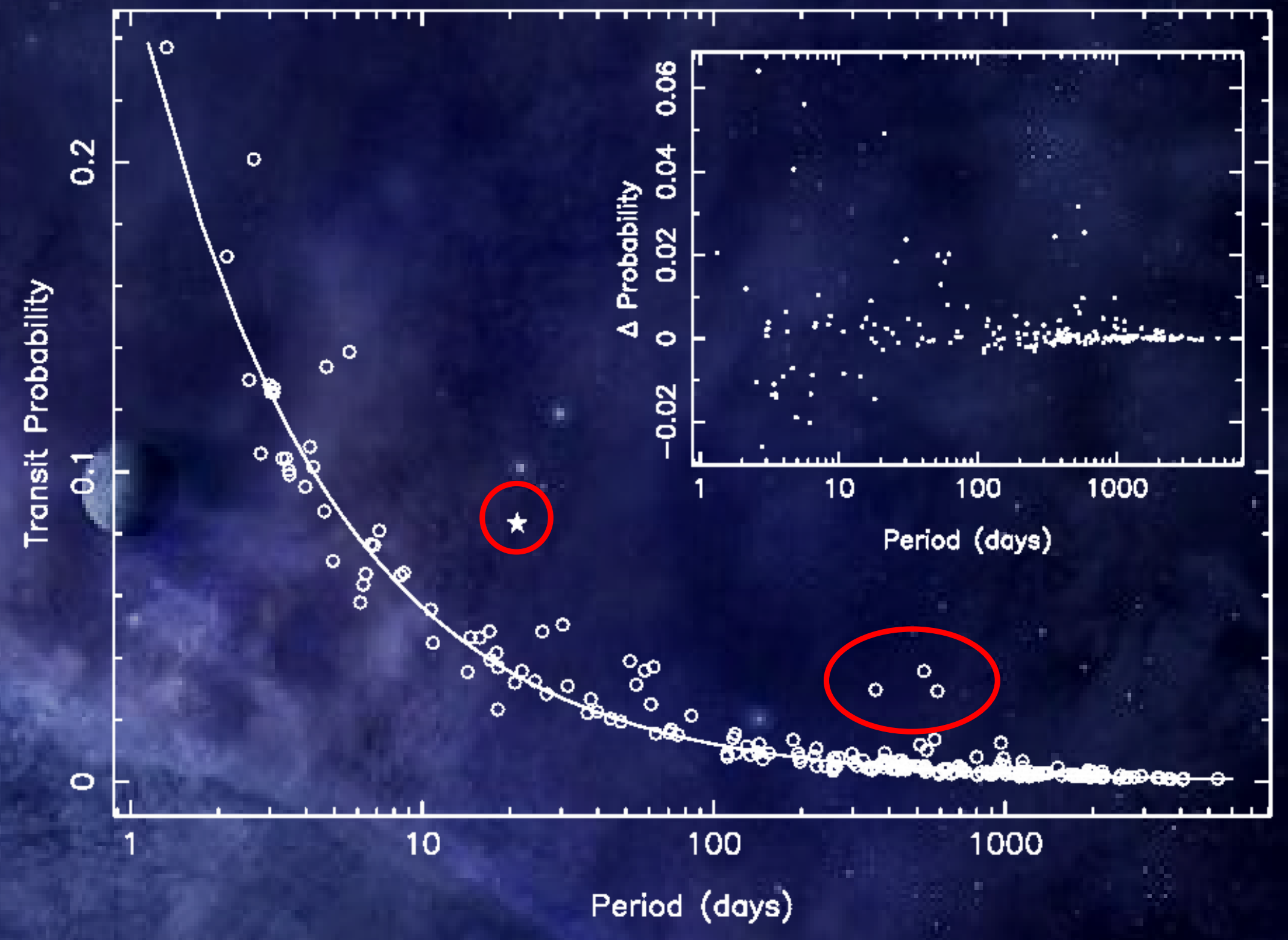




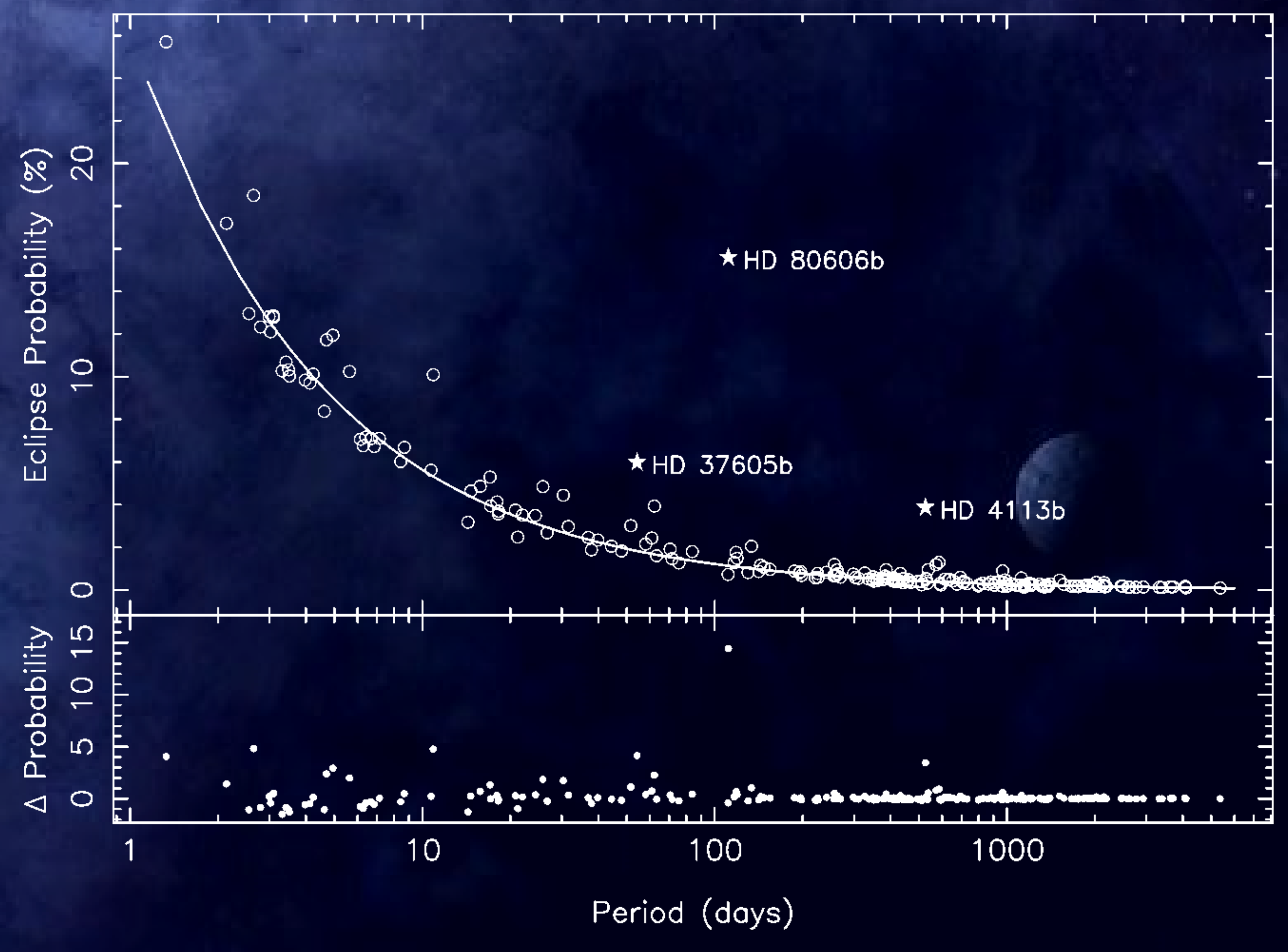
The above-left figure shows the effect upon the primary transit probability as we rotate the semi-major axis around the star for eccentricities of 0.0, 0.3, and 0.6. The angle θ in the above-right figure corresponds to the range of ω for which the elliptical probability is less than for a circular orbit (θ = 105° in this case). The eccentricity of long-period planets can raise their likelihood of transiting to a statistically viable number for detection.

4. Application to Known Planets

Applying the orbital parameters of e and ω should in general lead to an overall more favorable situation for transit/eclipse detection. The below figure shows the transit probability for 203 exoplanets calculated from orbital parameters provided by Butler et al (2006). The solid line indicates the transit probability for a circular orbit and the sub-panel in the plot shows the difference between the two values (residuals). The 21.2 day transiting planet, HD 17156b, is shown as a 5-pointed star and has a clear advantage due to its orbital parameters. Three long period planets (P > 350 days) also stand out, for which the probability residuals are ~0.03. The effect of this is to increase their transit probabilities to the same level as HD 17156b if it were in a circular rather than eccentric orbit.

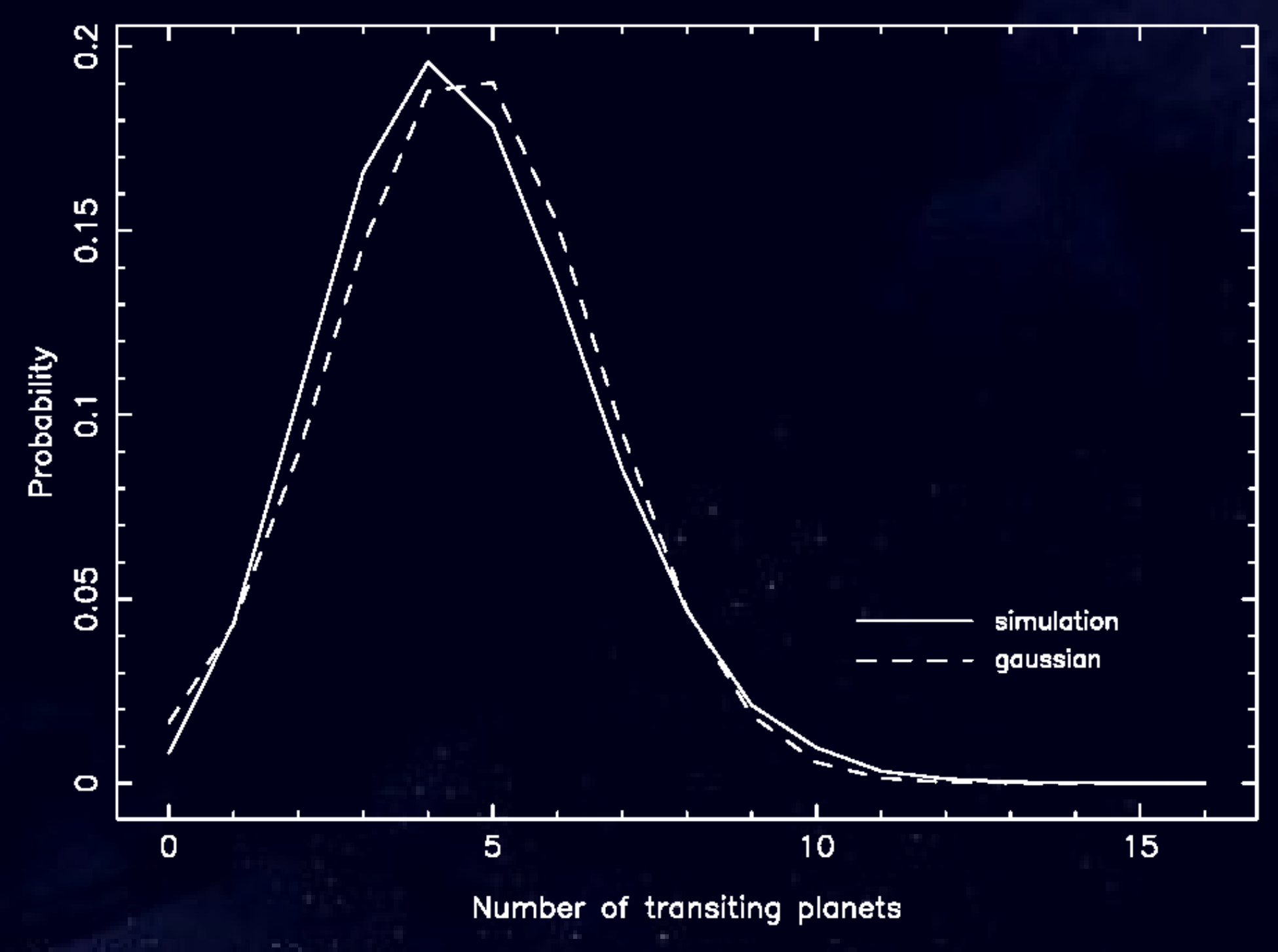


The figure below shows the geometric eclipse probability for the same sample of exoplanets. HD 80606b, HD4113b, and HD 37605b have been marked as examples with particularly high secondary eclipse probabilities.



5. Photometric Follow-up Strategy

The majority of radial velocity planets have been detected around V < 14 stars. Kane (2007) shows that 1.0m class telescopes are ideal instruments to photometrically monitor these targets. By selecting observable targets with well constrained transit windows and high transit probabilities, an optimised campaign can be constructed. This figure shows the probability distribution for the 203 planets in the Butler et al (2006) sample, predicting the number of transiting planets based on their estimated orbital parameters. We have begun an observing campaign of known southern host stars at predicted planetary transit times using the CTIO 0.9m and 1.0m telescopes. The significance of a null result from such an observing campaign, as well as subsequent constraints on orbital parameters, is discussed in detail by Kane & von Braun (2008).



References

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