The Binary Habitability Mechanism – BHM and On-line Calculator

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ABSTRACT

The binary habitability mechanism (BHM) is a combination of astrophysical circumstances allowing for potential life on planets in circumbinary orbits. Of particular importance is the accurate calculation of the rotational evolution of both stars. We review our previous work on the habitable zones of the Kepler circumbinary planets and highlight our analysis of the newly discovered planet KOI-2939b orbiting in the binary habitable zone. Our detailed rotational evolution calculations agree well with the observed near synchronism between the secondary star rotation period and the binary period. Calculations show that the secondary star's spin period is consistent with its estimated age and is now headed towards pseudo-synchronization.

We show examples using our binary habitablity and more calculator BHMCalc available at http//:www.bhmcalc.net.

The BHM Calculator http://bhmcalc.net

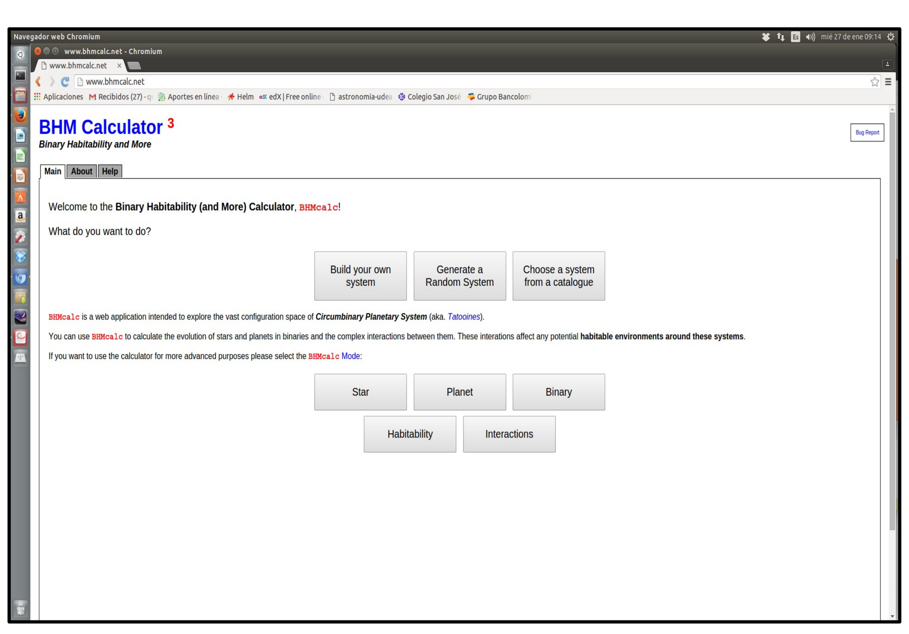

Figure 1. We investigate circumbinary environments using the BHM calculator (BHMcalc). This GUI implements and provides access to sophisticated stellar and planetary evolution models, binary and planetary orbital dynamics, as well as habitable zone and continuous habitable calculations, for both isolated and binary stars.

The circumbinary habitable zone is calculated as a function of time based on luminosity from stellar models.

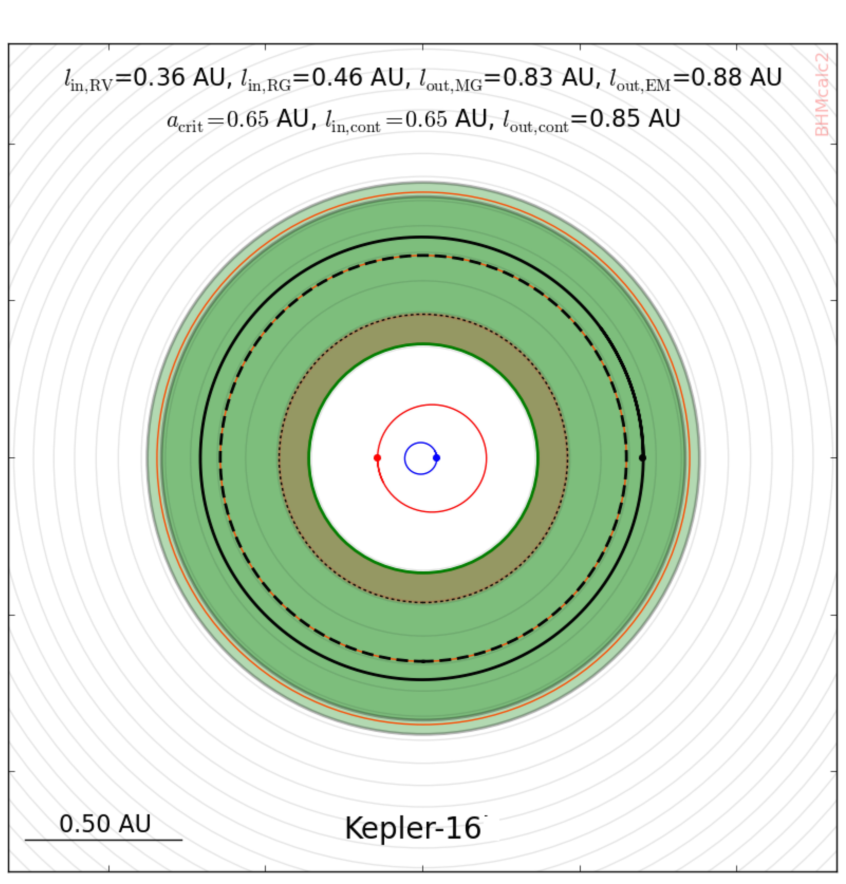

Figure 2. The Kepler 16 instantaneous circumbinary habitable zone limits, the binary orbit, the critical distance (dashed black line), the planet orbit (solid black line), the limits of the continuous BHZ (orange solid lines), and distances of binary orbit resonances (concentric gray circles) for Kepler 16. The distance at which the equivalent Earth insolation is received is marked with a dotted black line.

Circumbinary Habitable Zone Comparison

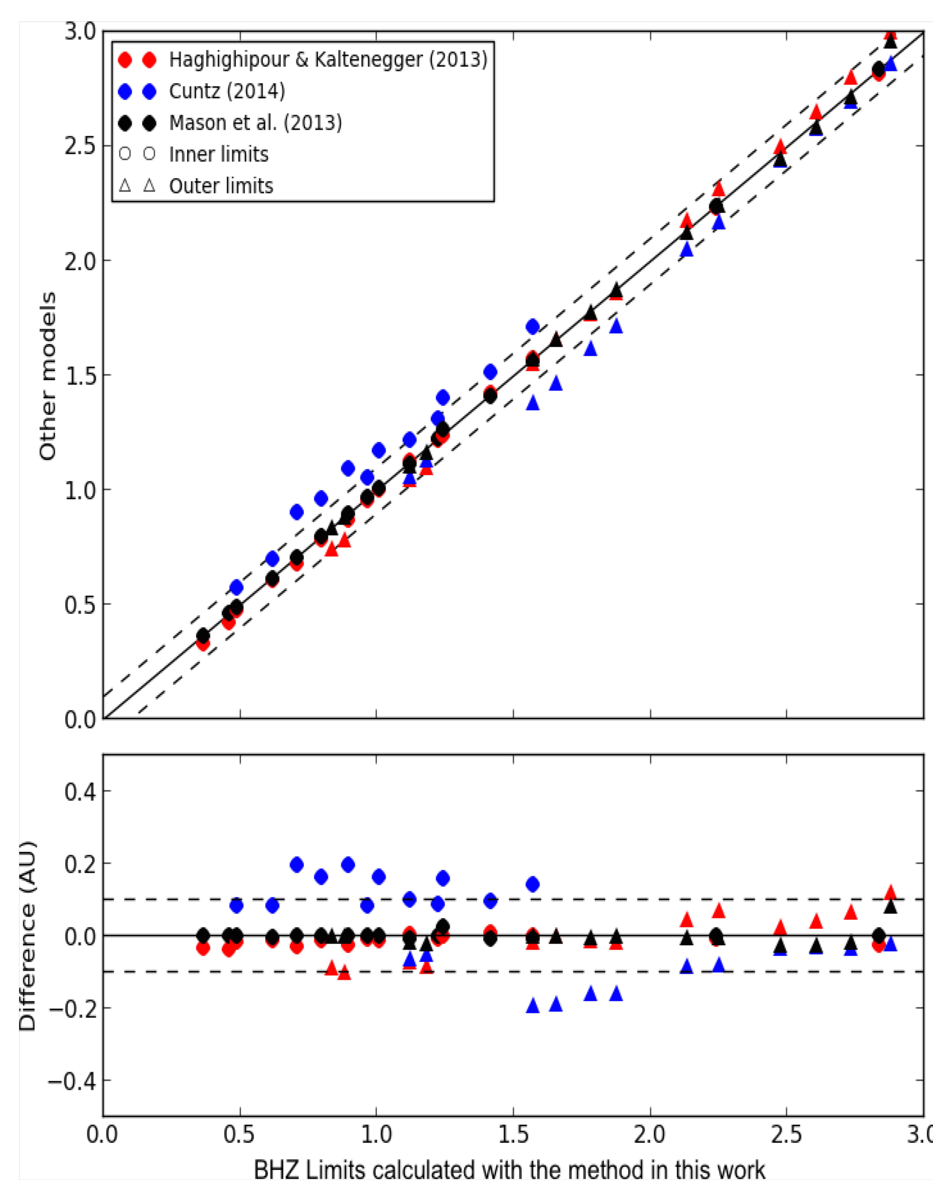

Figure 3. Comparison of BHZ limits for Kepler binaries calculated with independent methods (see legend).

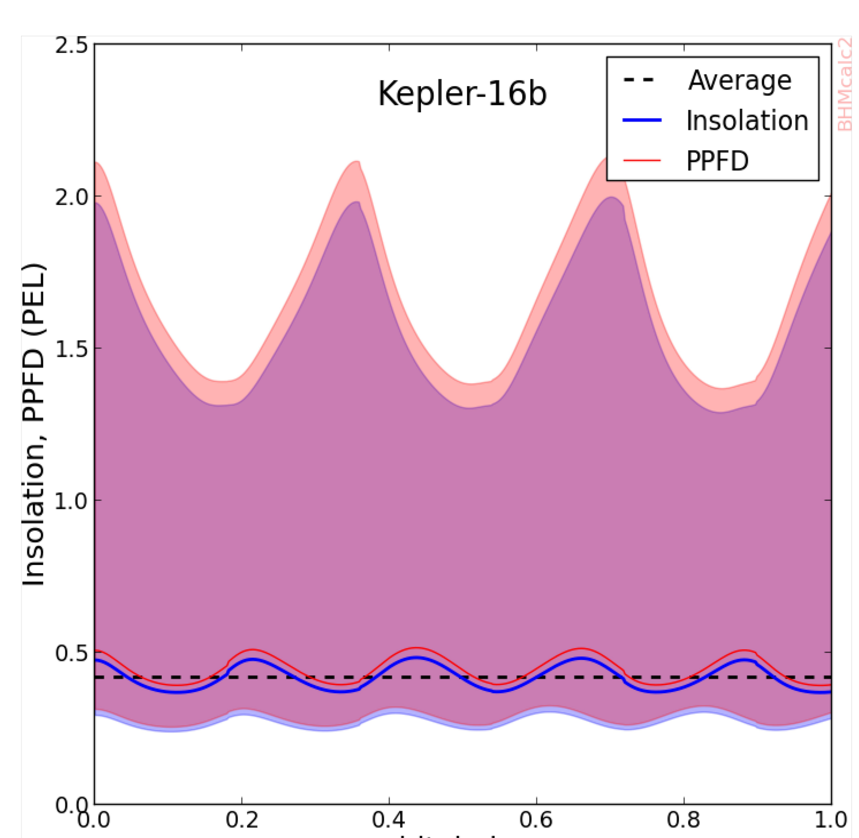

Figure 4. The insolation and photosynthetic photon flux density (PPFD see Mason et al, 2015) for Kepler 16 b. Insolation and PPFD are calculated in units of present Earth levels not only at the distance of the planet (blue and red solid lines respectively), but also at all locations within the BHZ (shaded areas).

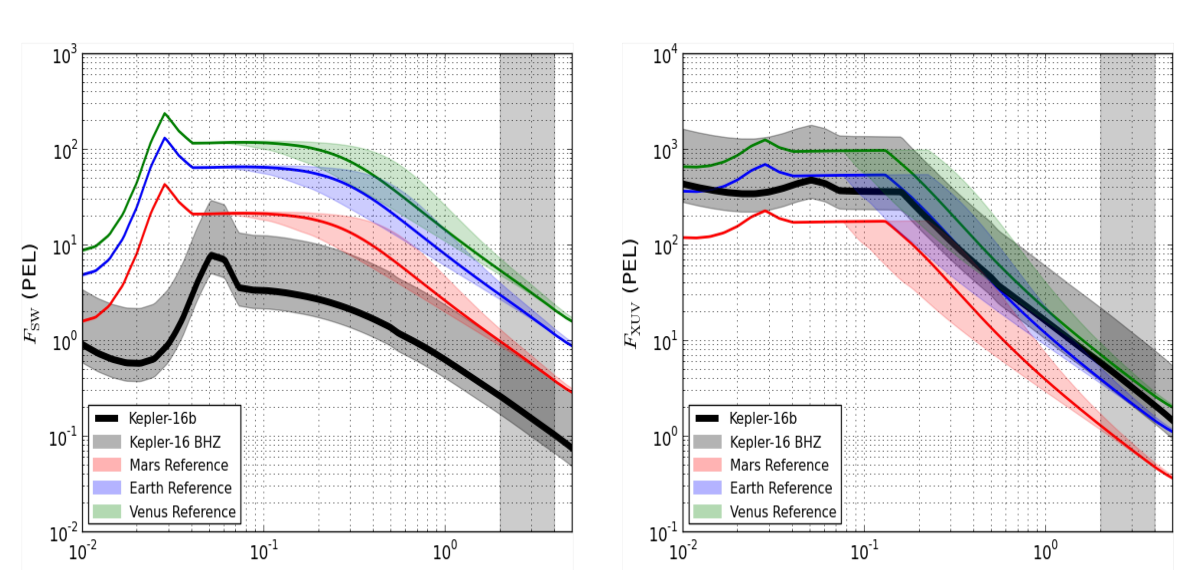

Figure 5. Stellar wind and XUV flux evolution for Kepler 16. While harsh XUV conditions exist in the BHZ (right), very favorable stellar wind conditions are estimated (left) to be better than in the solar system. A Mars-sized planet at the inner edge of the Kepler-16 BHZ resides in a plasma environment slightly better than Mars.

NEW! KOI 2939 binary results

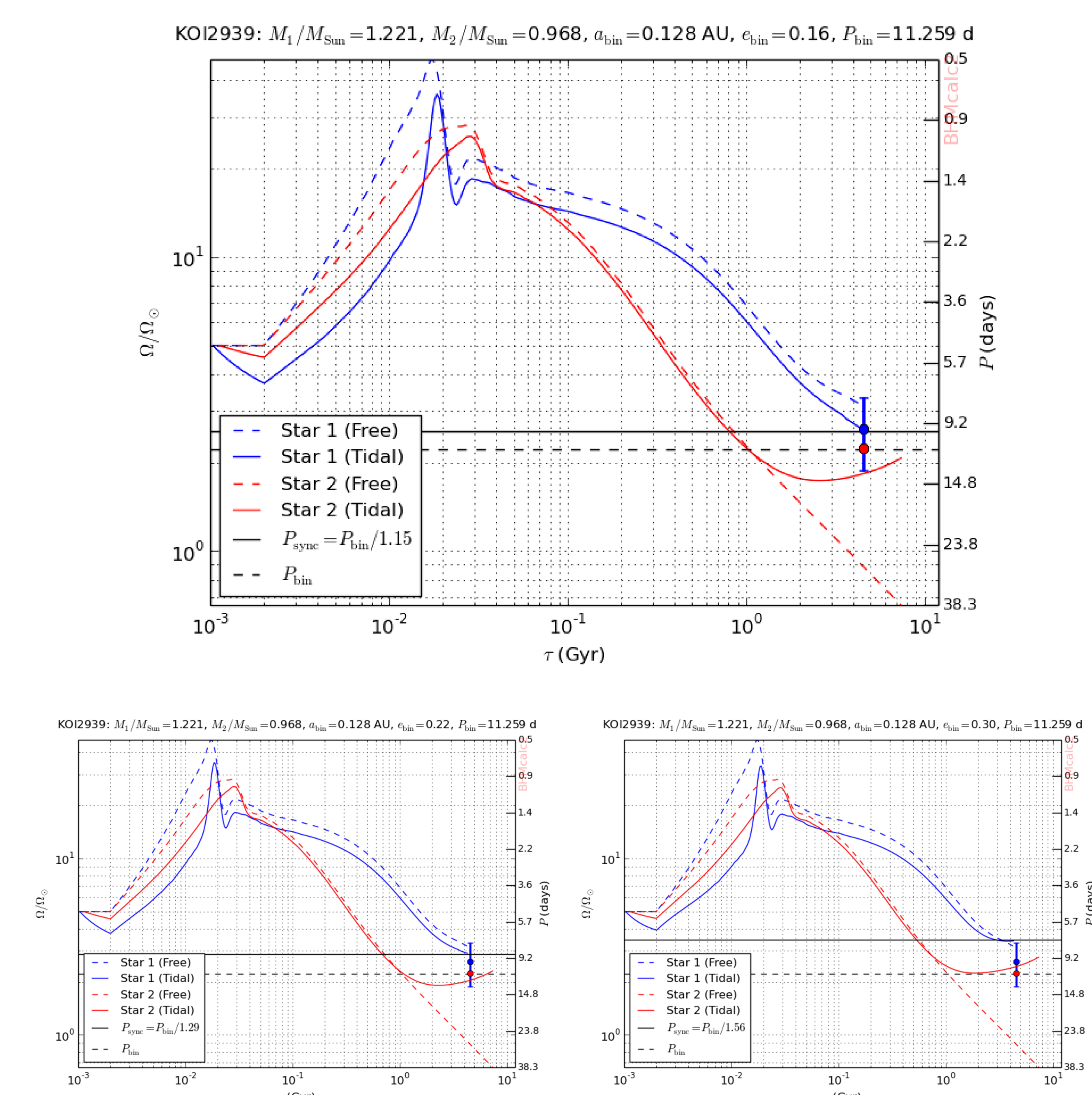

Figure 6. Calculation of rotational evolution is critical for circumbinary habitability. Our detailed stellar plus dynamical evolution results agree well with the observed rotational periods, shown in the plots. Since we do not know the initial binary eccentricity we show the present day value e = 0.16. (top) and two slightly higher initial eccentricities (bottom).

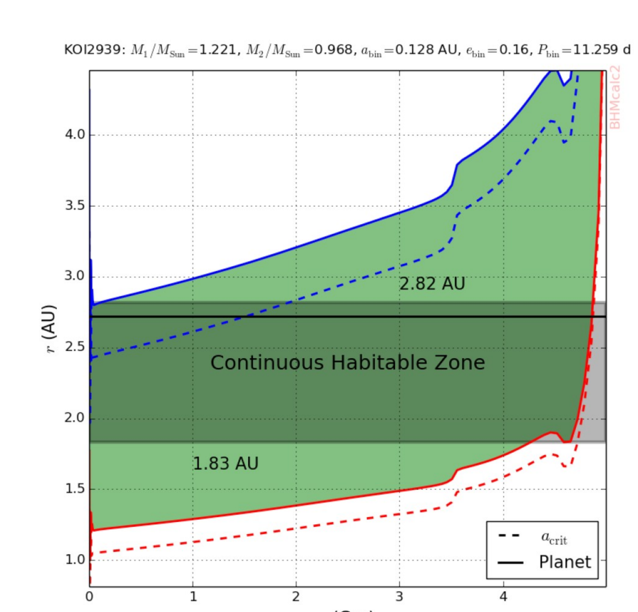

Figure 7. The evolution of the circumbinary habitable zone for KOI 2939 (green area). BHZ limits are shown as a function of age (solid blue and red lines). The HZ for a single star with a mass equal to the primary is also shown (dashed lines).

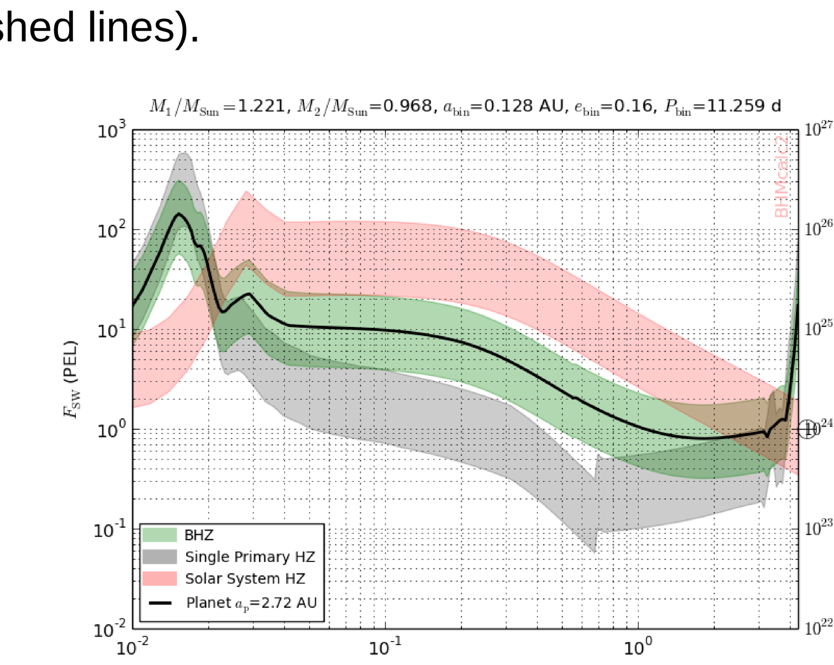

Figure 8. The stellar wind environment of the habitable zone of KOI 2939 remains better than in the solar system, until the higher mass primary evolves off of the main sequence.

References:

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