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Constraining the epoch of the potential emergence of life in exoplanets

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Abstract: Astrobiology-oriented studies of exoplanets generally focus on the possibility that the detected planets may host life at the present time. This type of approach usually ignores the evolution of the planetary climate conditions. Because of this, it is not clear if and when the planetary climate may have been suitable for the emergence of life. We have developed a flexible climate model for terrestrial-type exoplanets [1] that can be used, among other applications, to track the conditions of habitability as a function of the luminosity evolution of the central star [2]. With the same model, we can also track the impact of other evolving climate factors, such as the slowing down of the rotation period, which are not usually considered in studies of planetary habitability. We have applied our models to investigate the epoch of the onset of life-sustaining conditions in Kepler-452b, which is currently the best example of an Earth-size planet in the habitable zone of a sun-like star. This test case indicates the potential of our methodology to find out the epoch of the onset of appropriate conditions for the emergence of life in the large number of terrestrial-type exoplanets around solar-type stars that are expected to be detected in future observational surveys.

[1] Vladilo G et al. (2015) *Astrophysical Journal* 804:50. [2] Silva L et al. (2017) *International Journal of Astrobiology,* doi:10.1017/S1473550416000215

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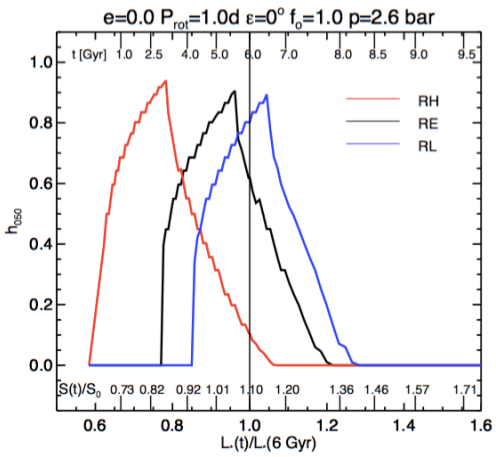

Figure 1 – Evolution of the habitability index h_{050} [2] in the extrasolar planet Kepler 452b. The habitability is plotted as a function of the evolving luminosity of the central star, $L_\star(t)/L_\star(6\ Gyr)$, of the resulting insolation in Earth's units, $S(t)/S_o$, and of the stellar age, t (Gyr). The curves of different colors correspond to three different values of CO_2 abundace in an otherwise Earth-like atmospheric composition (blue: pCO_2=10 ppmv; black: pCO_2=380 ppmv; red: pCO_2=38000 ppmv). The planet is assumed to have a surface atmospheric pressure p=2.6 bar, a rocky composition, and a surface gravity acceleration g=15.7 m/s^2. The initial rise of the habitability curves indicates the onset of conditions that would allow the emergence of life for the adopted set of planetary parameters.