Obliquity Variations of Habitable Zone Planets Kepler-62f and Kepler-186f. Y. Shan[1]and G. Li[1], [1]Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA, yshan@cfa.harvard.edu

Introduction: Obliquity variations play important roles in the climate and habitability of a planet, as they determine the latitude distribution of stellar radiation [e.g, 1]. Orbital modulations caused by planetary companions and planetary spin axis precession due to the torque from a host star may lead to resonant interactions and cause large amplitude obliquity variations [e.g., 2, 3]. Here, we select Kepler-62f and Kepler-186f from the list of habitable zone planets in multi-planet systems [4], and we characterize the parameter space where their obliquity angles are stable, which could represent a condition more favorable to habitability.

Methods: We use a numerical approach to calculate the obliquity evolution of planet Kepler-62f and Kepler-186f. An example of the obliquity variation of Kepler-186f is shown below.

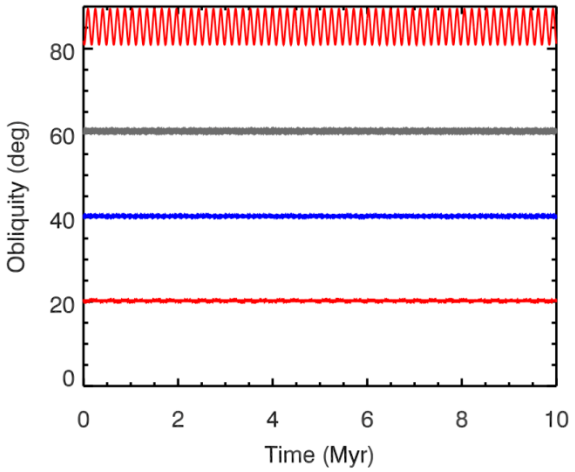

Figure 1. Obliquity of Kepler-186f as a function of time, assuming Kepler-186f has an Earth-like interior structure and a rotation period of 1 day.

Next, we adopt an analytical approach to interpret the numerical results and to characterize the regions in parameter space that allow high amplitude obliquity variations. In particular, we consider different planetary architectural configurations and planetary rotation periods, based on the observational results, and we estimate the orbital modulation frequencies and the planetary spin-axis precession frequencies to determine the locations of resonant regions, which correspond to regimes that allow large obliquity variations. The uncertainties in the mass and the orbital parameters of all the planets in the Kepler-62 and Kepler-186 systems are also considered in this approach.

Results: We find that the obliquity of both Kepler-62f and Kepler-186f have small variations in the low obliquity regime, assuming the planets are Earth analogues. This supports regular seasonal variations. However, the high obliquity regions allow moderate variabilities. In addition, farther planetary companions and/or the existence of a satellite may render the low obliquity region unstable. Better constraints on the existence of additional planetary companions and large satellites can further predict the variability of the obliquity angle.

References:

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