The Effect of Orbital Configuration on the Possible Climates and Habitability of Kepler-62f. A. L. Shields[1,4], R. Barnes[2,4], E. Agol[2,4], B. Charnay[2,4], C. M. Bitz[3,4], V. S. Meadows[2,4] [1]NSF Astronomy and Astrophysics Postdoctoral Fellow, Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Cambridge, MA 02138: aomawa.shields@cfa.harvard.edu [2]Department of Astronomy and Astrobiology Program, University of Washington [3]Department of Atmospheric Sciences, University of Washington [4]NASA Astrobiology Institute

Introduction: As lower-mass stars are likely candidates to host multiple rocky planets, it is important to consider whether gravitational interactions among planets may have significant effects on climate and habitability over long timescales. Using an *n*-body integrator, a specific case is explored—that of Kepler-62f [1], a potentially habitable planet in a five-planet system orbiting a K-dwarf star. The stable range of initial eccentricities possible for Kepler-62f is identified as $0.00 \leq e \leq 0.32$ (Figure 1). Simulations using a 3-D GCM indicate that with 3 bars of CO_2 in its atmosphere, Kepler-62f would only be warm enough for surface liquid water at the upper limit of this eccentricity range, providing it has a high planetary obliquity. A climate similar to modern-day Earth is possible throughout the entire range of stable eccentricities, assuming Earth's present obliquity, if atmospheric CO_2 is increased to 5-bar levels (Figure 2). In a low-CO_2 case (Earth-like levels), increases in planetary obliquity and orbital eccentricity coupled with an orbital configuration that places the summer solstice at or near periastron generate regions of the planet with above-freezing surface temperatures, which may cause surface melting of an ice sheet formed during an annual cycle. If Kepler-62f is synchronously rotating and has an ocean, CO_2 levels above 3 bars would be required to distribute enough heat to the night side of the planet to avoid atmospheric freeze-out and generate a large enough region of open water at the planet's substellar point to remain stable.

[1] Borucki, W. J. (2013) *Science, 340,* 587–590.

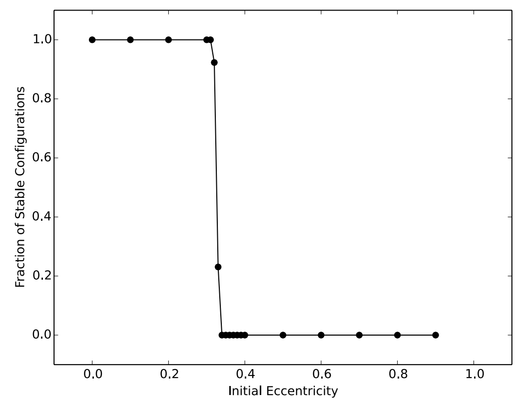

Figure 1: Fraction of stable configurations after a 10^6-yr HNBody integration for initial eccentricities between 0 and 0.9 for Kepler-62f. The eccentricities of all other planets in the Kepler-62 system were set to zero.

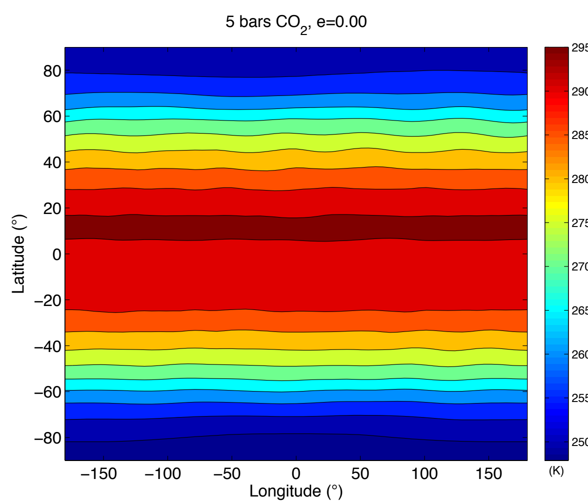

Figure 2: Surface temperature as a function of latitude for Kepler-62f after a 100-year LMD Generic GCM simulation, assuming an eccentricity of 0, an obliquity of 23.5°, 5 bars of CO_2 and an Earth-like rotation rate. The angle of the vernal equinox relative to the periastron of the planet's orbit is 0°.