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Generalized Milankovitch Cycles and the Influences on Climatic Habitability

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How likely are planets around other stars to have the climatic conditions that are suitable for liquid -water-based life? Are Earth-mass terrestrial exoplanets likelier to have nearly circular orbits with low obliquity, like the Earth, or are other orbital conditions more probable? And which kind of forcing condition is better from a climatic habitability perspective? In this talk, I show that terrestrial planets around other stars might experience substantial changes in eccentricity. Eccentricity variations could lead to climate changes, including possible "phase transitions" such as the snowball transition (or its opposite). There is evidence that Earth has gone through at least one globally frozen, "snowball" state in the last billion years, which it is thought to have exited after several million years of volcanic CO2 build-up. Due to the positive feedback caused by the high albedo of snow and ice, susceptibility to falling into snowball states might be a generic feature of water-rich planets with the capacity to host life. But if a terrestrial planet undergoes Milankovitch-like oscillations of orbital eccentricity that are of great enough magnitude, it could melt out of a snowball state. And, indeed, a giant planet on a sufficiently eccentric orbit can excite extreme eccentricity oscillations in the orbit of a habitable terrestrial planet. More generally, these two results demonstrate that the longterm habitability (and astronomical observables) of a terrestrial planet can depend on the detailed architecture of the planetary system in which it resides.

Keywords: Astrobiology, Climate, Exoplanets, Habitability