Climate dynamics of exotic exoplanet atmospheres

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ABSTRACT

Hypothetical exoplanet atmospheres engage a variety of novel climate regimes unlike any encountered in the Solar System, and very different from those that can be handled by conventional terrestrial climate models. These include supersonic rock-vapor atmospheres, circulations of Hot Jupiters, tide-locked planets and planets for which substantial parts of the atmosphere are subject to condensation. This talk will focus on problems related to the latter regime.

In Earth's present climate, the condensible component (water vapor) makes up only a small part of the mass of the atmosphere, so energy transport by condensate is small and the effect of condensation on surface pressure is slight. We refer to this as the dilute condensable case. Climate dynamics for the nondilute case engages a number of entirely novel phenomena, which cannot be treated within conventional terrestrial-type general circulation models. Nondilute climate dynamics is important for planets undergoing a water vapor runaway greenhouse, for planets near the inner edge of the habitable zone, for CO2-rich atmospheres near or beyond the outer edge of the conventional habitable zone, for methane-rich atmospheres on Titan-like planets, and in a variety of other circumstances, including water-dominated Super-Earths in orbits somewhat cooler than GJ1214b. In this lecture, I will build toward an understanding of the climate dynamics of the nondilute case, by means of simple physical scaling analyses and general circulation model simulations carried out for idealized situations. I will discuss some of the implications of these results for the boundaries of the liquid-water habitable zone, and for aspects of cloud formation that may have a bearing on interpretation of observed transit-depth spectra for exoplanets.

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