Characterizing Exoplanet Atmospheres

JONATHAN J. FORTNEY[1]

[1]Department of Astronomy and Astrophysics, University of California, Santa Cruz, CA 95064, jfortney@ucsc.edu

Planets around other Sun-like stars were first discovered in 1995, and the first data about atmospheres of these planets were obtained in 2002. Since that time, characterizing exoplanet atmospheres has become an important and growing area of planetary sciences and astronomy. Exoplanets have greatly expanding our modeling phase space and our imagination for the kinds of chemical and physical processes that might occur in planetary atmospheres.

Most data for exoplanets are from relatively large planets (gas giants like Jupiter that are hundreds of Earth masses) that are hot. High temperatures, which yields brighter planets, are either due to extreme proximity to a parent star, on a short period orbit, or extreme youth, before the rapid planetary cooling phase. High temperatures lead to more molecules in the vapor phase, rarther than being condensed deep in the atmosphere in clouds, which in principle allows for robust constraints on a variety of atmospheric abundances from remote sensing observations. More recently astronomers have attempted to characterize the atmospheres of smaller planets from 5-20 Earth masses around smaller and cooler M-type stars, which are much more numerous than Sun-like stars.

In this invited review I will show our ability to constrain the temperature structure of atmospheres, derive mixing ratios of important molecular absorbers, and constrain the location and variety of cloud-forming species. Data for these planets comes from the light emitted, transmitted, or reflected off of planetary atmospheres and each kind of observation provides different and complementary data. We are at the point now where deviations from equilibrium chemistry can be seen in some giant planets, particular those cool enough to potentially show CH_4 and CO absorption features. Photochemistry will also play a role for strongly irradiated atmospheres on short-period orbits.

We are at an interesting point in the study of exoplanet atmospheres. Space telescopes built for general astronomical use, such at the Hubble and Spitzer Space Telescopes, are not ideally suited for spectroscopy of planets. However, large investments of telescope time can overcome these obstacles, and I will showcase some early results from a large Hubble campaign to observe a few favorable planetary targets, including a 500 K planet of only 6 Earth masses, GJ 1214b, and a 1500 K gas giant planet in a 1-day orbit, WASP-43b. With the launch of the James Webb Space Telescope in 2018, the field will move to a new era of more robust constraints on atmospheric chemistry.