

Probing Exoplanet Atmospheres with Molecular Spectroscopy

The last two years have seen extraordinary progress in the field of detecting and characterizing the atmospheres of planets circling stars other than our sun. This progress has been aided by the rapid discovery rate for these bodies, called exoplanets, together with powerful new methods that now enable detailed atmospheric characterization. In the same way in which the Kirchhoff/Bunsen spectral analysis of the sun revolutionized astronomy in 1859, the spectroscopic detection of molecules in exoplanet atmospheres is now revolutionizing exoplanet characterization. Today, it is possible to compare the temperature structure and composition of exoplanet atmospheres, explore the role of non-equilibrium chemistry, examine the effect of extreme radiation forcing, detect dynamical processes, and search for signatures of evolutionary history. Spectroscopy is revealing exoplanet atmospheres to be complex with numerous parallels to the atmospheres of planets in our own solar system. Recent observations demonstrate that broad, simultaneous, spectroscopic coverage is essential for resolving the temperature composition ambiguity present in exoplanet emission spectra.

Given the significant number of bright exoplanet systems, there is an important discovery space accessible with modest-sized space-based telescopes, while new calibration methods hold the promise of allowing large ground-based telescopes to provide improved sensitivity and spectral resolution. Today, exoplanet spectroscopy stands poised to radically alter our understanding of exoplanets and to explore questions more typical of planetary atmospheres in our own solar system. This rapid and remarkable process is building rapidly towards the next step; in the very near future, it is probable that we will be able to detect molecules that represent the building blocks of life on an exoplanet positioned in a star's "habitable zone." This talk will follow the scientific journey from the discovery of exoplanets to current efforts to use molecules as probes of the conditions, composition, chemistry, and dynamics of exoplanet atmospheres.