Exploring the Atmosphere of the Hot Jupiter WASP-39b Using Available Opacity Data

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Adequate atomic and molecular data are essential for the scientific interpretation of the spectroscopic data of hot Jupiters recorded from space. Recent advancements in the James Webb Space Telescope (JWST) and the upcoming Ariel mission promise unprecedented transit spectroscopic data across the optical to near and mid-infrared ranges of exoplanet atmospheres. As one of the first exoplanets meticulously observed by JWST, WASP-39b has quickly emerged as an iconic target in astrophysical research and exploration. This exoplanet has attracted considerable attention due to its unique characteristics and the extensive data available for analysis. Transit spectra captured using various instruments—including NIRISS, NIRCAM, NIRSpec G395H, NIRSpec, PRISM and MIRI—are currently accessible, paving the way for in-depth studies of its intriguing atmosphere. In this talk, we present a novel and comprehensive approach to interpreting transit spectroscopic data, with WASP-39b as our example target, using the opacity data available in the community, most of which were collected by ExoMol.
Our methodology employs ab initio chemistry models alongside blind retrievals, which are used iteratively to uncover physically robust optimal solutions. By adopting this innovative approach, we successfully identify a new scenario to explain the enigmatic atmospheric composition of WASP-39b, involving the chemistry of over 20 elements and their relevant spectral signatures. Taking this study as a case, we advocate for obtaining more comprehensive opacity data, including the atomic, molecular, and aerosol species that have high abundances in our thermal chemical simulations, potentially at higher spectral resolutions for specific wavelengths to further validate and constrain the exoplanetary atmospheric compositions.