Z114a Experimental Determination of CH_4 Pressure-Broadening in Hot H_2/He Atmosphere Using Bayesian Inference

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Accurate knowledge of molecular line broadening in H_2&He-dominated atmospheres is crucial for interpreting high-resolution spectra of substellar objects (brown dwarfs and exoplanets). We present experimental measurements of CH_4 pressure-broadening in H_2&He atmospheres at temperatures up to 1000 K in the 1.60–1.63 μm wavelength range, where its strong absorption is observed in the spectrum. A full Bayesian inference approach was employed to simultaneously model the absorption lines measured under eight experimental conditions, varying in temperature and methane concentration for 22 selected lines. Using the auto-differentiable spectral model `ExoJAX` and the Hamiltonian Monte Carlo No-U-Turn Sampler (HMC-NUTS) via `NumPyro`, we obtained robust joint posterior distributions for more than 50 parameters simultaneously, including pressure-broadening parameters and their temperature dependencies. This method allowed us to disentangle the contributions from adjacent lines with quantified uncertainties. Our results reveal systematically narrower broadening parameters compared to those in the existing molecular database (ExoMol), especially at lower temperatures, and milder temperature dependence. This study underscores the necessity of experimentally derived broadening data and demonstrates the capability of differentiable spectral modeling in the analysis of experimental data.