

Z121a High-resolution spectral analysis of Luhman 16AB with Gaussian Process T-P profile and auto-differentiable spectrum model ExoJAX

Hibiki Yama (The University of Osaka), Kento Masuda (The University of Osaka), Hajime Kawahara (ISAS), Yui Kawashima (Kyoto University)

High-resolution spectroscopy is a powerful tool for probing the atmospheres of brown dwarfs. It enables the precise detection of both the continuum and individual molecular absorption lines, allowing accurate estimation of molecular abundances, temperature-pressure (T-P) profiles, and surface gravity.

However, results from high-resolution spectral analysis can be strongly biased by prior assumptions, such as the choice of T-P profile models. For example, Picos et al. (2025) showed that using different prior-constrained T-P profiles led to significant variation in the estimated surface gravity.

In this study, we developed a Gaussian Process (GP) T-P profile model without assuming any parametric form, treating each pressure layer's temperature as a free parameter. Using a GP prior incorporates the physical correlation that nearby layers tend to have similar temperatures, ensuring a smooth profile without strong shape constraints. Because estimating so many correlated temperatures results in a complex parameter space, efficient sampling using Hamiltonian Monte Carlo (HMC) is required. Since HMC needs model differentiability, we implemented the spectra model, including the GP T-P profile, using the auto-differentiable spectrum model ExoJAX. We applied this method to high-resolution spectra of the brown dwarf binary Luhman 16AB and validated its effectiveness in estimating atmospheric parameters.