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“Constructing Flexible Likelihood Functions for Spectroscopic Inference in the Systematics-Dominated Regime“

Spectroscopic observations can provide an immense amount of information about an astrophysical source. Depending on the nature of the source, however, fully extracting this information can be a difficult and meticulous process. For the specific application of inferring fundamental stellar parameters from spectroscopic observations of stars, we are now in an exciting era where synthetic stellar models can deliver high resolution spectra over a wide range of input fundamental stellar parameters (e.g., effective temperature, composition) with full wavelength coverage across the optical and infrared windows. Although these models typically show decent bulk agreement with observed spectra, there is often significant disagreement at the level of individual spectral lines, which results from intrinsic model imperfections (e.g., in the atomic molecular databases or opacity prescriptions). We present a modular, extensible likelihood framework for spectroscopic inference that aims to mitigate the influence of these spectral line outliers on the inferred fundamental stellar parameters. This framework specifically addresses the common problem of mismatches in model spectral line strengths (with respect to data) by using Gaussian process kernels to identify and self-consistently downweight pathological spectral line “outliers.” I will discuss some potential applications of this approach to cooler stars (M spectral type) and young stars (variable spectrum).

Beyond systematic model imperfections, a central challenge for full-spectrum inference is the expense of calculating synthetic spectra at new input parameters. Typically, synthetic spectra are published in large libraries spanning a range of parameters (albeit sparsely sampled with respect to the changes in the emergent spectrum). Because simple interpolation schemes lead to artifacts, we developed a Bayesian emulator to provide smooth interpolations of the library while also marginalizing over uncertainties resulting from the interpolation process. Lastly, I will highlight some related challenges of spectroscopic inference, such as searching for blended light from spatially unresolved binary stars using templates, as well as other topics, which will hopefully lead to interesting discussion during the workshop.