Both the input and the model spectra have ~400,000 elements, so we expect the chi-square value of a good fit to be ~400,000 as well (a value of 1 per element). Since our models do not have noise incorporated, we must decide a way of assessing the model uncertainties. There are several possible ways of doing this: We could decide a minimum believable line depth (e.g. x percent of the continuum) and decide some fraction of that line depth to be the uncertainty. This requires decisions about where the continuum falls (which could be complicated in cases like Figure 1) and what a “believable” line depth really entails, but does have the advantage of being observationally based (what line depth we can resolve).

Another option would be to add random Gaussian noise to the model by simulating a continuum with a blackbody at the star’s fitted temperature (i.e. the model’s T_{eff}), and adding random noise at each wavelength point, normalizing it at some fraction (something like 1%) of the continuum level at that wavelength location. This simulates normal observing conditions more closely than a noiseless spectrum, and means that we can can subsequently easily assess the noise properties of the model, including the variance. However, this requires a base assumption of 1) the blackbody nature of the continuum and 2) what we would judge is a high quality spectrum (which would determine what continuum level the noise falls at). This method also neglects the model uncertainties themselves, such as line location, existence, and depths.

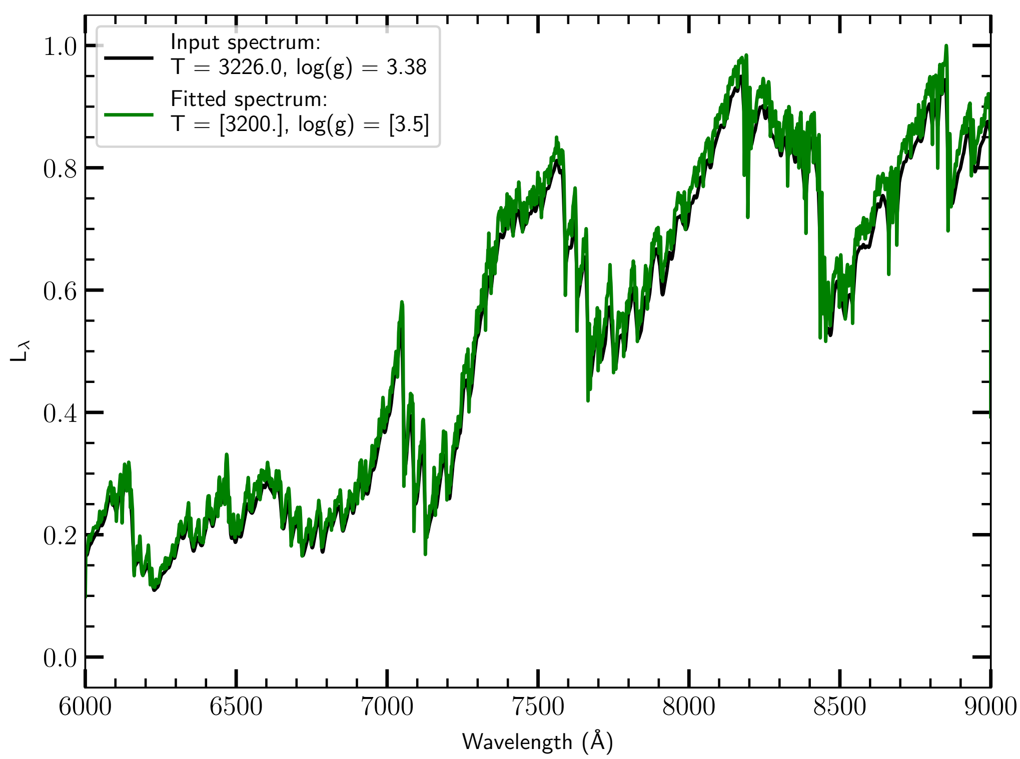

FIGURE 1: AN M DWARF WITH PROMINENT ABSORPTION BANDS

After a brief implementation of both of these techniques, the chi-square (divided by the number of data points, to give a mean chi-square value per point) of the line-depth technique gives more realistic chi-square values (closer to 1) for a good fit than the gaussian noise method. However, the Gaussian noise method is more complicated, so it is likely that there is some error in my quick implementation, rather than the line-depth noise estimation being genuinely more reliable. However, in terms of being less error prone, the simpler method is still to decide on a minimum plausible line depth and infer some error from that. Those values typically end up being about 1% of the continuum (when the maximum of the spectrum is normalized to 1) which is consistent with what we would expect for a good SNR spectrum.

An automated version of that technique is to look at the difference in absorption lines between a model and its good fit (e.g. the closest possible temperature and gravity model for the single stars) and use the residuals to judge the general deviation between the model and the fit. One straightforward implementation of this is to calculate a residual spectrum from the model and data, calculate the standard deviation of that residual, and use it as the 1 sigma noise level. A large mismatch in line depths should correspond to a noisier spectrum, which in turn leads to greater noise and a less good fit/a larger chi-square. It does not require manual assessment of line depths, but instead uses the full spectral region to assess the noise, and ultimately should produce similar results to manually measuring detectable line depths. The best fit can thus be “observationally” constrained using the mechanics of the fitting (that the data and model are an imperfect fit) instead of relying on theory of noise in spectra like adding random Gaussian noise does, or rely on guessing where the continuum level falls or what a detectable line is.