Infrared Spectral Synthesis & Comparison: Cataclysmic Variables and More!

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Cataclysmic What?

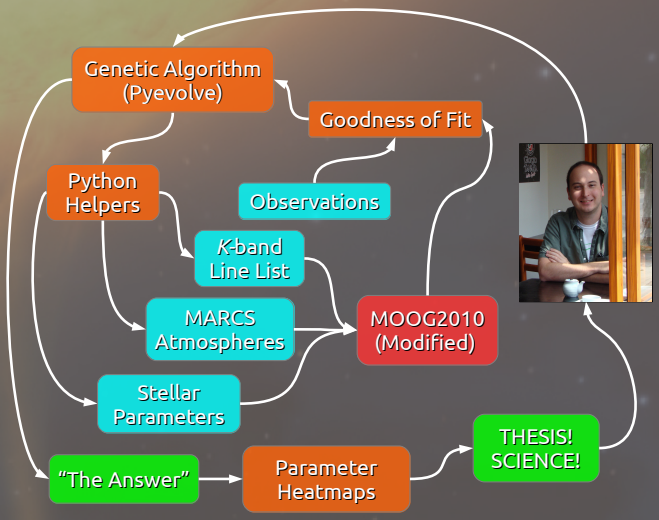
Cataclysmic Variables (CVs) are interacting binary systems containing a white dwarf primary and a low mass secondary star. Typically, the secondary stars have spectral types ranging from early K to late M, though there is evidence for brown dwarf secondaries in some systems. There are two broad subclasses of CVs: magnetic and non-magnetic. In non-magnetic CVs, an accretion disk is formed around the white dwarf to conserve angular momentum, and processes within the disk give rise to a wide variety of variability.

Yeah, So?

Given their low masses, the secondary stars should be unevolved. Recent observations, however, seem to indicate otherwise: near-IR spectroscopy reveals that a number of systems that do not appear as expected for the spectral type of the secondary star, and UV spectroscopy reveals anomalous C/N ratios as well. See Hamilton et al. 2011 (2011ApJ...728...16H) for a full breakdown, but we believe these systems are best explained by a deficit of C in the secondary star atmosphere as a result of CNO processing. This is problematic, however, since the evolutionary paradigm of CVs says they should be low mass stars from the beginning and thus have no time to evolve, let alone have CNO processed material!

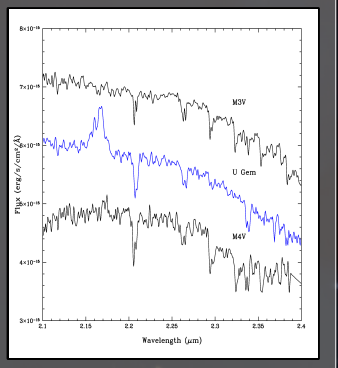
To explore this, we set out to model our IR spectra in a self consistent manner using MOOG, MARCS model atmospheres, and a genetic algorithm that I've developed to explore the many dimensional parameter space. The algorithm and method are described in this poster, and applications to my current research and other research topics are presented as well.

Algorithm & Code Flow

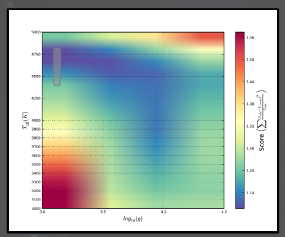


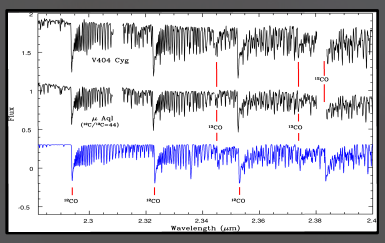
What The Spectra Look Like

A classic example of an anomalous NIR spectrum from the secondary star of a CV is shown on the right. U Gem, a prototype of an entire class of CVs, shows Na and Ca lines as expected for its expected spectral type, M3-4, *but shows little to no CO band absorption!* These data were presented in Harrison et al. 2005 (2005AJ....129.2400H), and were obtained at the IRTF using SpeX in 2002.



Below on the right is a comparison of the synthetic spectra in the *k*-band created with my code shown in blue compared to μ Aql and V404 Cyg (middle and top resp., both K3III). Below on the left is a heatmap in a slice of composition ([C/H], [Fe/H]) and T_{eff} and $\log_{10}(g)$ with a box highlighting the range parameters from the literature.



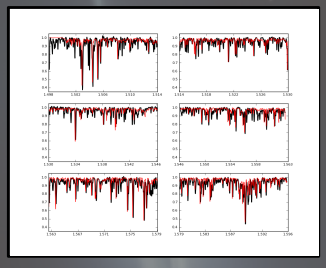


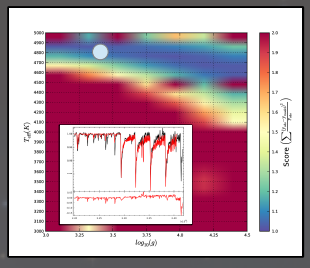
Status & Notes

Pros:
- Compliments other methods and adaptable to different fitting parameters
- Easily parallizable! Tested successfully with up to 48 threads so far
- Freely available & open after publication/thesis (approx. March 2013)
- Spectral Grid creation/comparison tools already complete

Cons:
- Needs optimizations!
- No triatomic molecules :(
  - Very early M as low as can go before H_2O absorption becomes important
- "Goodness of Fit" function needs revision!

To Do:
- Shake out all the bugs in the Genetic Algorithm
  - Currently being rewritten/optimized; recent test shown bottom right
- "Easy" optimizations to MOOG (input, queuing, etc.)
  - Benchmarks still to be completed! R ~ 3000ish is fast, though
- Experimental extensions to *H*-band for APOGEE ongoing!
  - Bottom left shows Arcturus (black) vs. model (red)





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