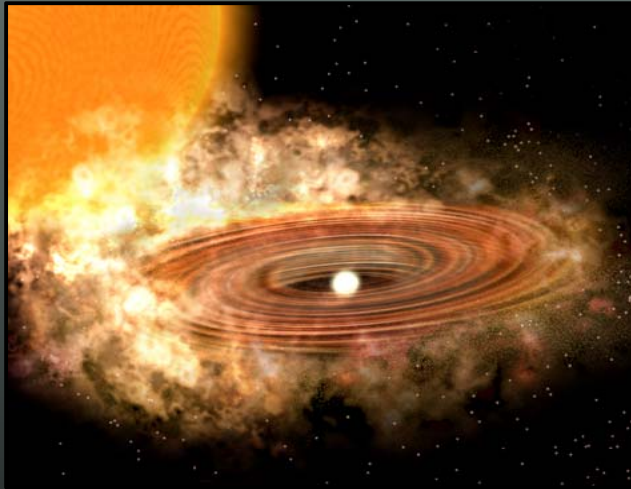


Star Formation Histories

with Dr. Jon Holtzman

and



Cataclysmic Variable Stars

with Dr. Tom Harrison

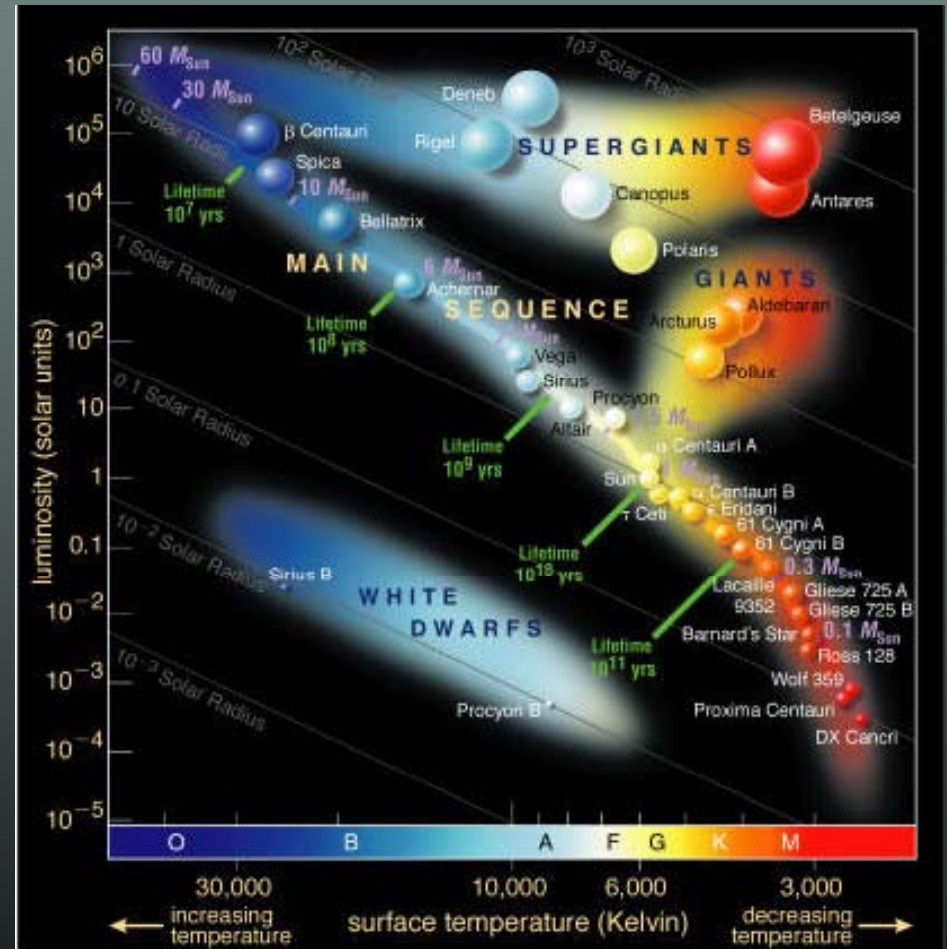
Ryan T. Hamilton
NMSU Astronomy
NM Space Grant Presentation, October 31st 2008

Star Formation History Motivation

- Important for understanding our own galaxy and how it has changed since its formation
 - Star formation in other galaxies uses our own galaxy as a benchmark, so it's important to get right!
- Poorly constrained problem, degenerate
 - Age and Metal content are both mixed up
 - Can get a result with established techniques, but is it right??
- Can tell us about chemical evolution of the milky way
- Project with Dr. Holtzman began in Fall 2006 to remove some of the ambiguity, bring in extra information
 - Custom approach needed, tools built from scratch
 - Needed to be flexible for future use and expansion

The Lives of Stars

- Stars live life on main sequence, then evolve off to giant branches as age
 - More massive stars lead shorter lives, evolve much quicker
 - Hummer vs. Volkswagen
 - CMD = “fossil record”
 - Fit models of different age stars to CMD to tell when stars formed



The Lives of Stars

- Stars form at different times
 - Inhomogeneous population and a general mishmash as observed from Earth
- Can get age information if observing a cluster, where all stars formed at the same epoch
 - Galaxies aren't as nice

388 *W. Dehnen and J. J. Binney*

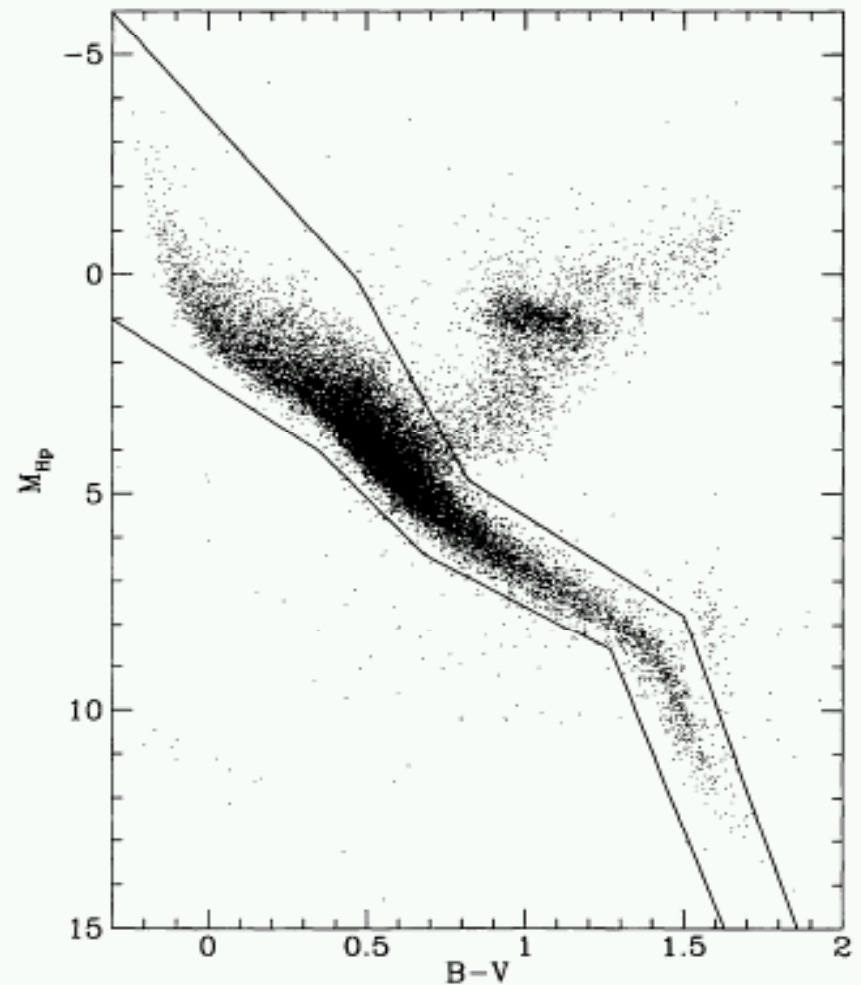
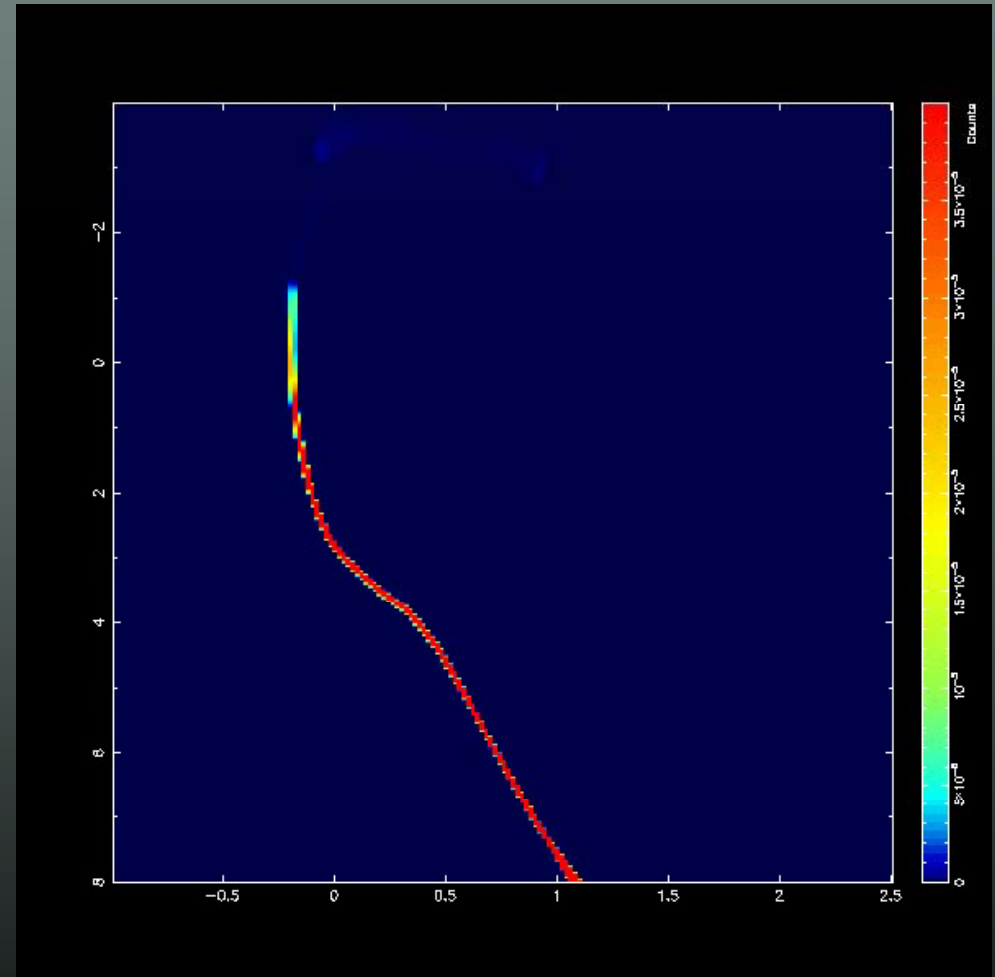


Figure 1. Hertzsprung–Russell diagram (M_{Hip} is the absolute magnitude in *Hipparcos*'s own passband) of the 18 860 single *Hipparcos* stars with relative parallax errors less than 10 per cent. The lines are used to select the main sequence and have 16 054 stars between them.

Untangling it All

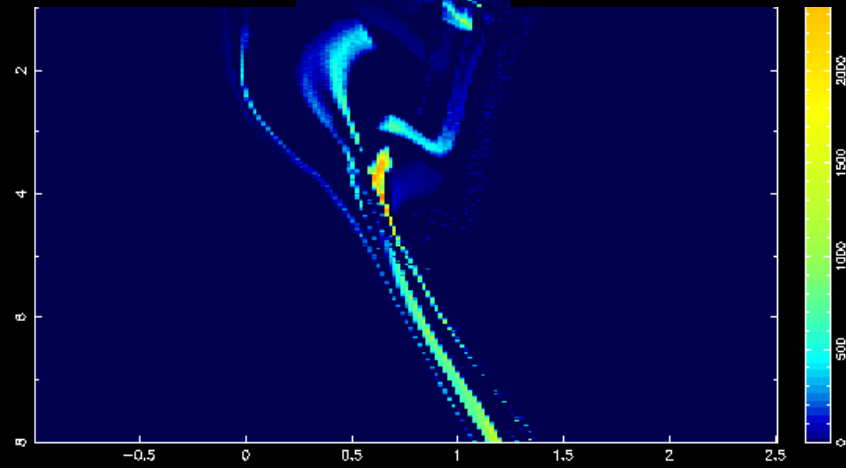
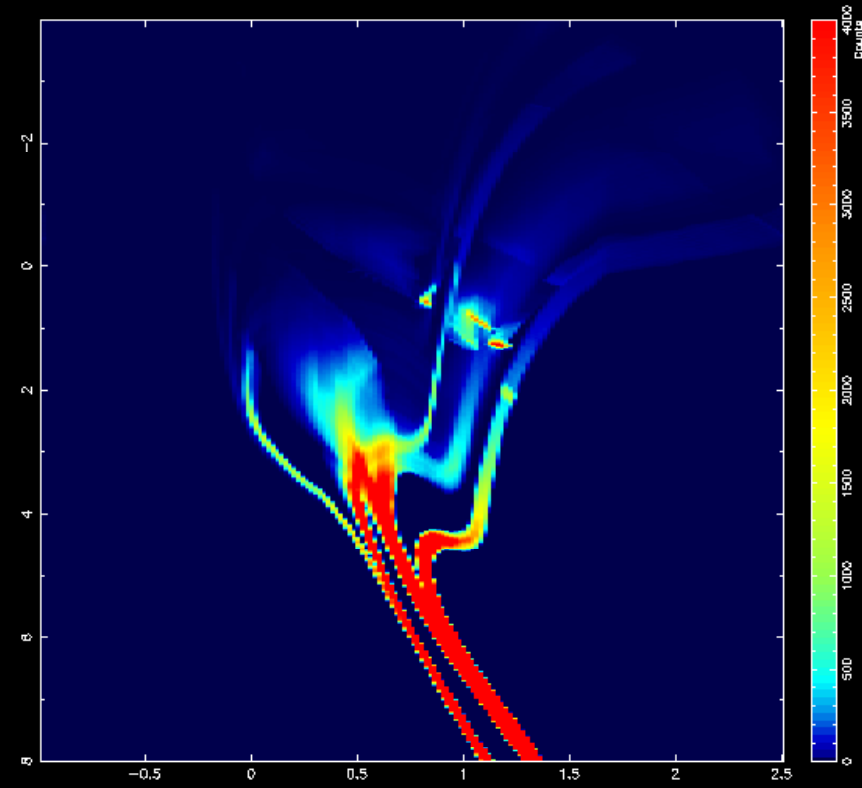
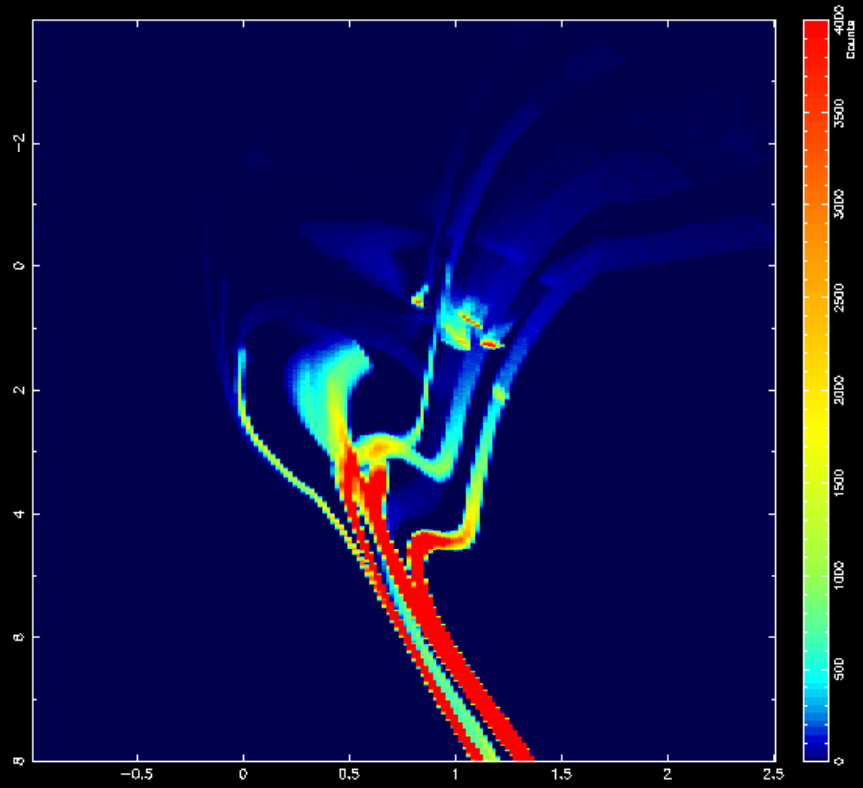
- Models have been created (Dr. Holtzman et al.)
- Models are isochrones
 - set of stars of the same age but different masses & metal content
- Each incorporates a *spread* of both abundances and ages
 - Isochrones separate only in some areas of CMD



Finding the Best Fit

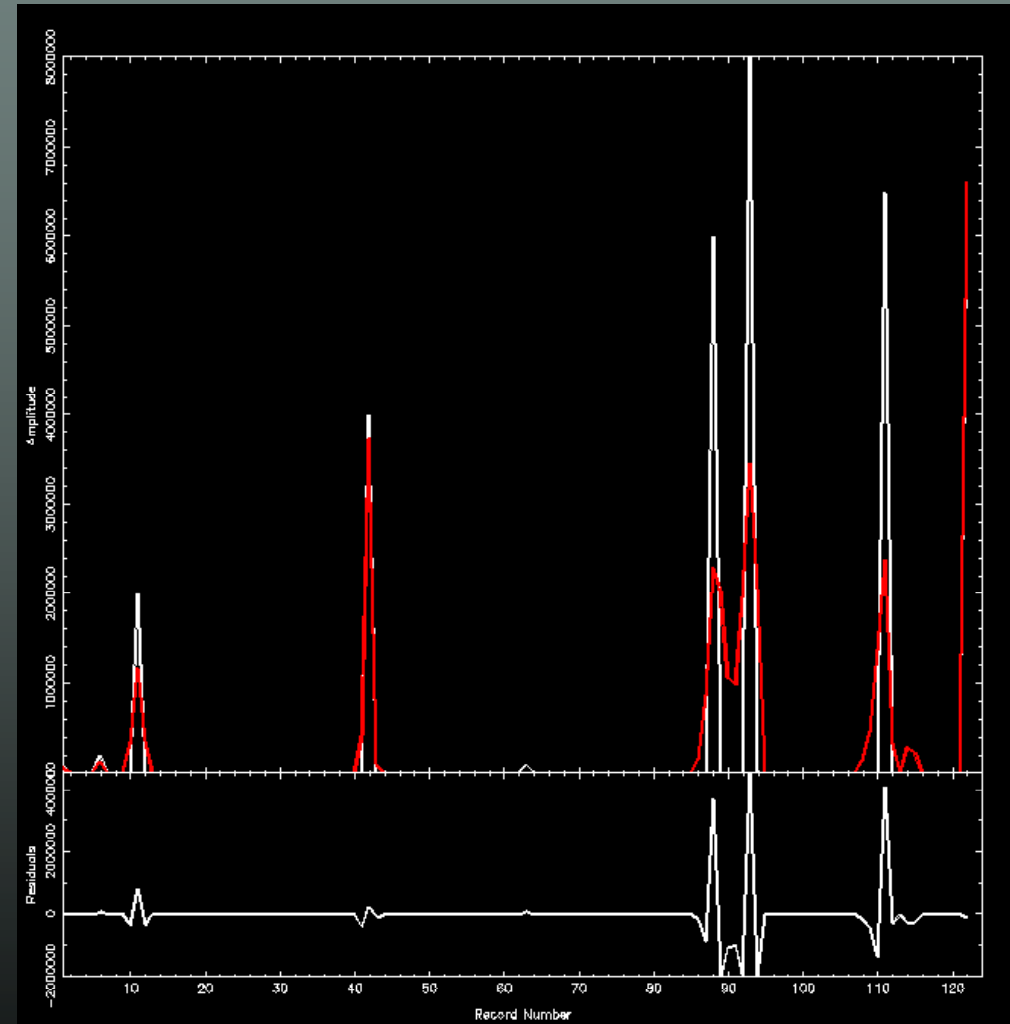
- Determination of the goodness of the fit is taken from literature, a maximum-likelihood approach
 - Poisson Likelihood Ratio (PLR)
$$\ln(\text{PLR}) = \sum m_i - n_i + (n_i \ln(n_i/m_i));$$
 - m_i : value of model in bin i
 - n_i : value of data in bin i
 - Closer to 0 \rightarrow better fit
- 1D Approach – Extremely fast and flexible!
- Important to use this instead of X^2 else won't minimize proper errors (Gaussian vs. Poisson data)

Mock Data

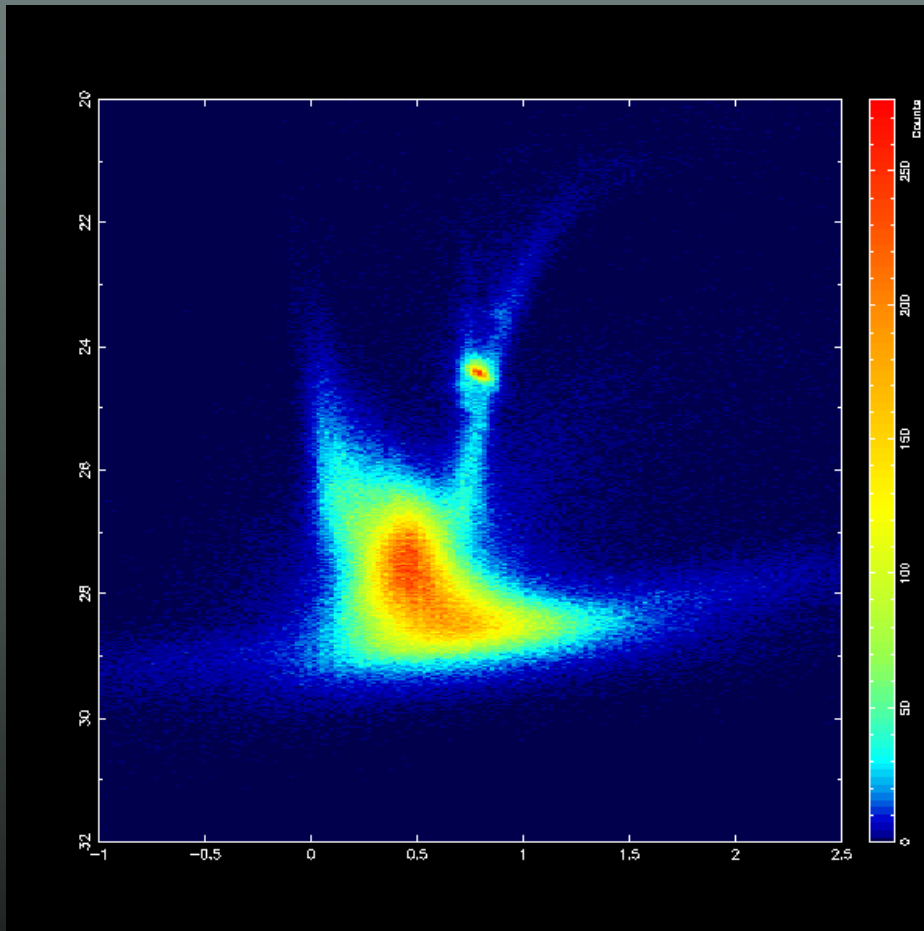


Mock Data

- Random selection of isochrones each assigned some amplitude and added together
 - Poisson distributed noise added to the combination to simulate sample noise
 - NO observational effects currently taken into account
 - NO initial guesses
 - Test shown with fake CMD made of 9 isochrones fit against full list of 123 isochrones



Tests and Results

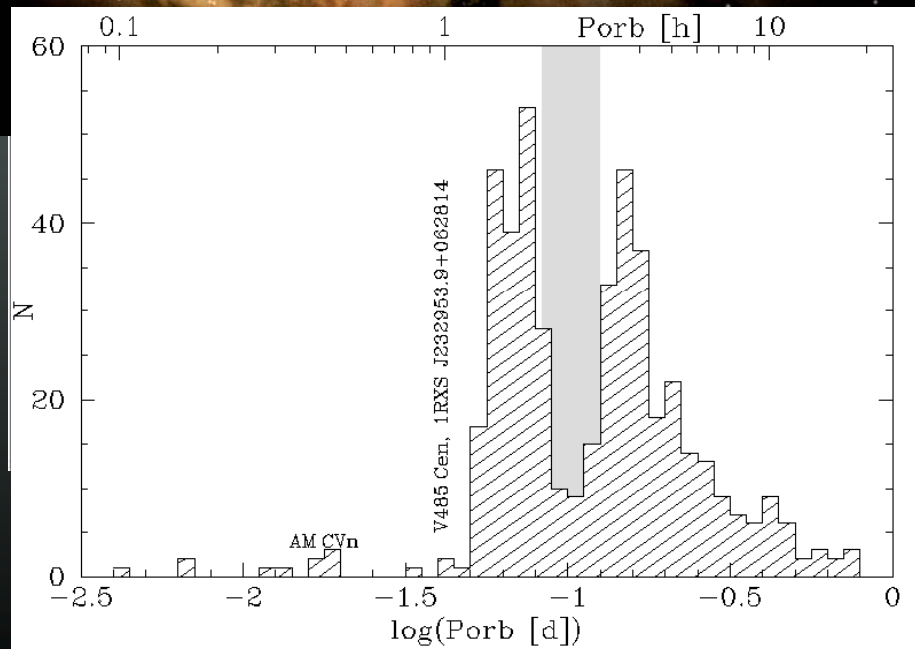
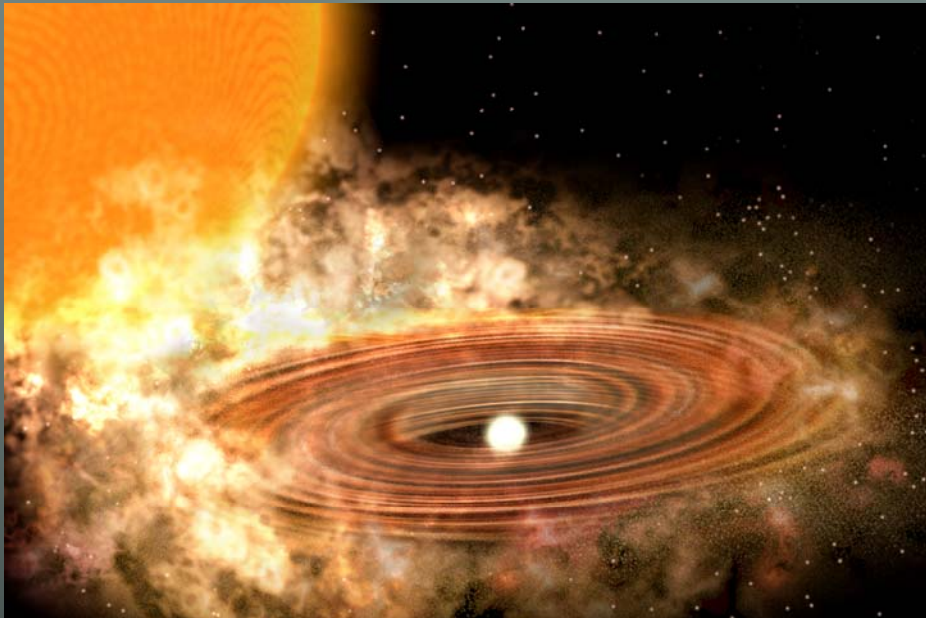


- Code written and undergoing more testing
 - Flexible enough to add more constraints
 - Error analysis pending
 - Computationally expensive, more so than the fitting
- Code passed on to Dr. Holtzman for further work and completion
 - Applying to other galaxy as further test

Cataclysmic Variables: So What?

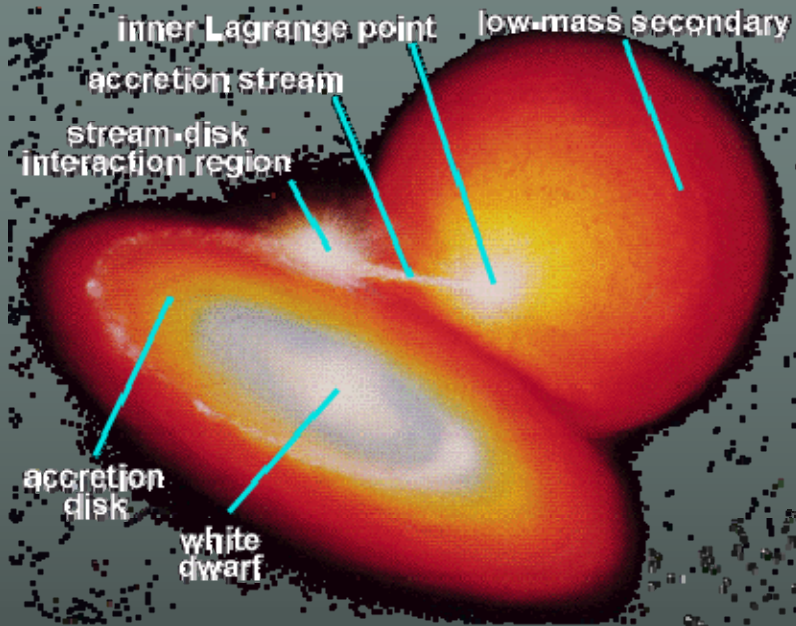
- Important to understand because they are one of the more visible phenomena out there
 - Usually first detected by strong optical or x-ray variations
 - Involve white dwarfs, the end state of stars like our Sun
 - Have implications for other areas: young stars, black holes, etc.
- Began working with Dr. Tom Harrison here at NMSU at the beginning of the Fall 2008 semester to investigate the evolutionary picture of these systems
 - The standard model of how they evolve hasn't changed substantially in nearly 20 years?!
 - New observations casting serious doubts on some aspects...

Switch: Cataclysmic Variables

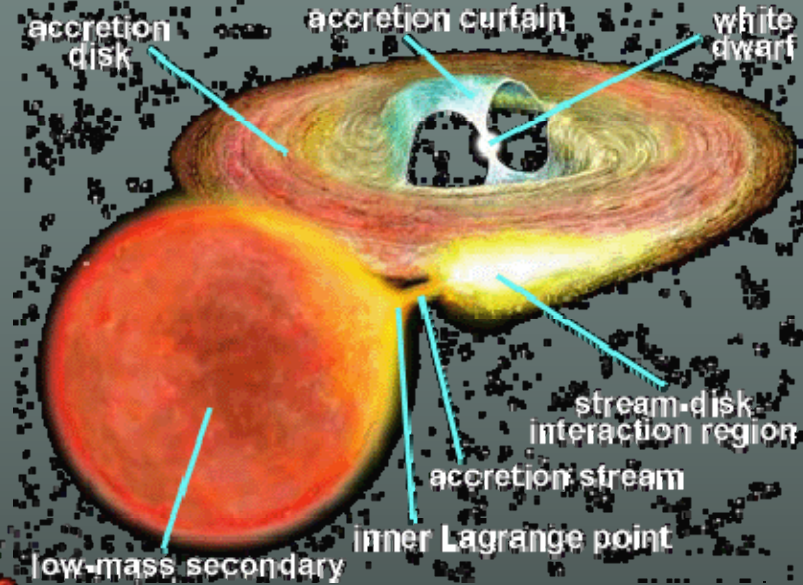


- Cataclysmic Variables (CVs) are a diverse class of short-period semi-detached binaries
 - White dwarf primary star and a low-mass main-sequence secondary star
 - Mass transfer between the two fills an accretion disk
- Orbital periods can be 14 to ~ 1.5 hours
 - Period gap *poorly* understood!

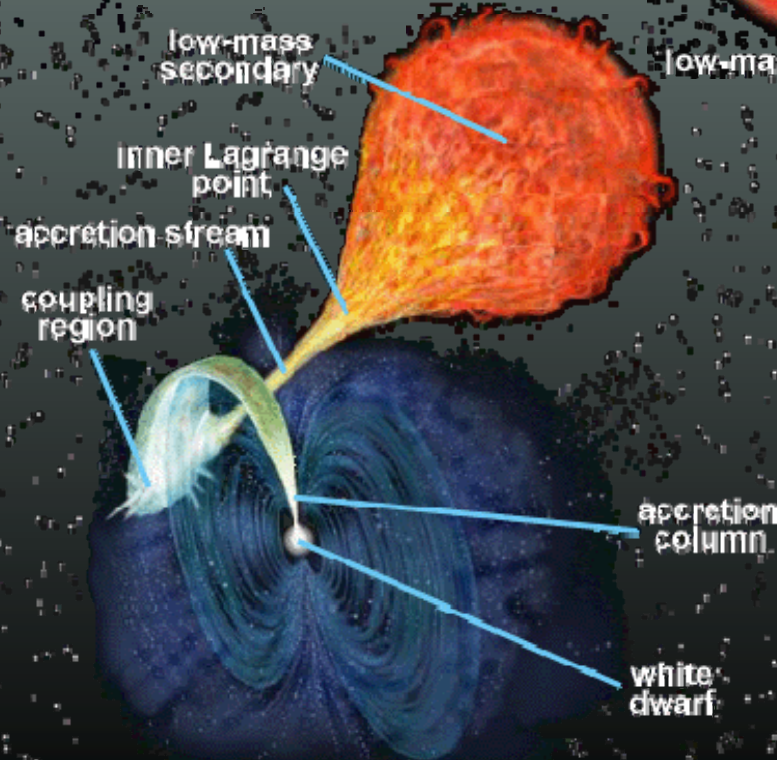
The CV Zoo



Dwarf Novae



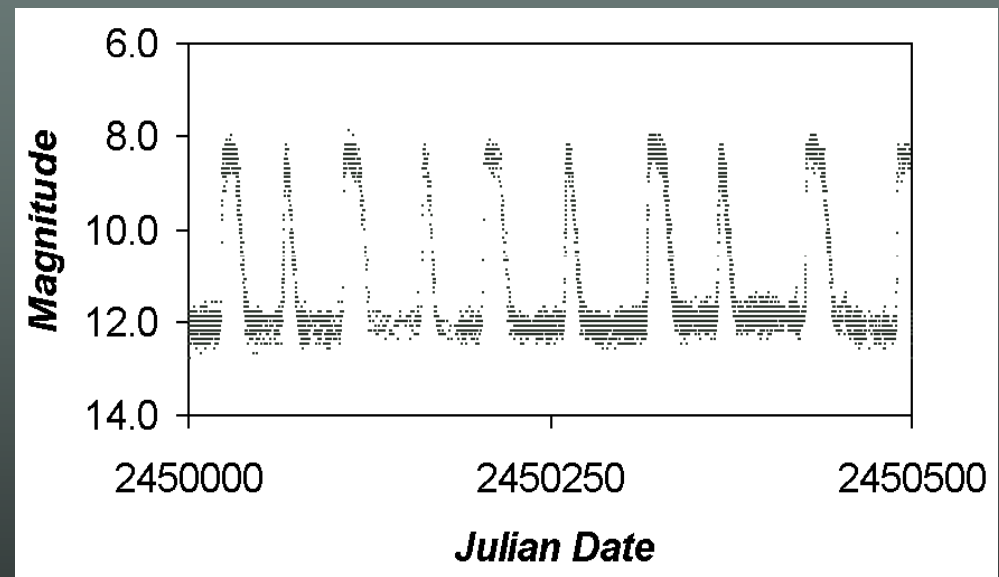
Intermediate Polars



Polars

CVs go Bump in the Night

- Accretion in disk causes buildup of energy, eventual release in large explosion
- Cyclical events
- A non-magnetic CV outburst can be equivalent to 1 million trillion megatons of TNT!
 - Hiroshima: 13 kilotons
 - Largest: 50 megatons

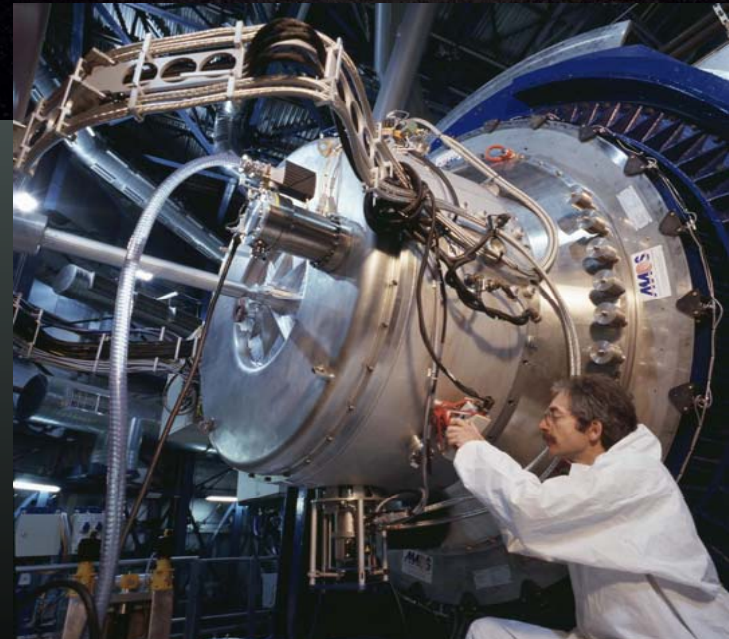
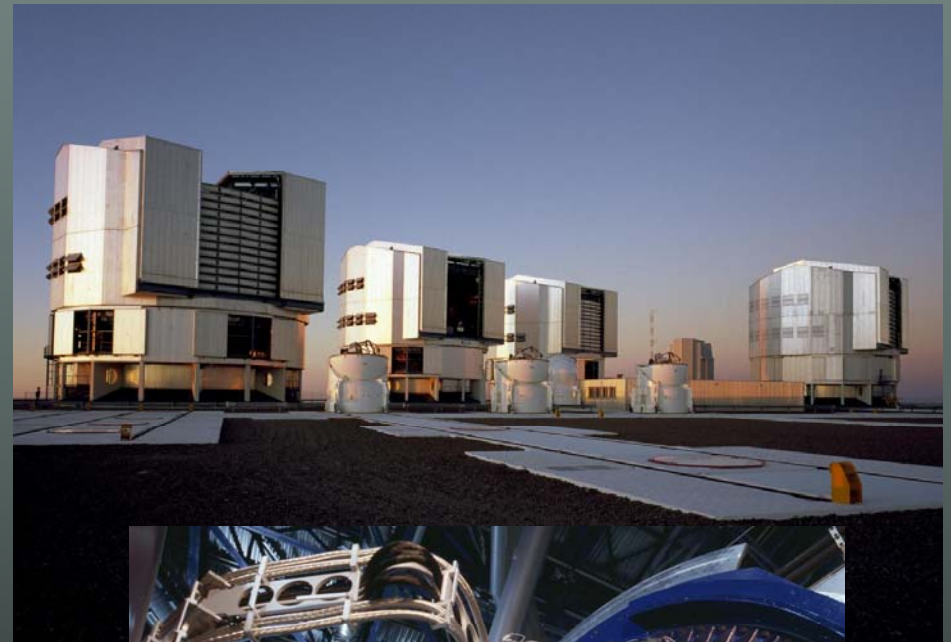


How'd they get that way?

- Start as a binary system with a larger mass primary star and a low mass secondary star in a large orbit around each other
 - More mass = faster evolution
- As the massive star evolves, its atmosphere swells and the the stars' orbit shrinks due to the loss of orbital angular momentum
 - They become so close that mass transfer begins, and a CV is born.
- **It is predicted that the low mass star should escape this process unscathed and appear normal. But is this true?**

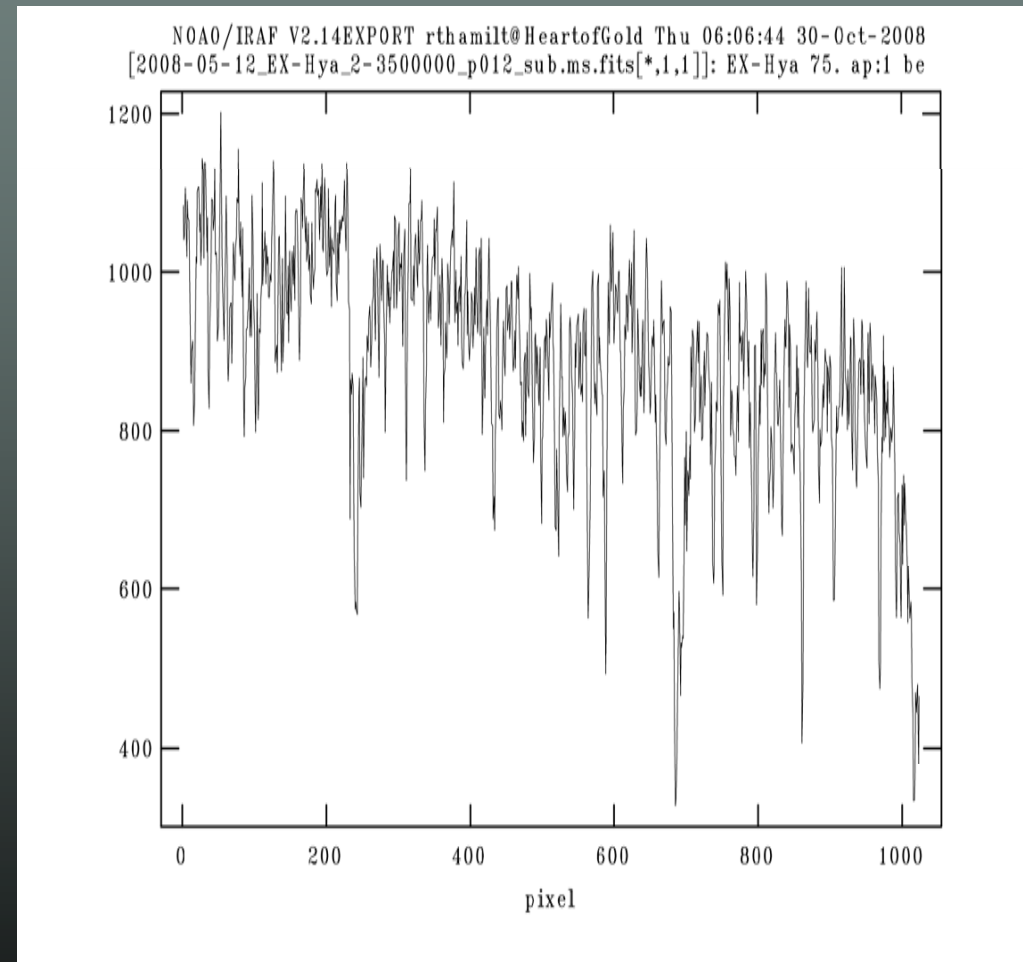
Are CV Secondaries Normal?

- Magnetic: Yes
- “Pre-CVs”: Yes
- Long Period (> 3 hrs): No
- Short Period (< 2 hrs): ??
 - Observe CVs with large telescopes ($> 8\text{m}$) in the IR where secondary is visible
 - VLT observations “complete”, looking to get more...



The Results...

- Currently working on the VLT ISAAC spectra
- Seeing the secondary is not guaranteed!
 - Faint to begin with, low signal to noise data
 - Proposals in for more telescope time to observe other short period CVs
- Results will be presented Jan. 2009 at AAS meeting in Long Beach, CA!



Acknowledgements

This work has been made possible by generous support from NASA and the New Mexico Space Grant for the Spring of 2007 through the Fall of 2008. I would like to especially thank my advisor(s) Dr. Jon Holtzman and Dr. Tom Harrison for their support.

