RATS: A SEARCH FOR FAINT VARIABLE OBJECTS

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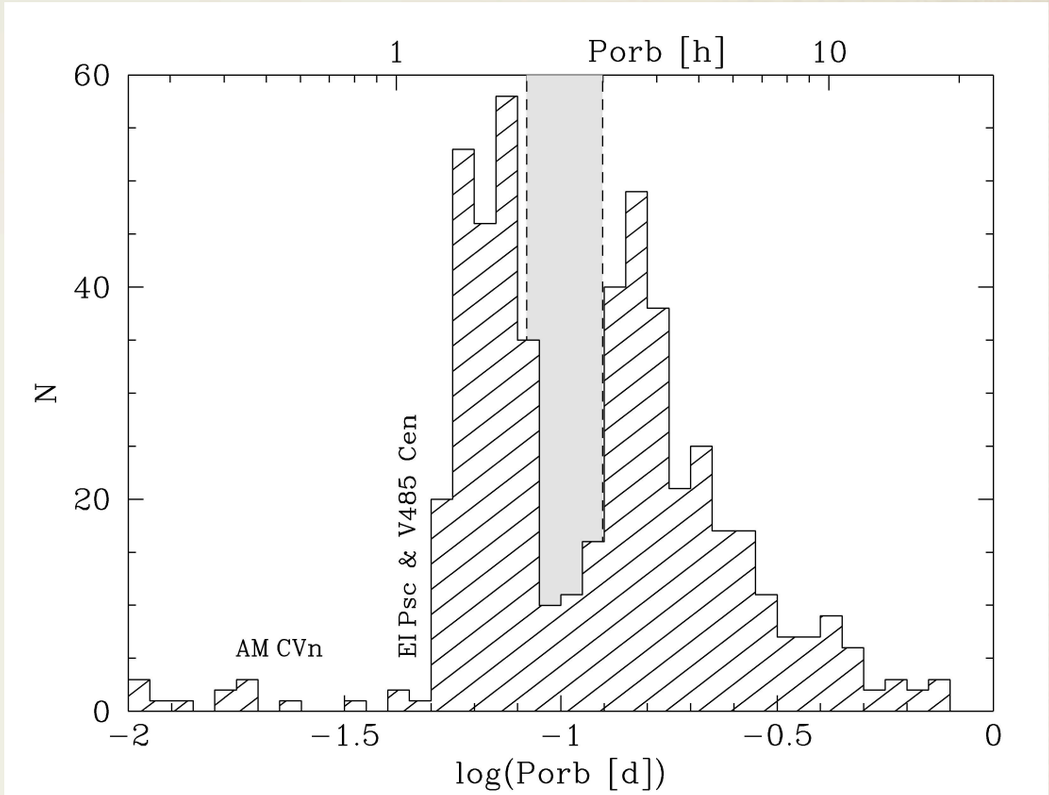
What are ultra-compact binaries (aka AM CVn stars)?

- Accreting binaries with white dwarf primaries and main sequence secondaries have binary orbital periods greater than 80 mins.

- For shorter period systems the secondary must have degenerate or semi-degenerate. eg white dwarf - white dwarf binaries.



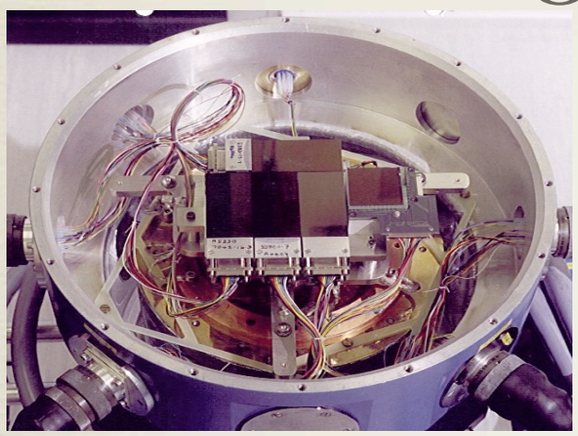
What is RATS?

- RApid Temporal Survey - RATS
- A survey of variability of the faint optical sky
- Our prime goal is to detect new UCB systems (AM CVn stars). Only the shorter period UCBs show optical variability, $P_{orb} < 30$ minutes.
- A complete census of optical variability on timescales of less than 2 hours.

Strategy

* Two strands

Optical Photometry



We take a series of short exposures (30 sec) of the same field for 2-3 hrs using small-medium class telescopes. Primarily the WFC on the INT. Observations in white light.

Follow-up

To determine the nature of newly discovered objects followup spectroscopy and photometry is required. UCBs show helium lines.

Why this strategy?

- Previous surveys weren't sensitive to periods < 10 mins
  - Faint Sky Variable Survey - 10's min & V<23 (Groot et al 2003)
  - SuperWasp - a few mins but V~7-15 (Pollacco et al 2006)
- Our data defines a new parameter space
  - Sensitive to variations on timescales as short as 2 minutes
  - Sensitive to sources as faint as V=22

Goals

- Test the predictions of the Nelemans et al models
- These models predict ~18 UCBs in 40 sq degs coverage with b < 10 degs.
- Only by increasing the known number of systems can we compare the observed global properties (eg. period, masses, chemical abundance distributions)

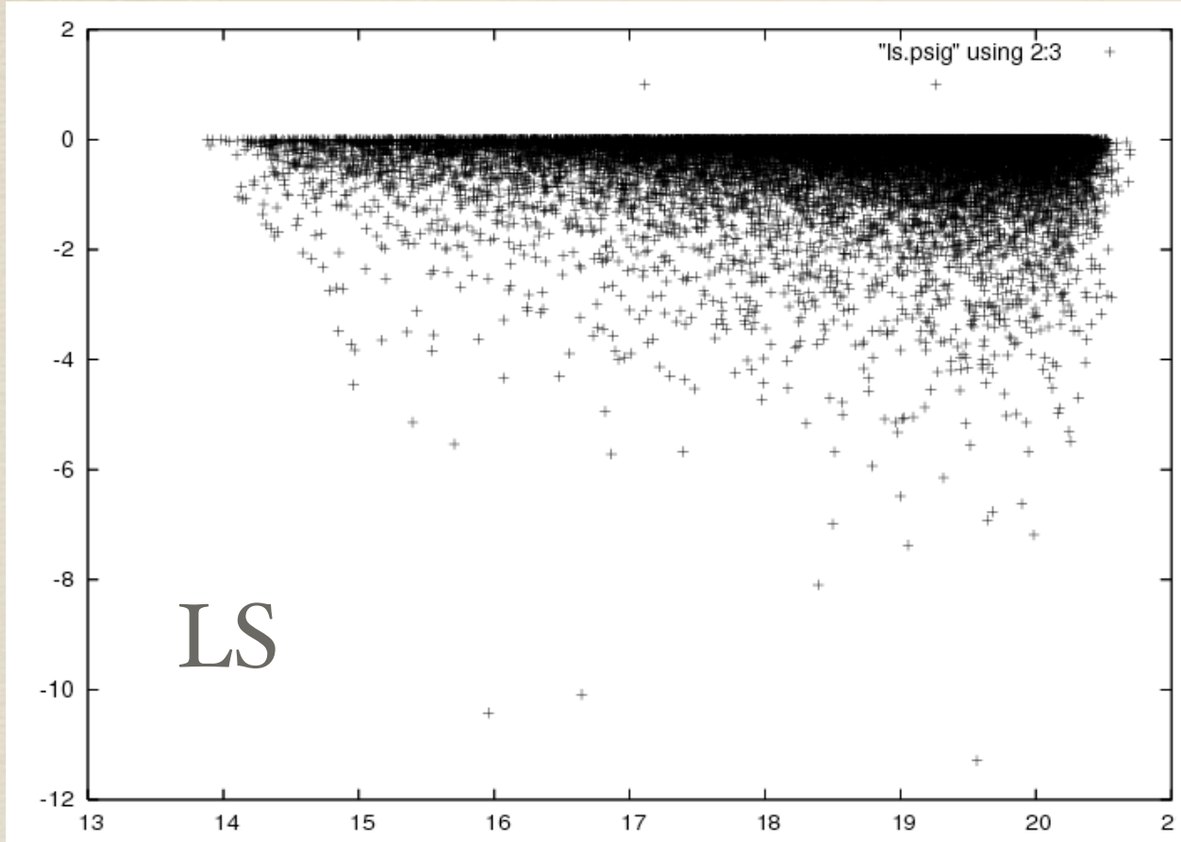
Photometry obtained so far

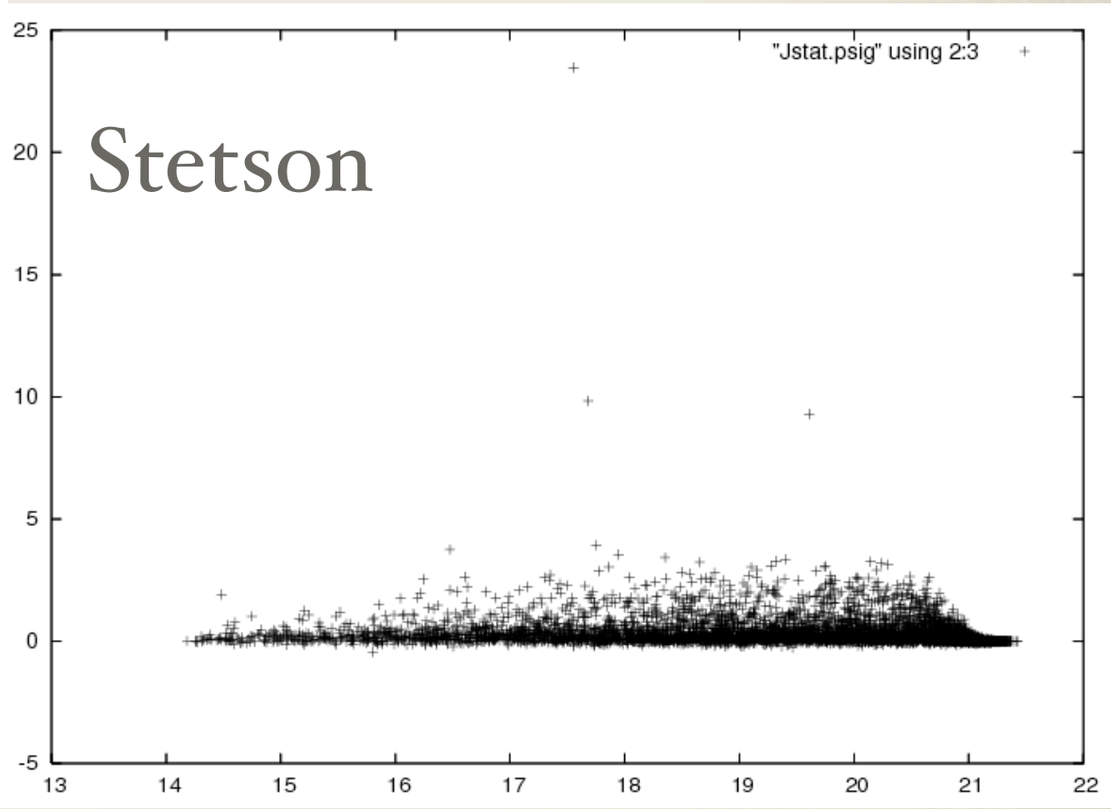
* 4 INT runs
  * INT1 3 sq degs (20<b<30)
  * INT2 5 sq degs (0<b<40)
  * INT3 7 sq degs (b<10)
  * INT4 7 sq degs (b<10)
* 1 ESO 2.2m 5 sq deg (20<b<40)
* Total sky coverage of ~20 sq. degs b < 10 degs

Data reduction

* Aperture Photometry for INT1/2 ESO, b>10 degs
* Difference image analysis.
  * We use the *Dandia* code (Bramich 2008) developed by Ian Todd.
  * Subtracted and reference images analysed - AC and DC signal.
  * Relatively fast and essential for crowded fields.

Variability Tests





- We use a number of different methods to test for variability.
- Stetson, false alarm probabilty

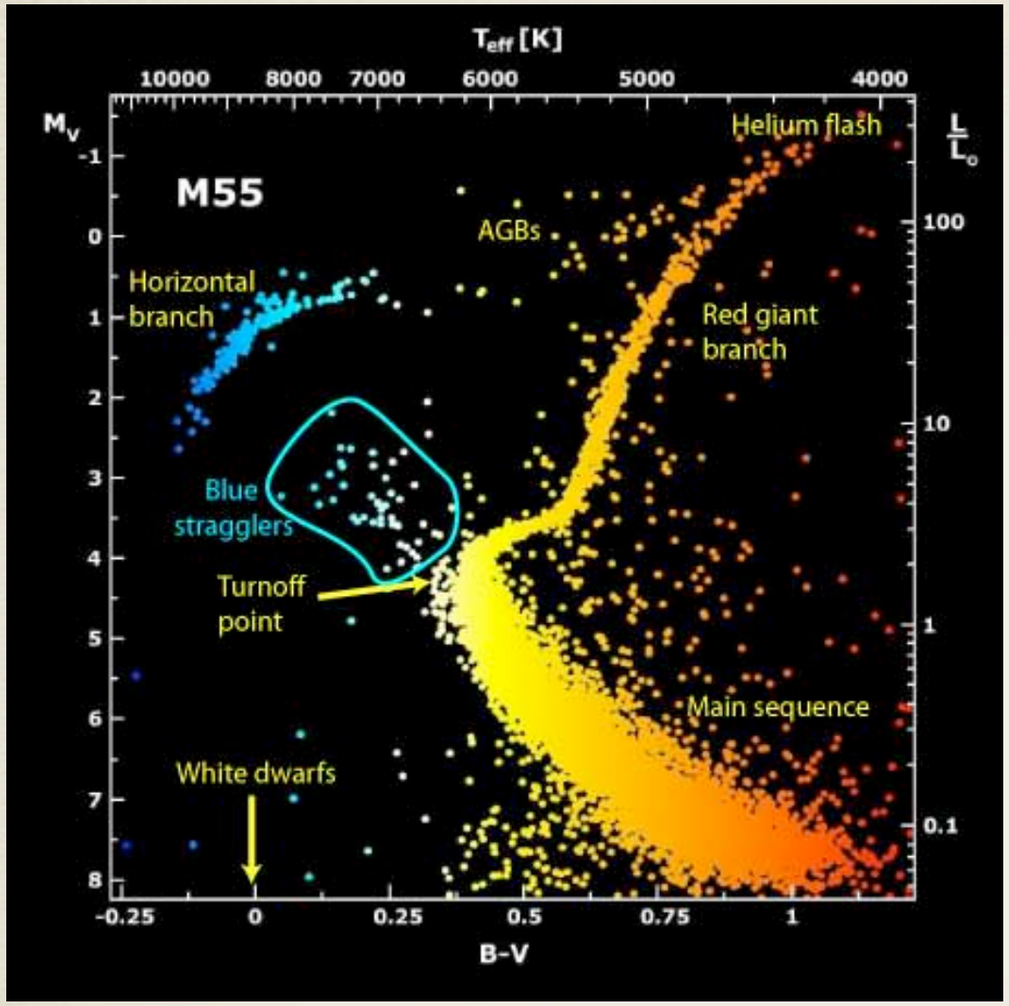
Status

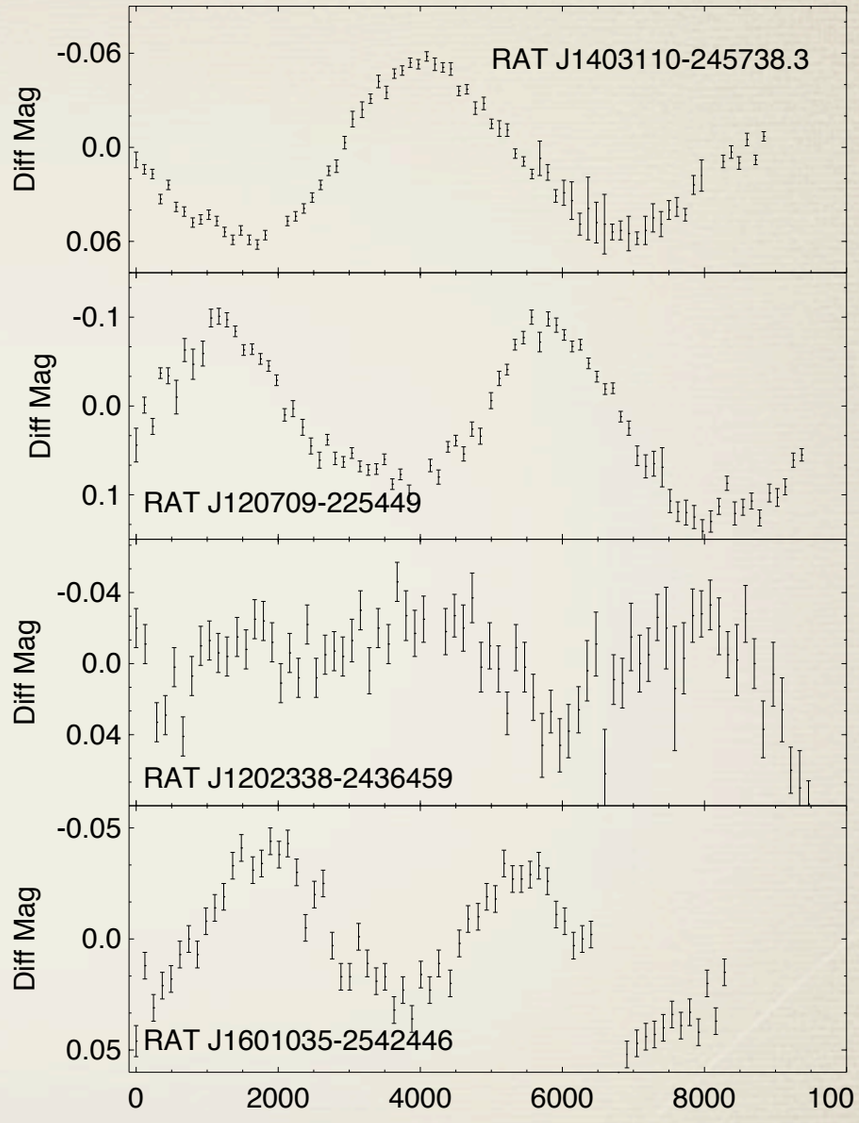
- In the data reduced so far we have ~1 million stars of which ~1000 have been flagged as having periods on timescales shorter than 1 hour.
- 10's thousand have periods longer than an hour. Several thousand other variables.
  - INT 1 - Ramsay & Hakala 2005
  - INT2 - Reduced, WHT spectra of short period systems
  - ESO - Reduced, ESO 3.6m spectra, paper submitted
  - INT4 - Reduced - WHT spectra of short period systems
  - INT3 - Reduction ongoing

Results so far -UCBs

* No UCB found so far.
    * From INT4 we expect 2.8 UCBs.
        * From ESO + INT1 we expect 0.065 UCBs.
* So far our results are consistent with Nelemans et al.
* Definitive results only once our survey is complete.

SX Phe stars



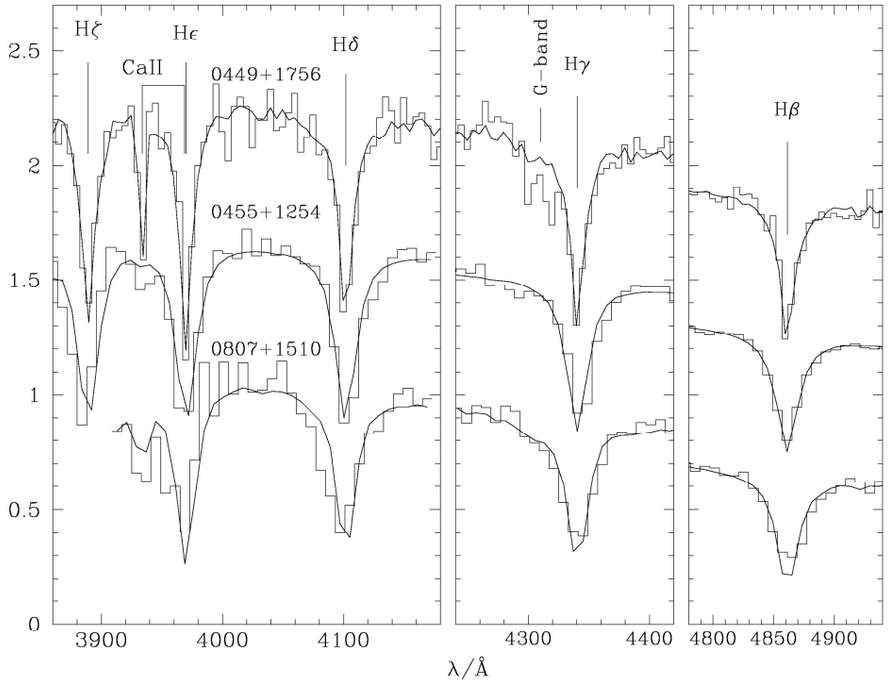


- Dwarf delta Scuti stars, blue stragglers.
- Formation mechanism not clear.
- 13 field known in 2001. We are going to find hundreds of these.

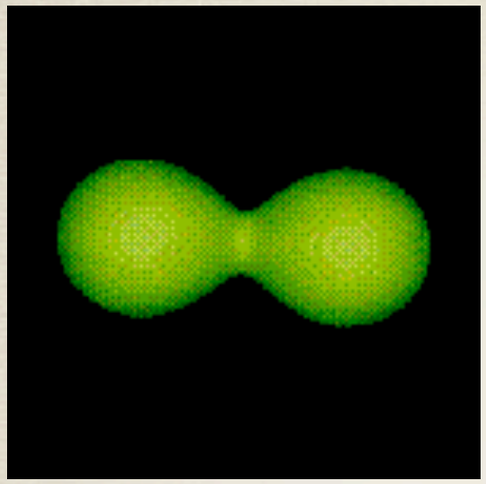
SX Phe stars

- Our simulations predict 40000 - 65000 visible in our galaxy brighter than V=22.

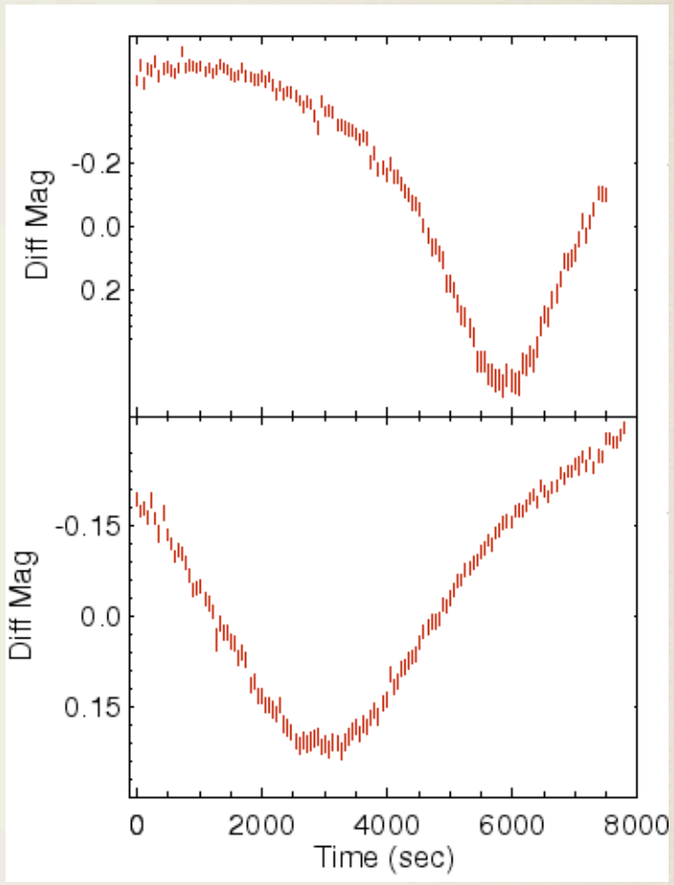
- This number is less per mass compared with globular clusters and Fornax dwarf galaxy.



Contact Binaries

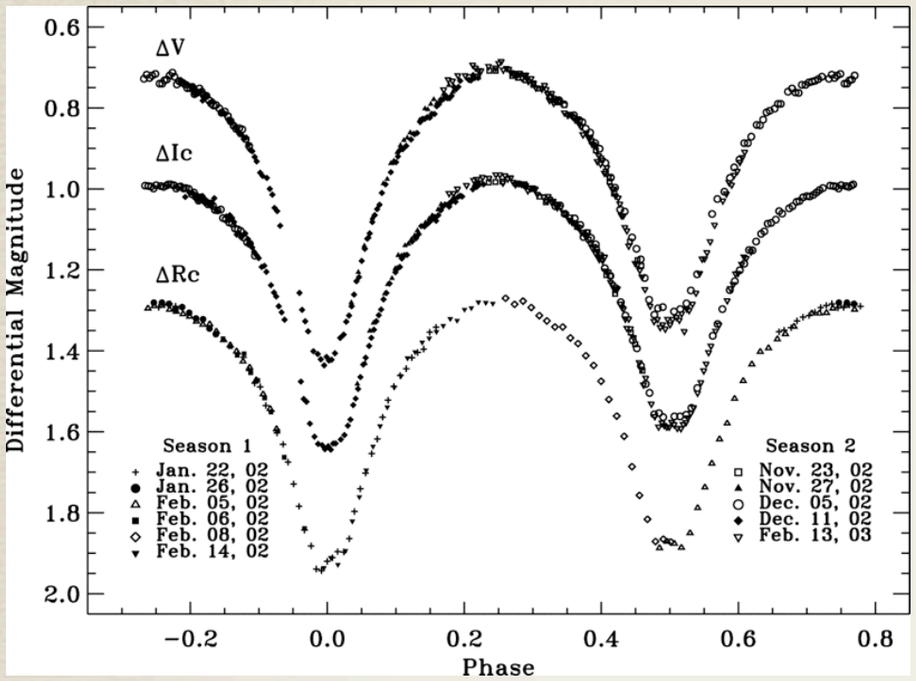


- Very common systems. About 1 in 500 F-K main sequence stars are in contact binaries!



- We have already discovered several thousand candidate contact binaries. We predict around 5000 once our survey is complete.

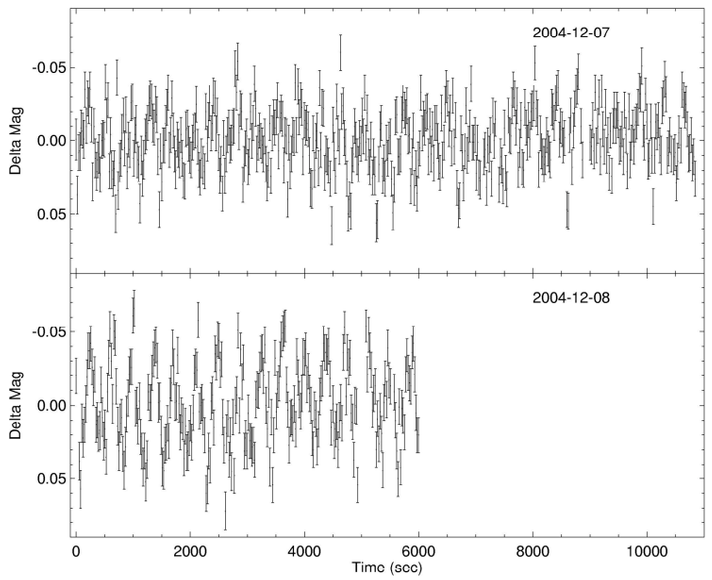
Modeling CB Lightcurves

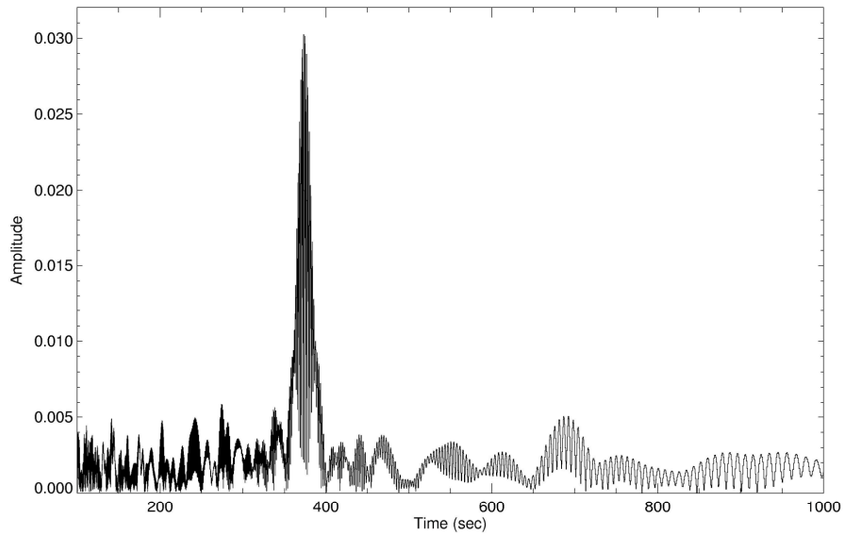


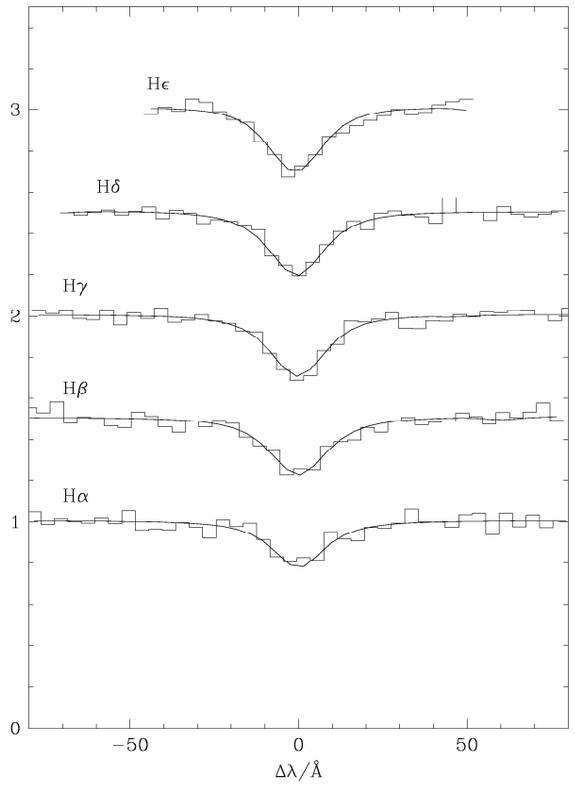
- Simulations of light curves show we can determine system parameters (eg, period, inclination, mass ratio) which are surprisingly robust even using incomplete orbital phase light curves.

- Systems which show poor fits are probably eclipsing or partially eclipsing binaries. Aim to get parameter distributions of contact binary as a function of Galactic position.

sdB stars - eg 2nd highest amplitude

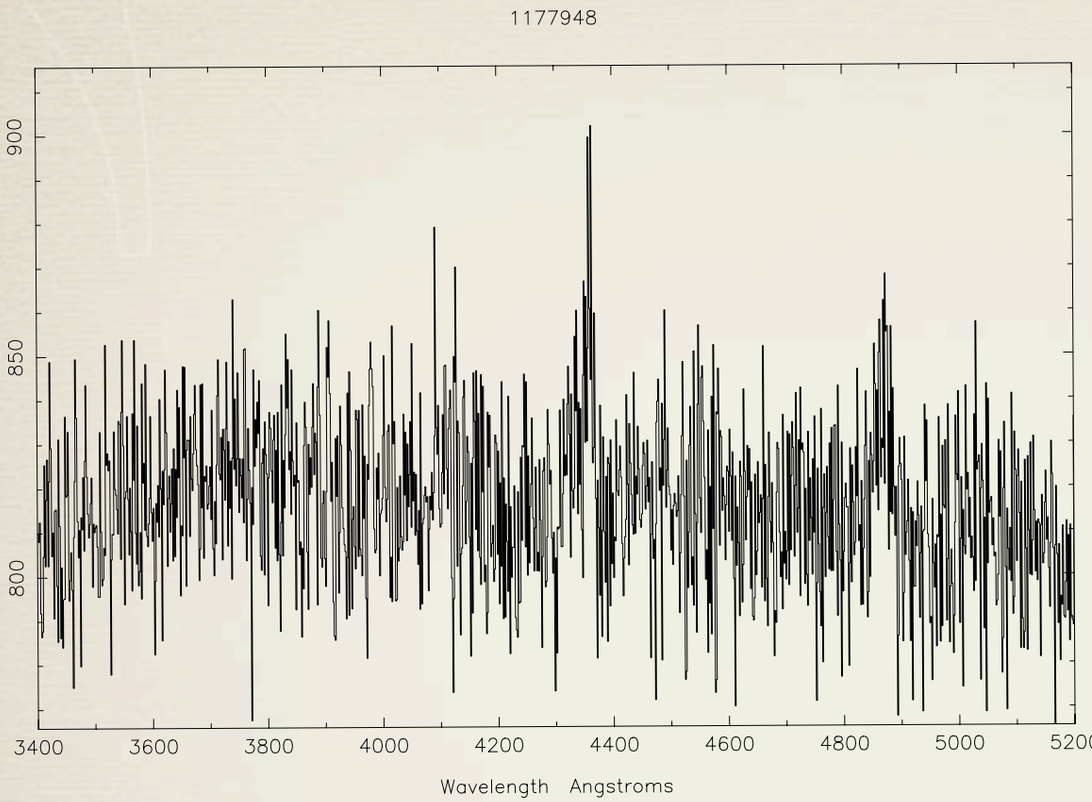


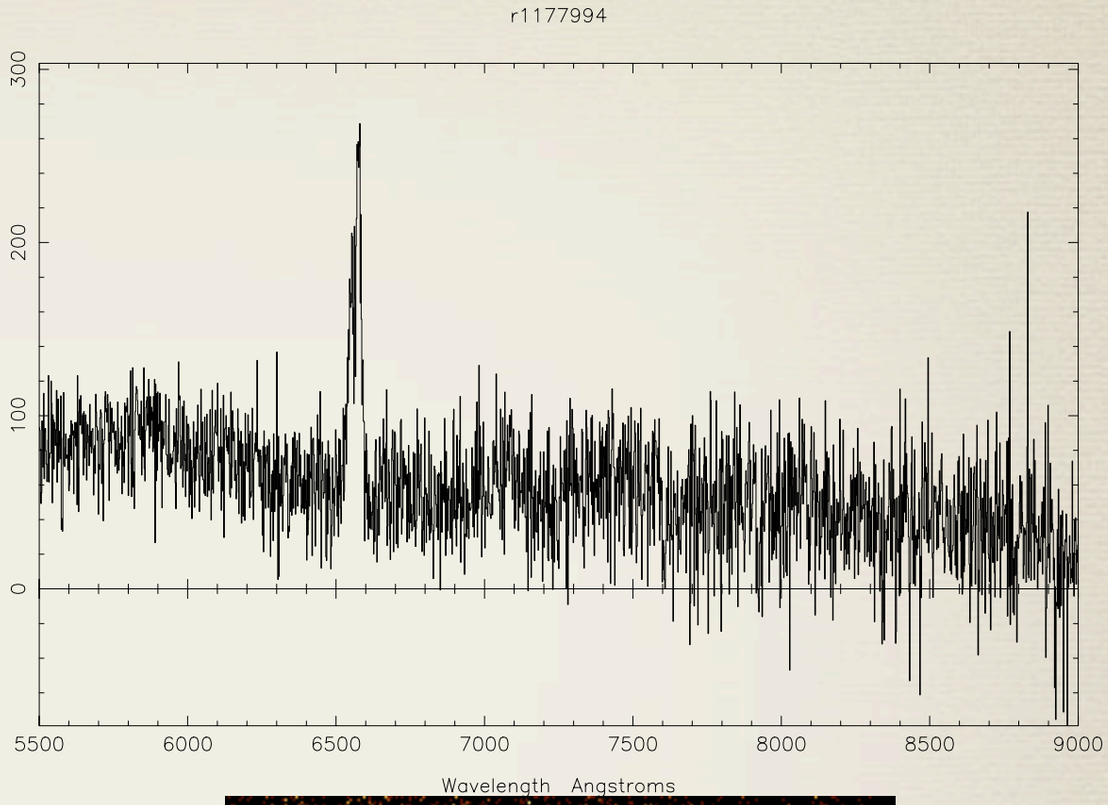




- Spectral fits: T=29200, log g=5.2
- This places it at the cool end of the sdB instability strip - consistent with its high amplitude modulation.

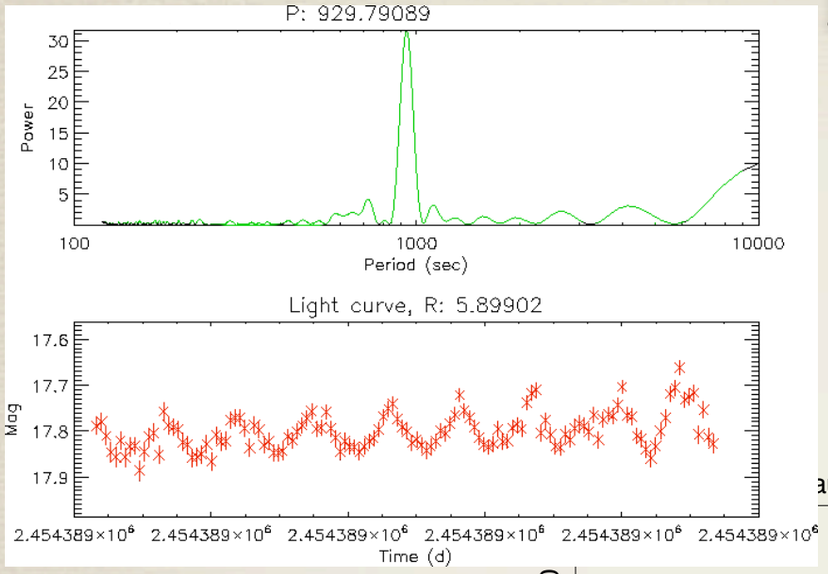
IP candidate - WHT spectra August 2008

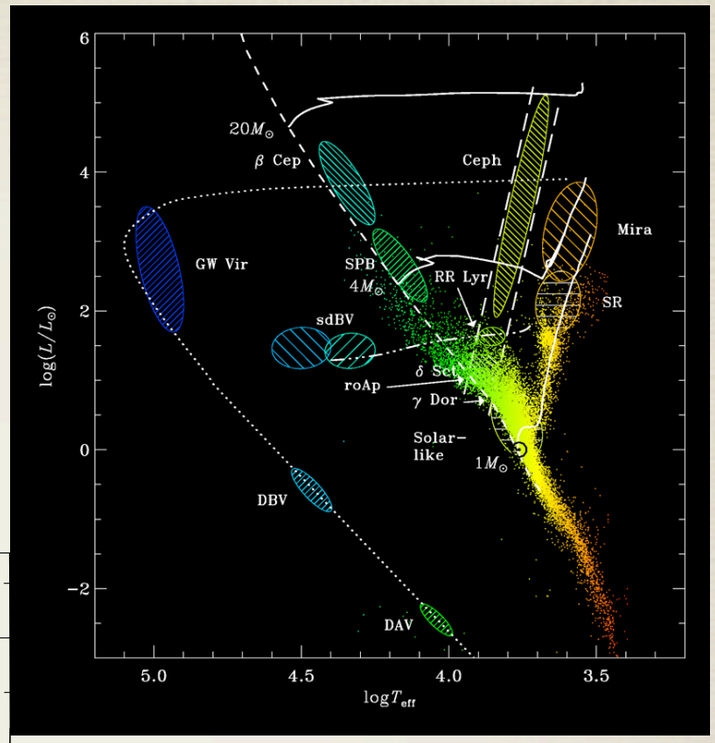


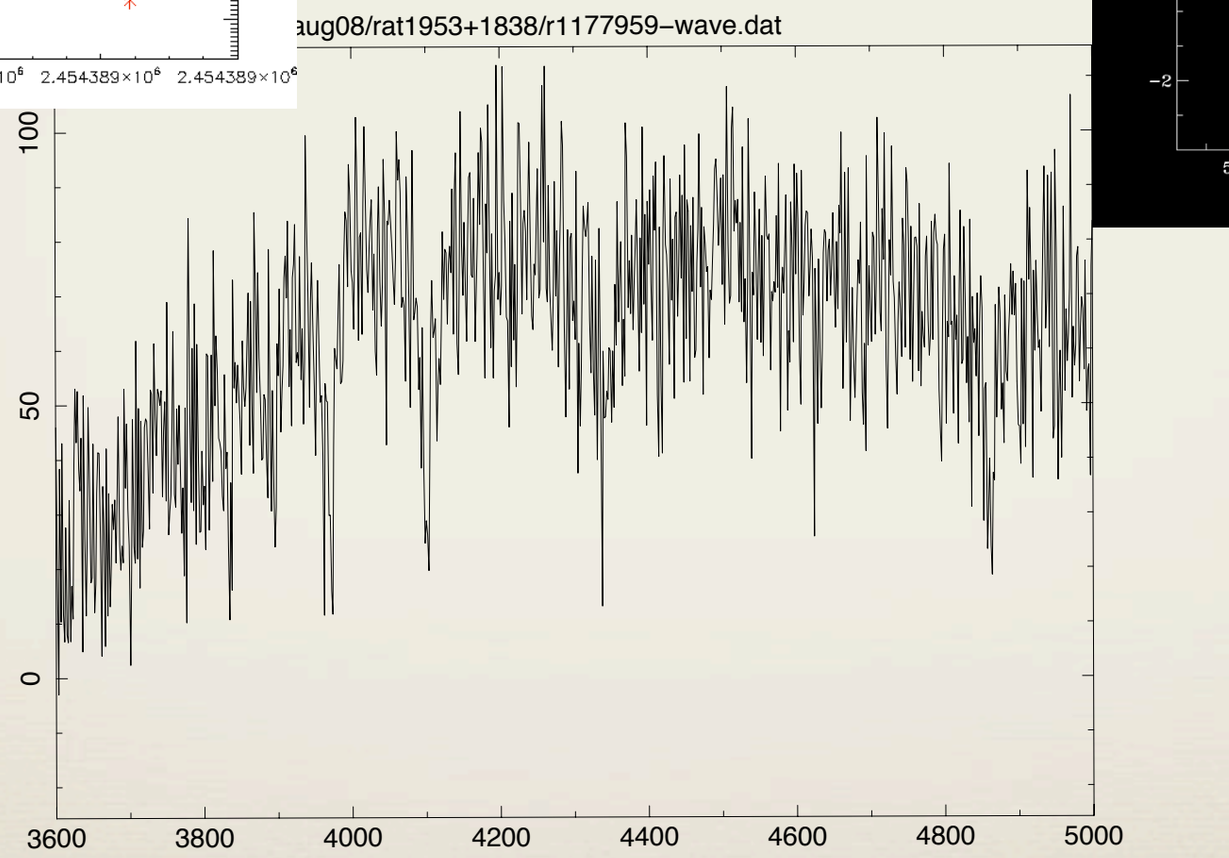


* Our first accreting source discovered!
* Hydrogen emission lines
* ROSAT xray source

Stellar pulsators - WHT spectra from Aug 2008







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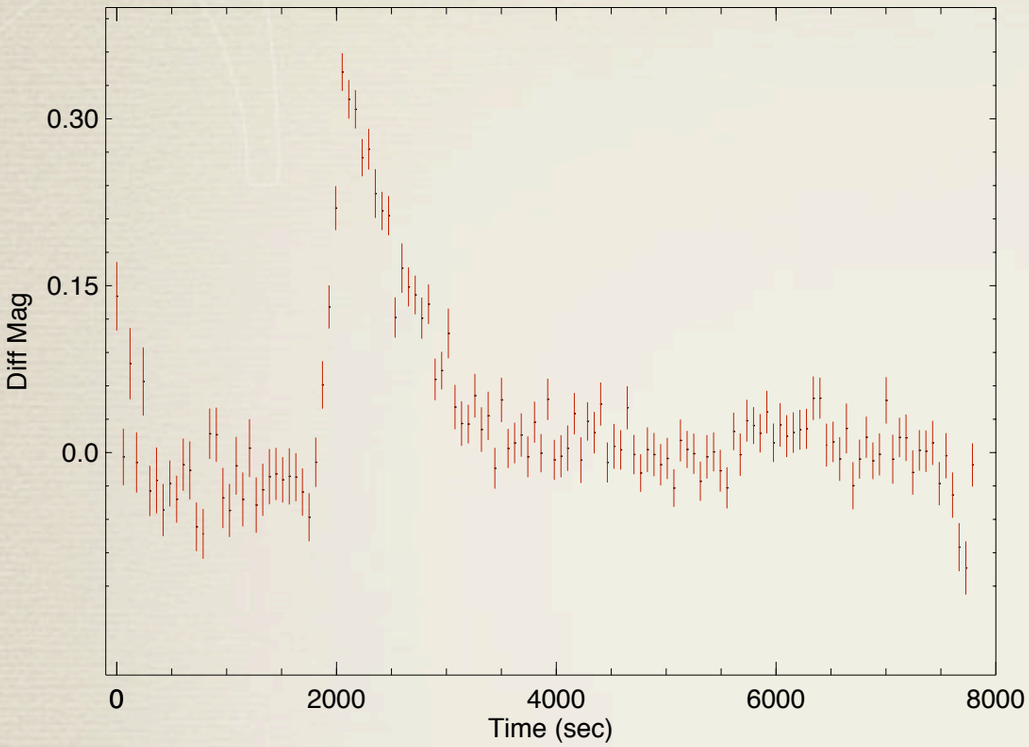
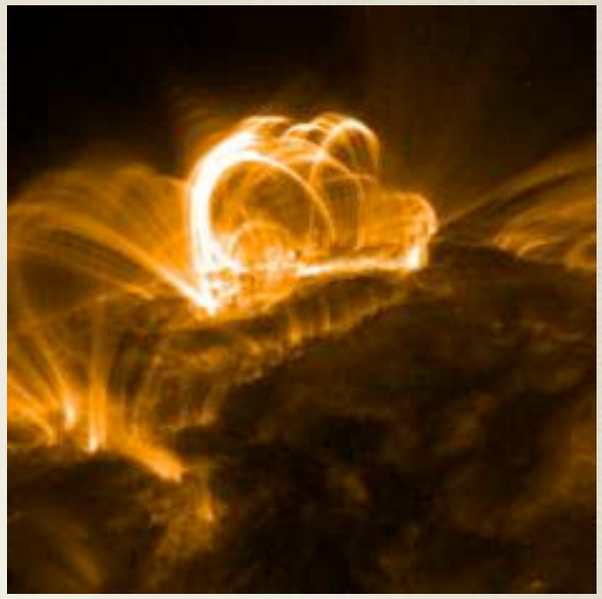
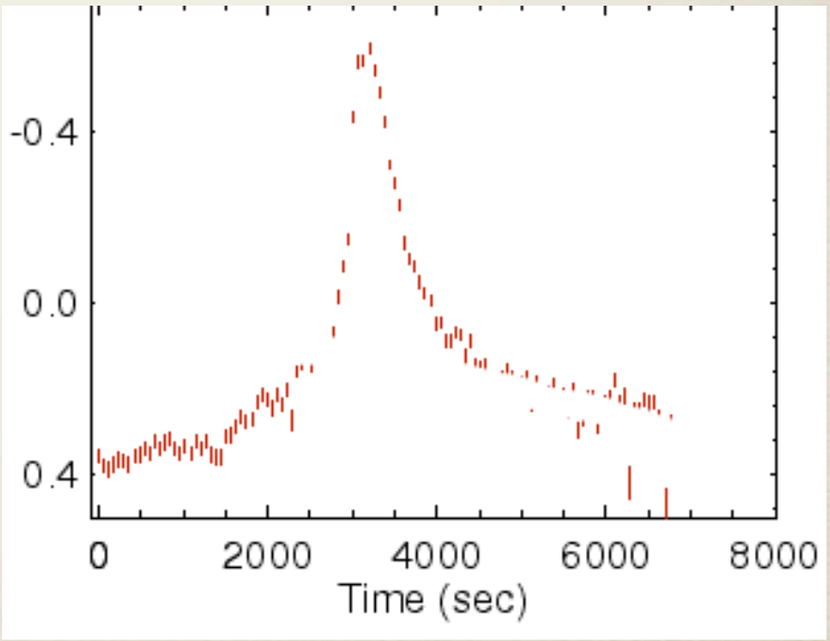
* ZZ Ceti, pulsating white dwarf

Flare Stars





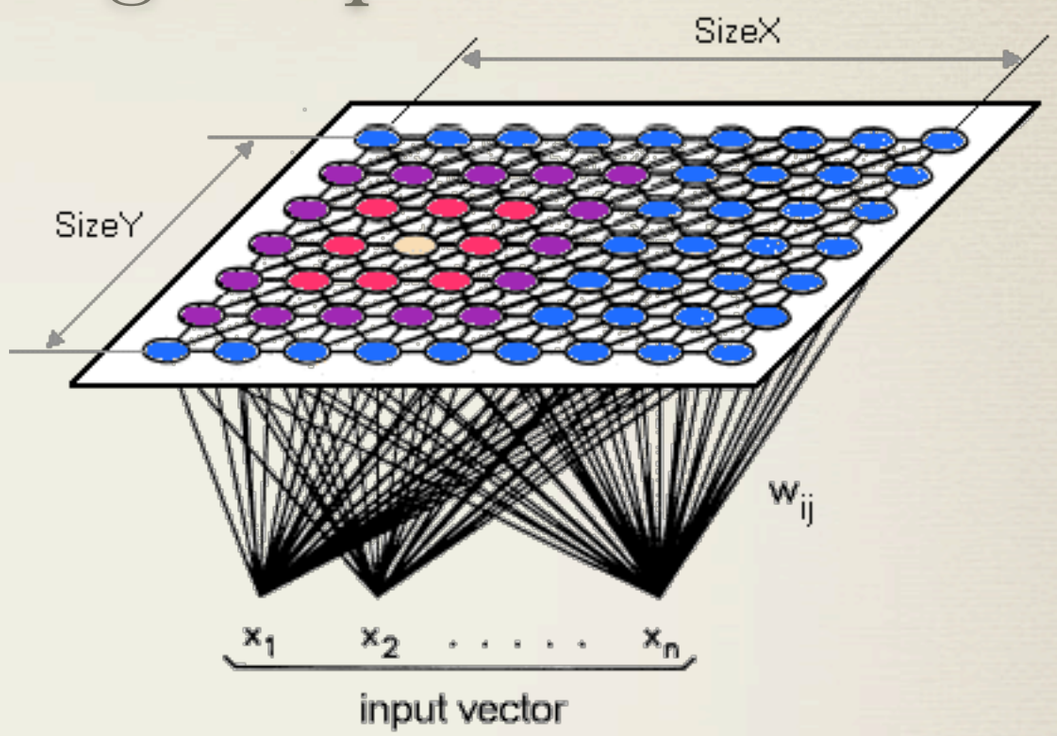


- Similar to flares on the Sun
- Large range in flare brightness
- Our survey is ideally place to pick these up

Automatic classification

Self Organizing Maps

- We have an enormous data set.
- Automated way of classifying them.
- Plot multi-dimensional data onto a 2D map.
- SuperWasp are doing something similar.



Future Observations

* 10 nights in November 2008 on the INT.
* 10 nights in the 09A semester bring us close to our desired sky coverage.
* 2 night follow-up spectroscopy at the end of September on the NOT.
* 1 night on the WHT in September.

Further Work

* We expect to complete INT 3 reduction by Oct 2008.
* Testing for false positives and completeness.
* Comprehensive space density of UCBs, SX Phe stars, contact binaries etc.
* Determine the implications for the Omega White survey.

Catalogue

* In the end expect to have variability information on over 5 million stars close to the galactic plane.

* This will be release to the public

Thanks