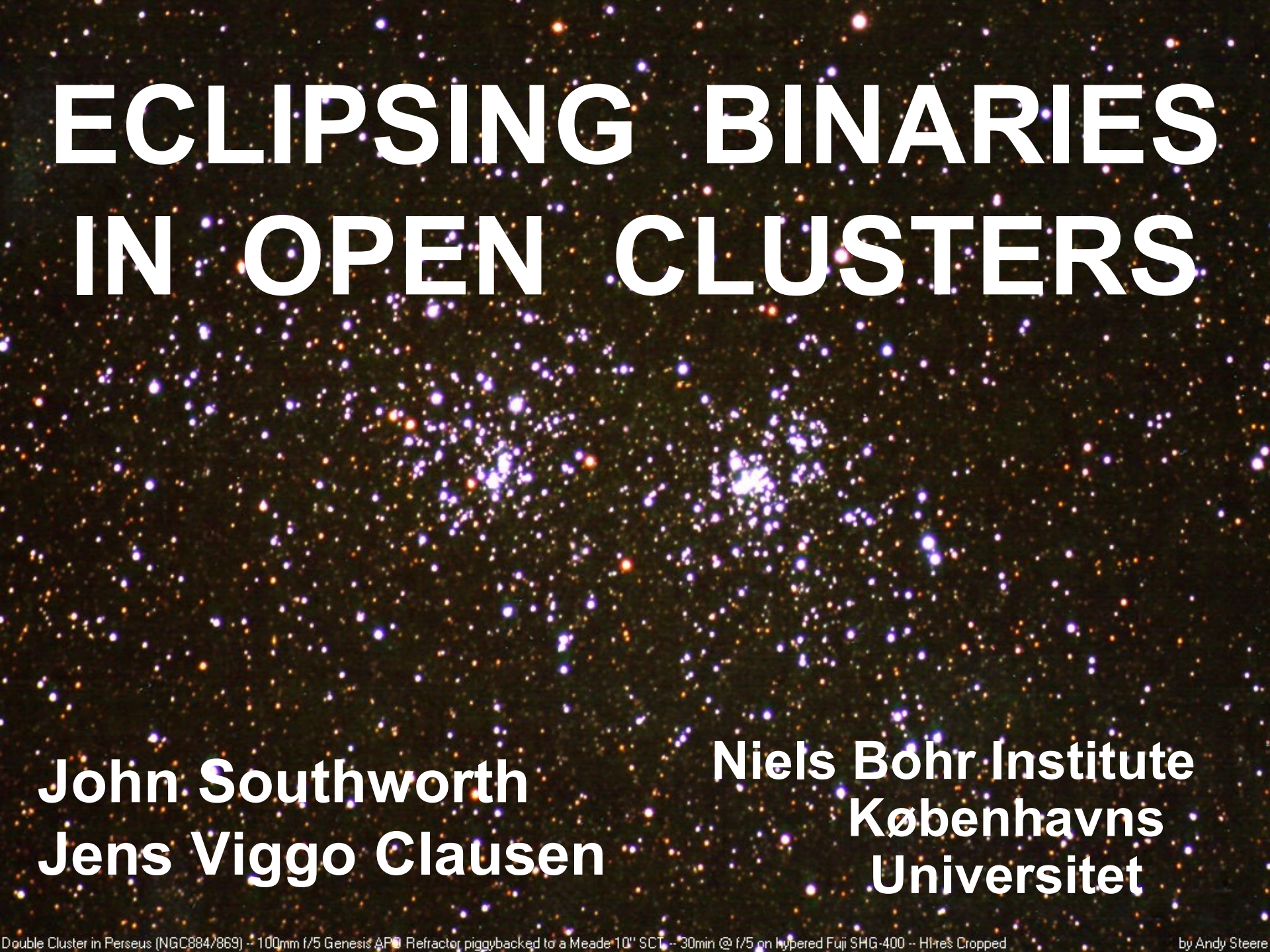
ECLIPSING BINARIES IN OPEN CLUSTERS



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Double Cluster in Perseus (NGC884/869) - 100mm f/5 Genesis APO Refractor piggybacked to a Meade 10" SCT -- 30min @ f/5 on hypered Fuji SHG-400 -- Hires Cropped by Andy Steere

Eclipsing binaries in open clusters

- Get absolute dimensions of the two EB stars
  - Spectroscopic radial velocities give accurate masses
  - Light curve analysis gives accurate radii
  - $T_{\rm eff}$ and luminosity from spectral analysis or calibrations
- Get metallicity and age from cluster membership
  - Theoretical stellar models must simultaneously match cluster and EB

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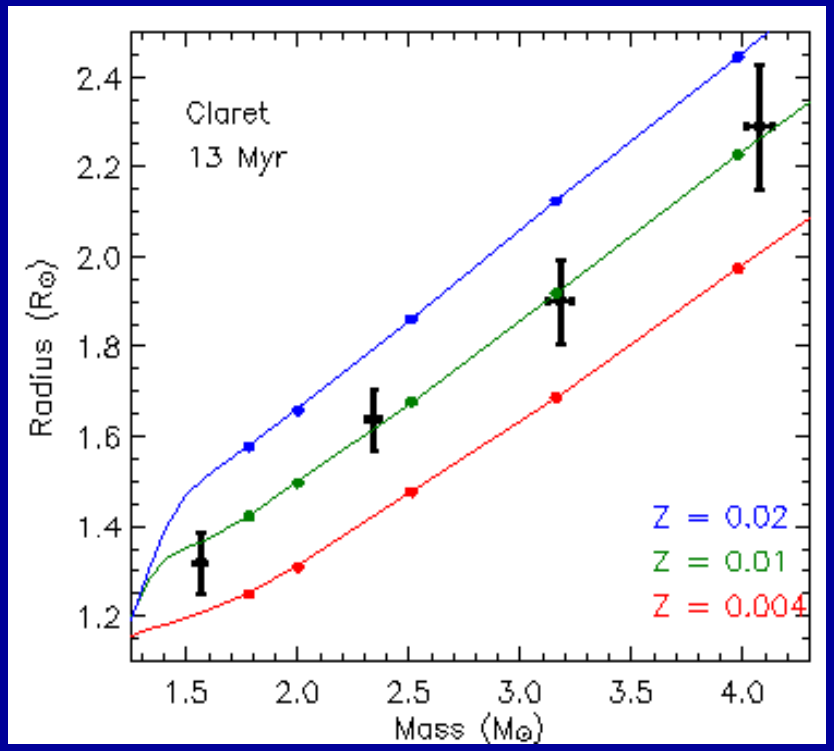
  - Theoretical stellar models must simultaneously match cluster and EB
- Example: NGC 869
  - V615 Per (B7V + B9V)
    V618 Per (A3V + A5V)
  - Metal abundance: $Z = 0.01$



Southworth et al, 2004, MNRAS, 349, 547

EBs in open clusters - distance

- Eclipsing binaries are excellent distance indicators
  - Can use bolometric corrections to get M_V from luminosity
  - Or you can use surface brightness calibrations to get distance to EB:

$$d = 10^{0.2 m_\lambda} \sqrt{\left[\frac{2R_{\rm A}}{\phi_{\rm A}^{(m_\lambda=0)}}\right]^2 + \left[\frac{2R_{\rm B}}{\phi_{\rm B}^{(m_\lambda=0)}}\right]^2}$$

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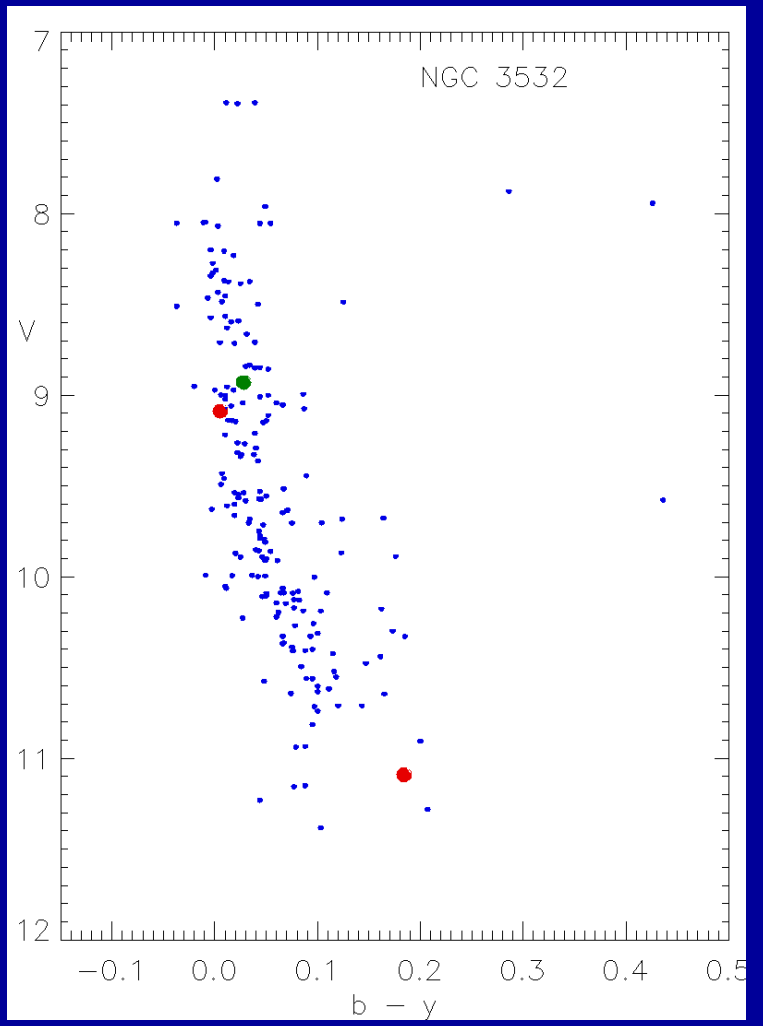
- Example: Pleiades HD 23642 (A0 + Am)
  - *K*-band surface brightness relations
  - Distance = 139 ± 4 pc

Southworth et al, 2005, A&A, 429, 645
(based on data from Munari et al 2004)

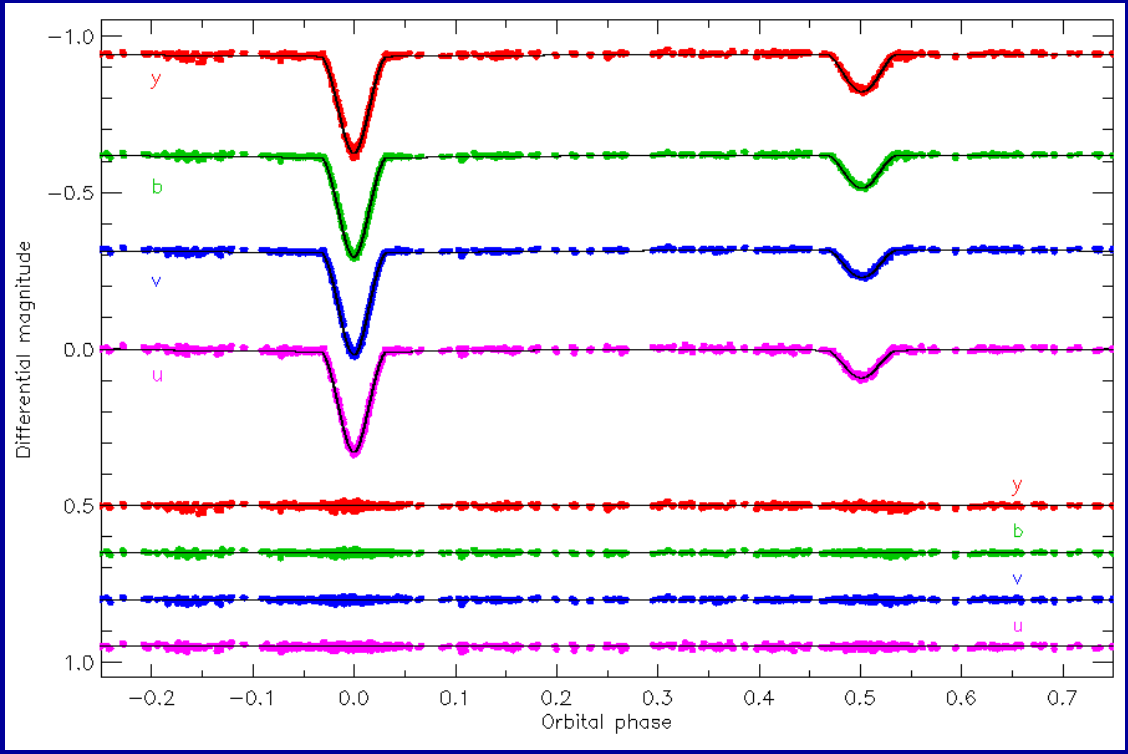
GV Car in NGC 3532

www.seds.org



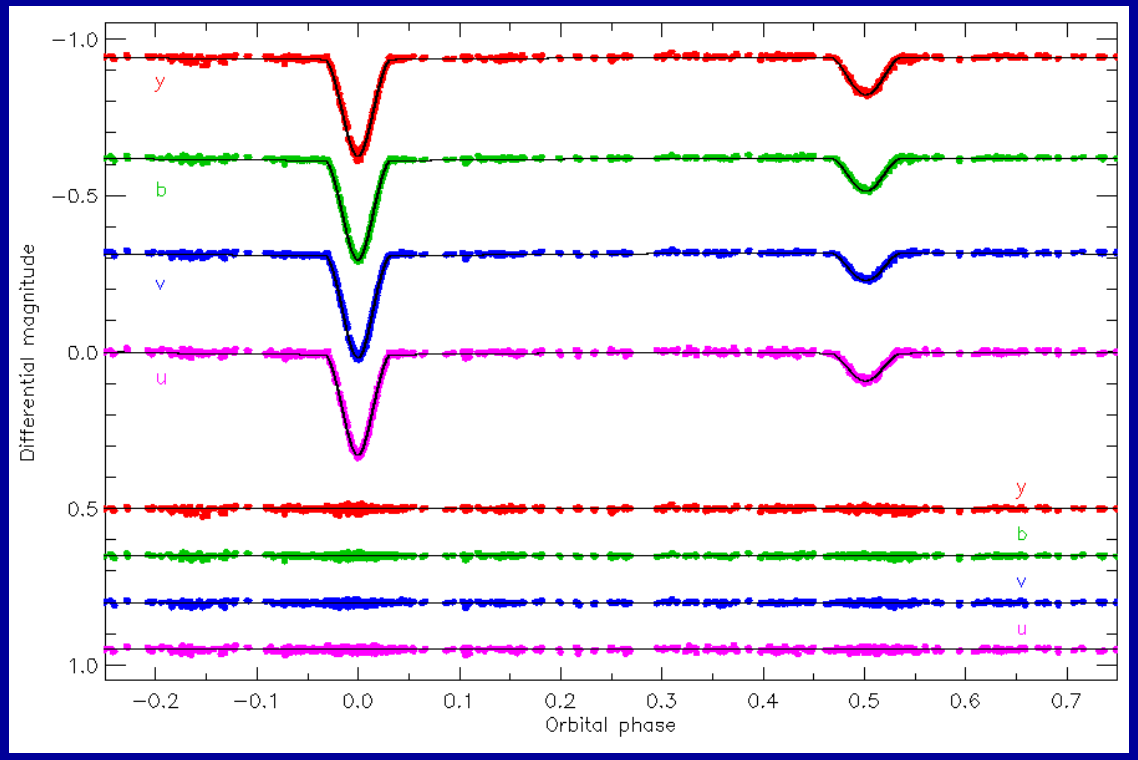
- NGC 3532
  - 522 ± 15 pc 300 Myr old
- GV Carinae
  - Period: 4.2 days A0 + A8 metallic-lined stars
  - Eccentric orbit Apsidal motion

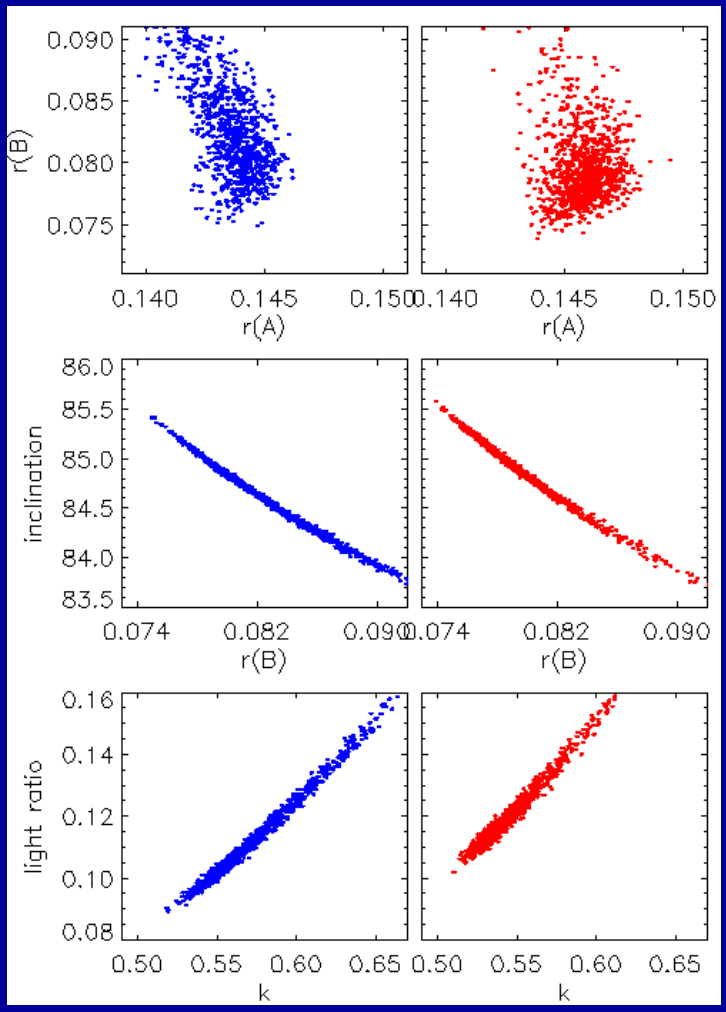
GV Car photometry



- Complete light curves in Strömgren *uvby*
  - Radii and orbital inclination derived using EBOP

GV Car photometry

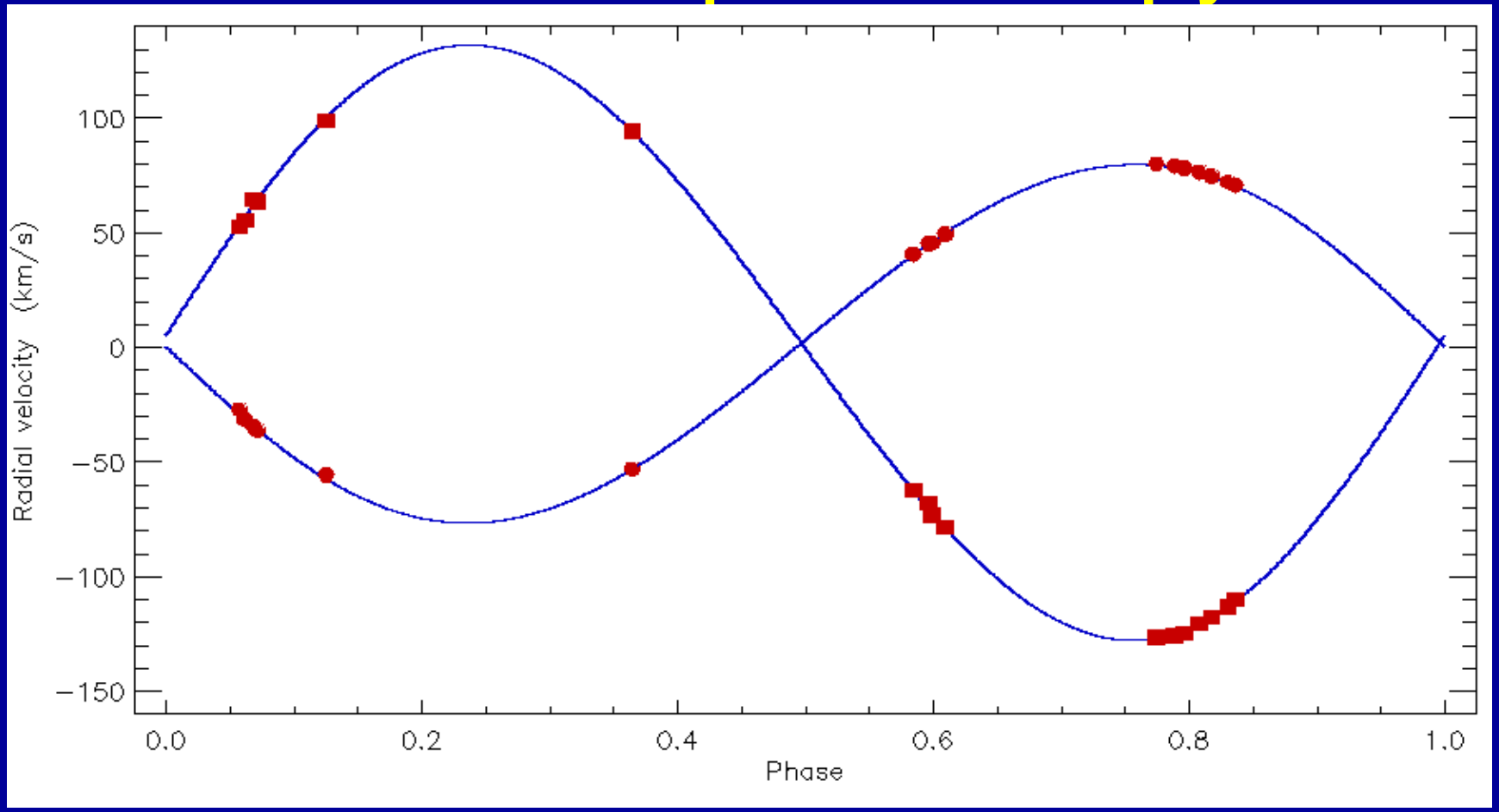




b light curve *y* light curve

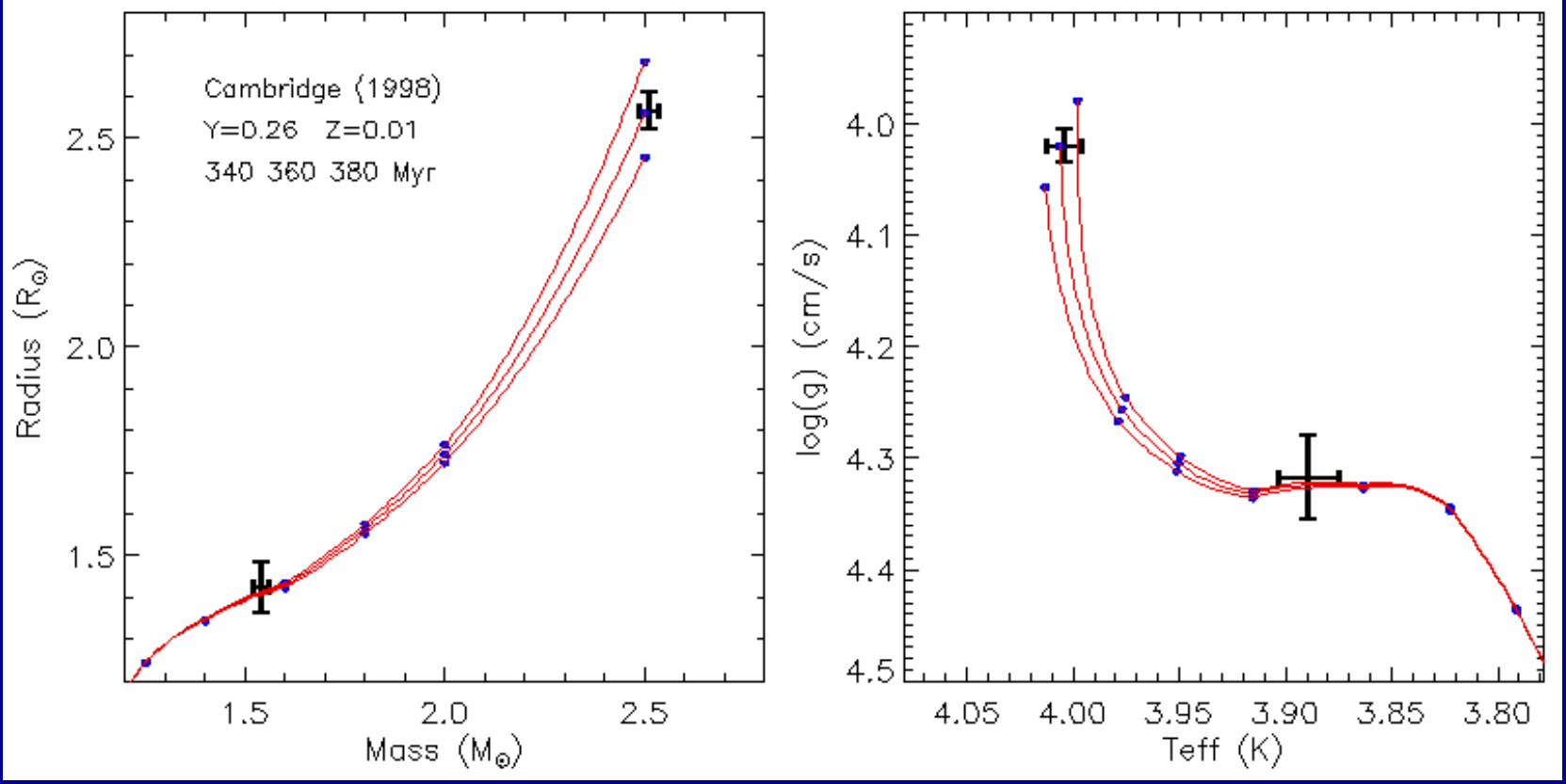
- Complete light curves in Strömgren *uvby*
  - Radii and orbital inclination derived using EBOP
  - Monte Carlo simulations used to find uncertainties

GV Car spectroscopy



- 20 FEROS échelle spectra
  - Radial velocities found using cross-correlation
  - Masses found by fitting radial velocities with SBOP

GV Car absolute dimensions



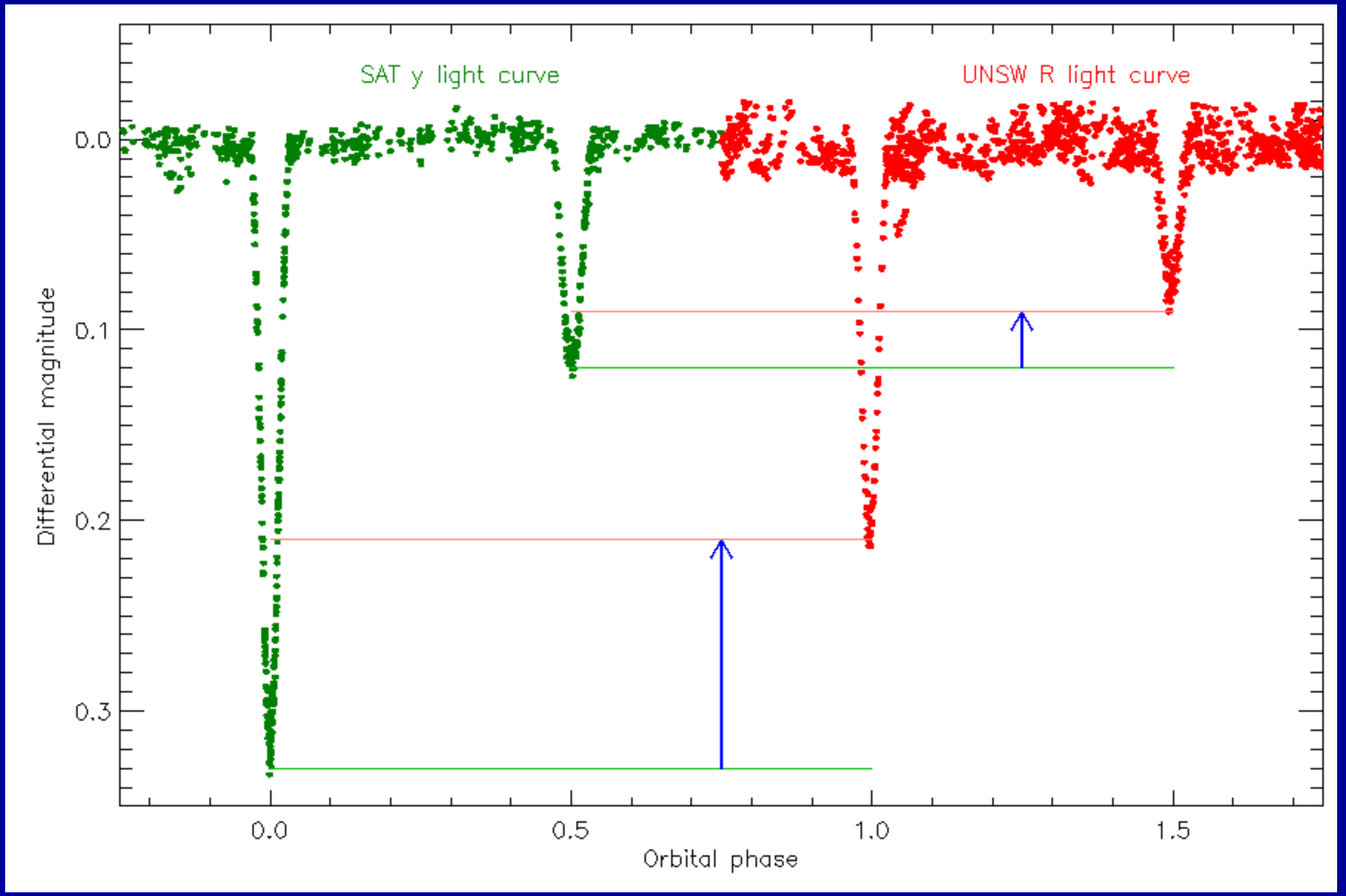
M_A = 2.508 ± 0.025 M

M_B = 1.540 ± 0.018 M

R_A = 2.567 ± 0.045 R

R_B = 1.428 ± 0.061 R

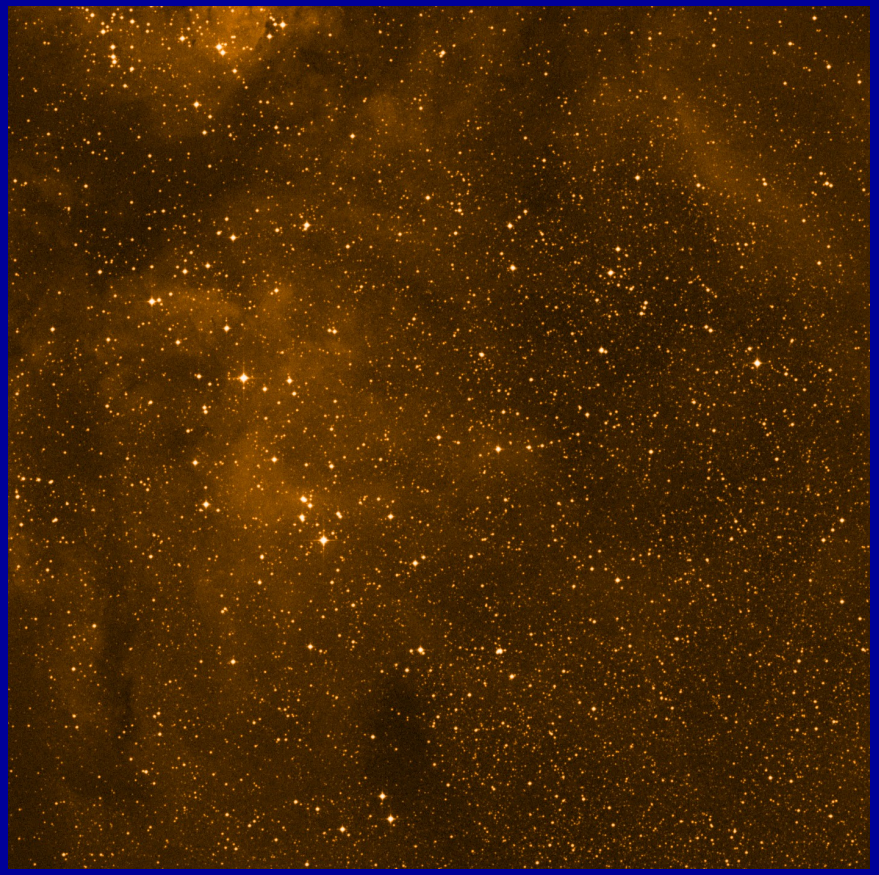
- Compare to Cambridge (1998) theoretical models
  - Age: 360 ± 15 Myr
  - Metal abundance: Z = 0.01



but... the light curve has changed between the 1980s and 2001

DW Car in Collinder 228

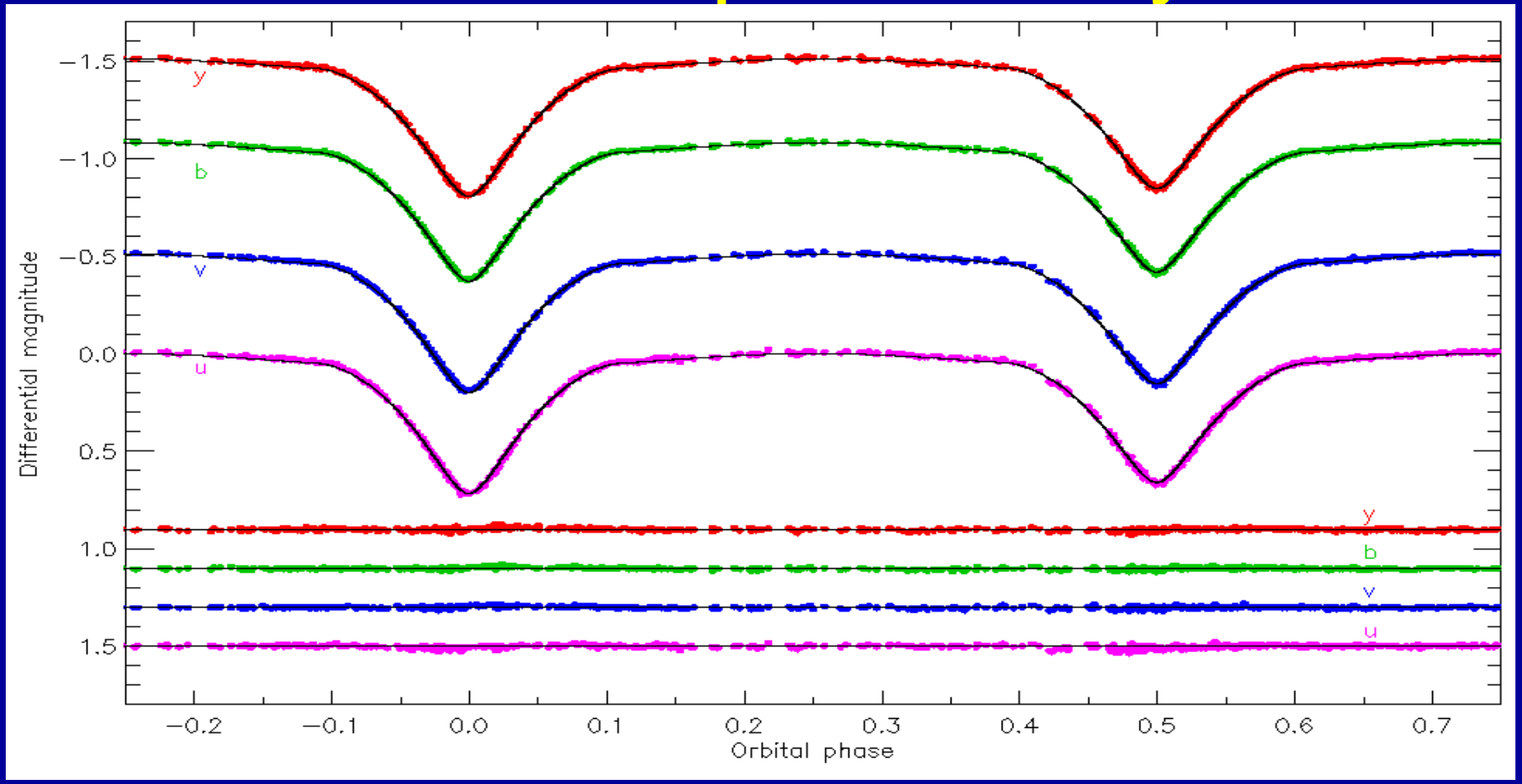
www.seds.org



www.eso.org / dss

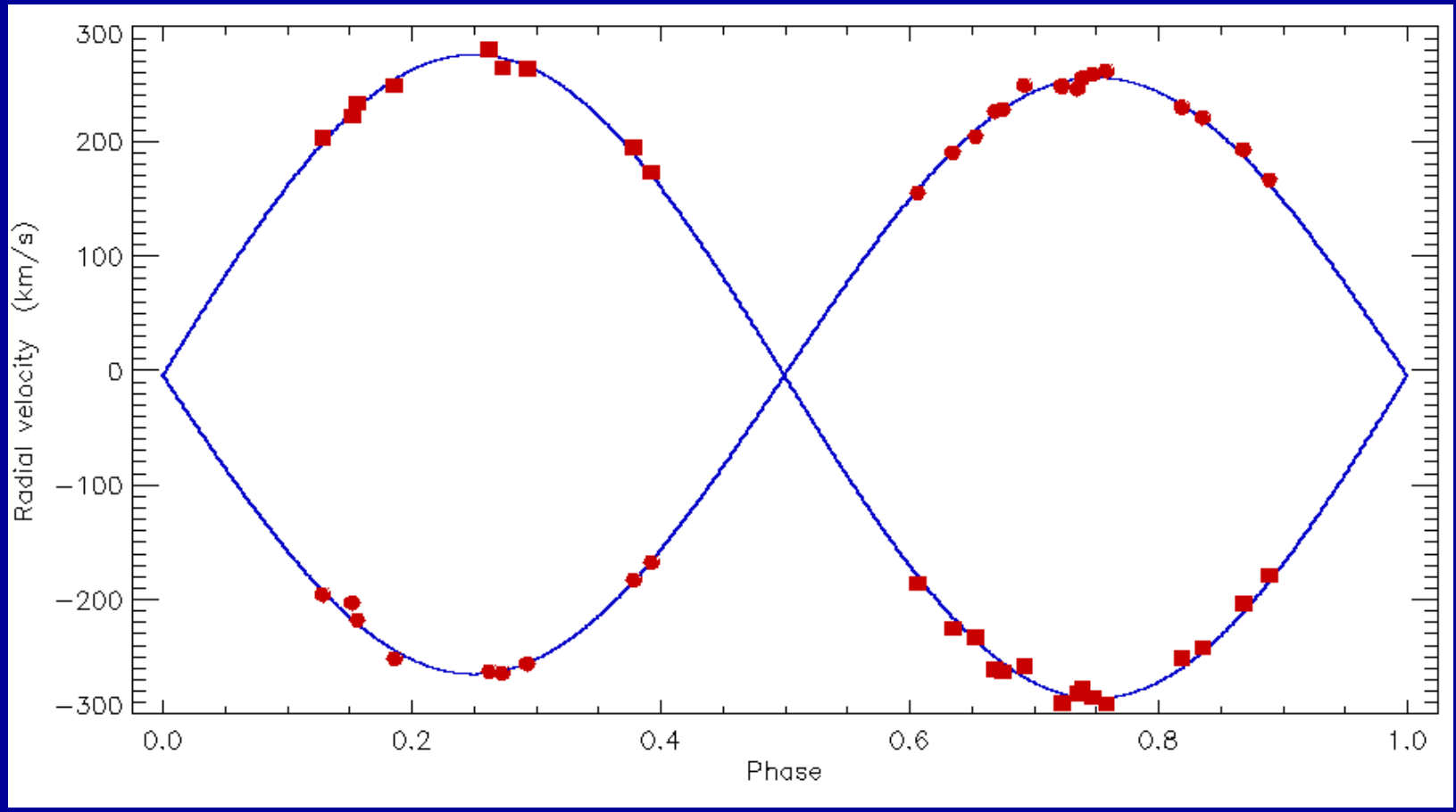
- Collinder 228
  - Distance: 1.9 ± 0.2 kpc
  - Age: 8 Myr
- DW Car
  - Period: 1.33 days
  - B1 V + B1 V ZAMS stars

DW Car photometry



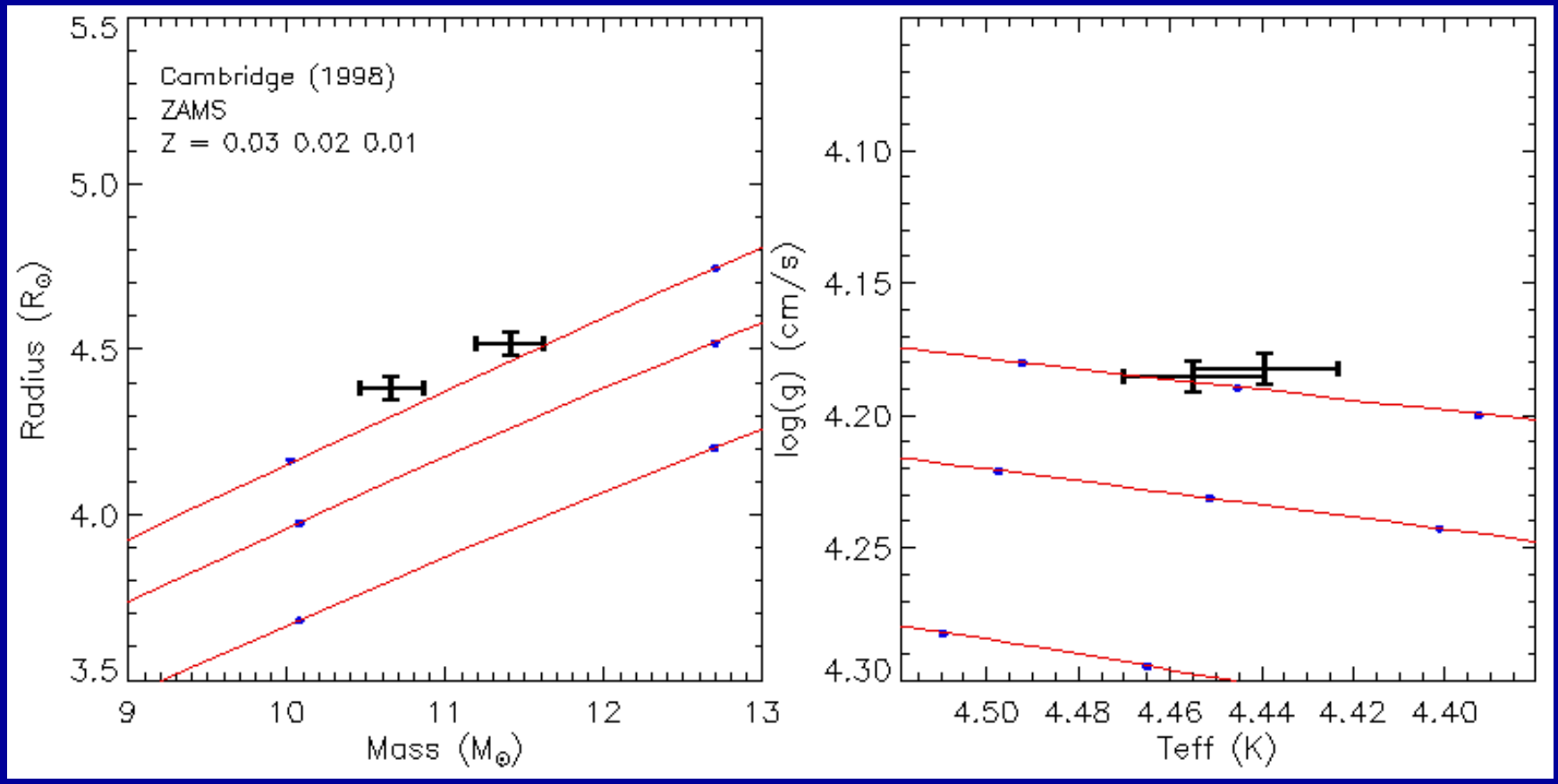
- Complete light curves in the Strömgren *uvby* system
  - Light curves solved with Wilson-Devinney (2003) code
  - Uncertainties will be from Monte Carlo simulations

DW Car spectroscopy



- 30 FEROS spectra: contain only 12 identifiable lines
  - Radial velocities from cross-correlation: okay
  - Radial velocities from fitting Gaussians: good
  - Spectral disentangling: χ^2 surface a nightmare

DW Car absolute dimensions



M_A = 11.41 ± 0.21 M

M_B = 10.66 ± 0.20 M

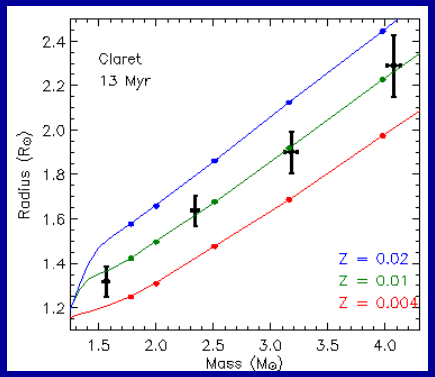
R_A = 4.52 ± 0.04 R

R_B = 4.39 ± 0.04 R

- Cambridge (1998) models:
  - Several possible fits:
  - Z = 0.03 and ZAMS
  - Z = 0.02 and 2 Myr

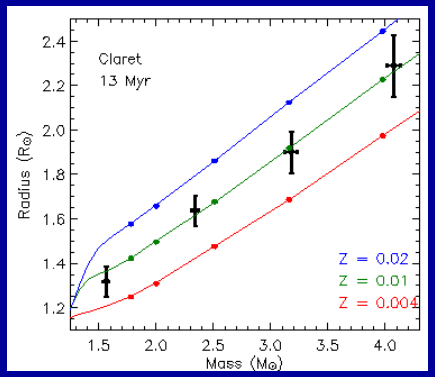
Conclusions

- Eclipsing binaries in clusters
  - Get masses, radii, luminosities and distance of two stars
  - Cluster membership gives age and metallicity (sometimes...)
  - Challenge theoretical models
    - convective core overshooting, opacities, mixing length, etc.

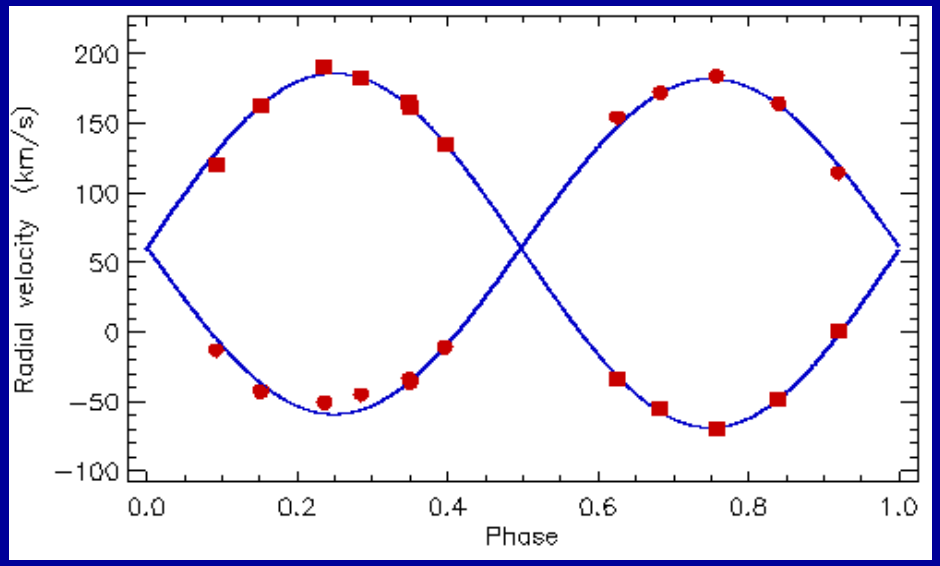


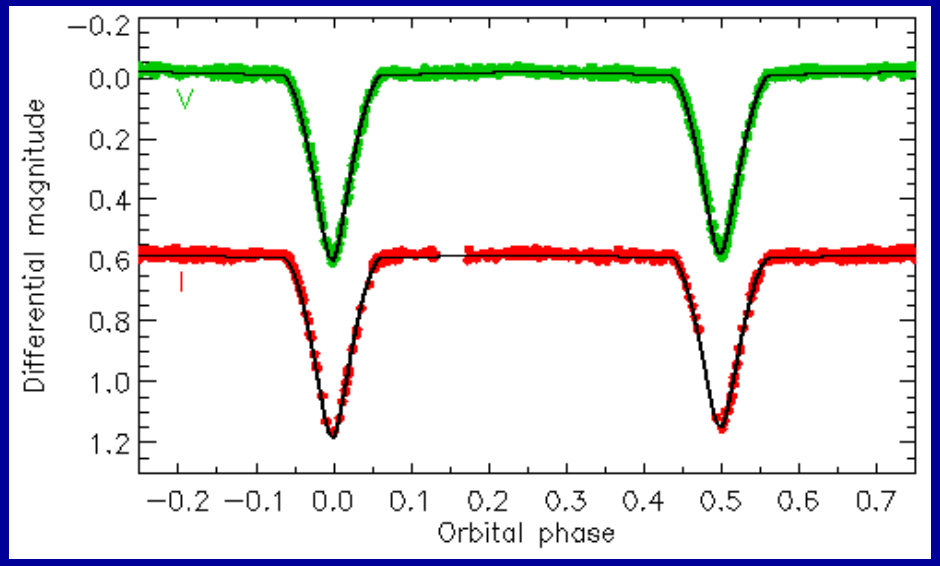
Conclusions

- Eclipsing binaries in clusters
  - Get masses, radii, luminosities and distance of two stars
  - Cluster membership gives age and metallicity (sometimes...)
  - Challenge theoretical models
    - convective core overshooting, opacities, mixing length, etc.
- We haven't quite got there yet
  - Need to study populous clusters
  - Globular clusters are good targets, e.g., OGLE-GC17 in ω Cen

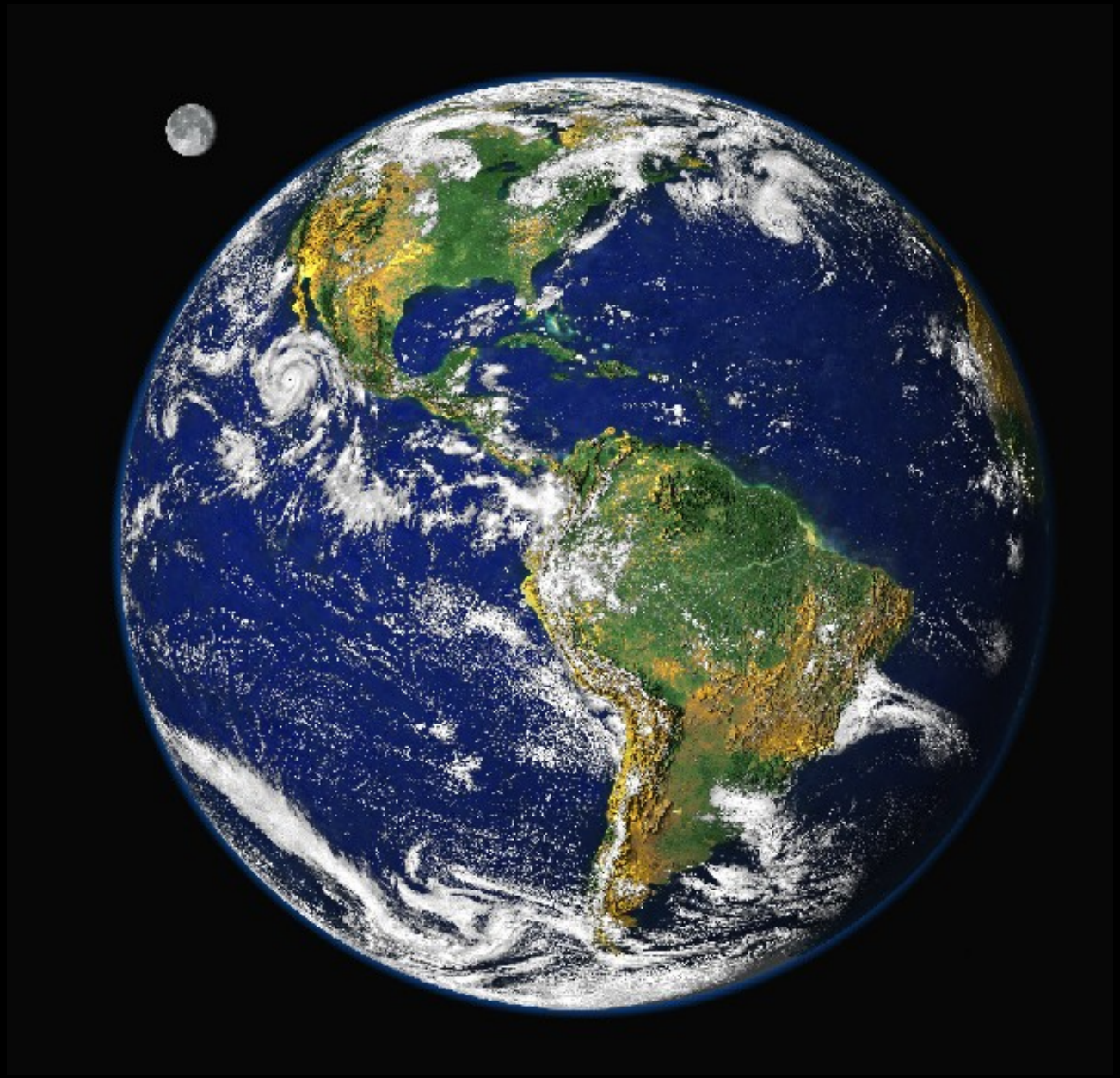


NV CMa in NGC 2243





- NV CMa was discovered by Kałużny et al (1996)
  - NGC 2243 is an old, metal-poor, open cluster
  - NV CMa is at MS turn-off of NGC 2243
- Being studied by Frank Grundahl et al
  - 17 VLT / UVES spectra
  - Good *V* and *I* light curves
  - Radial velocity and abundance study of cluster



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