The W UMa-type variable star V759 Cen

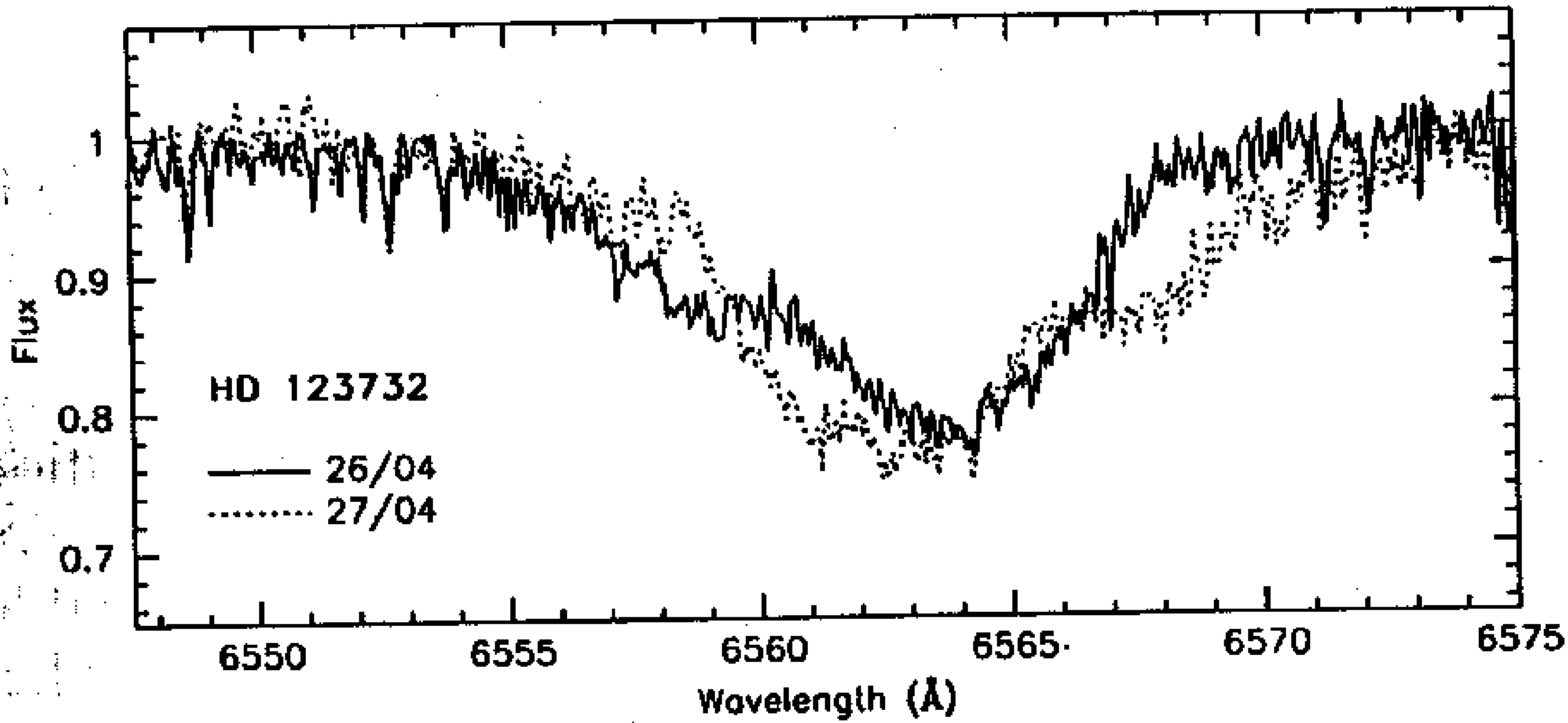
Derck P Smits

Dept Maths, Applied Maths & Astronomy

Unisa

Discovery

- Objective prism plates of moderately high dispersion regularly contain objects with abnormally wide or double spectral lines.
- Majority are visual binaries with nearly equal components and separations of a few mas.
- Bond (1970) did differential photometry of 6 stars found on Michigan Curtis-Schmidt plates that showed broad or double-lined spectra and were not visual binaries



10 FIG. 11.—Unsmoothed spectra of the Hα region of HD 123732 acquired on consecutive nights, showing the broad- and double-lined nature of this W Ursae Majoris system.

Discovery

- 3 of the stars were found to be variable through a Strömgren *y*-filter
- Complete *uvby* photometry obtained on 3 nights

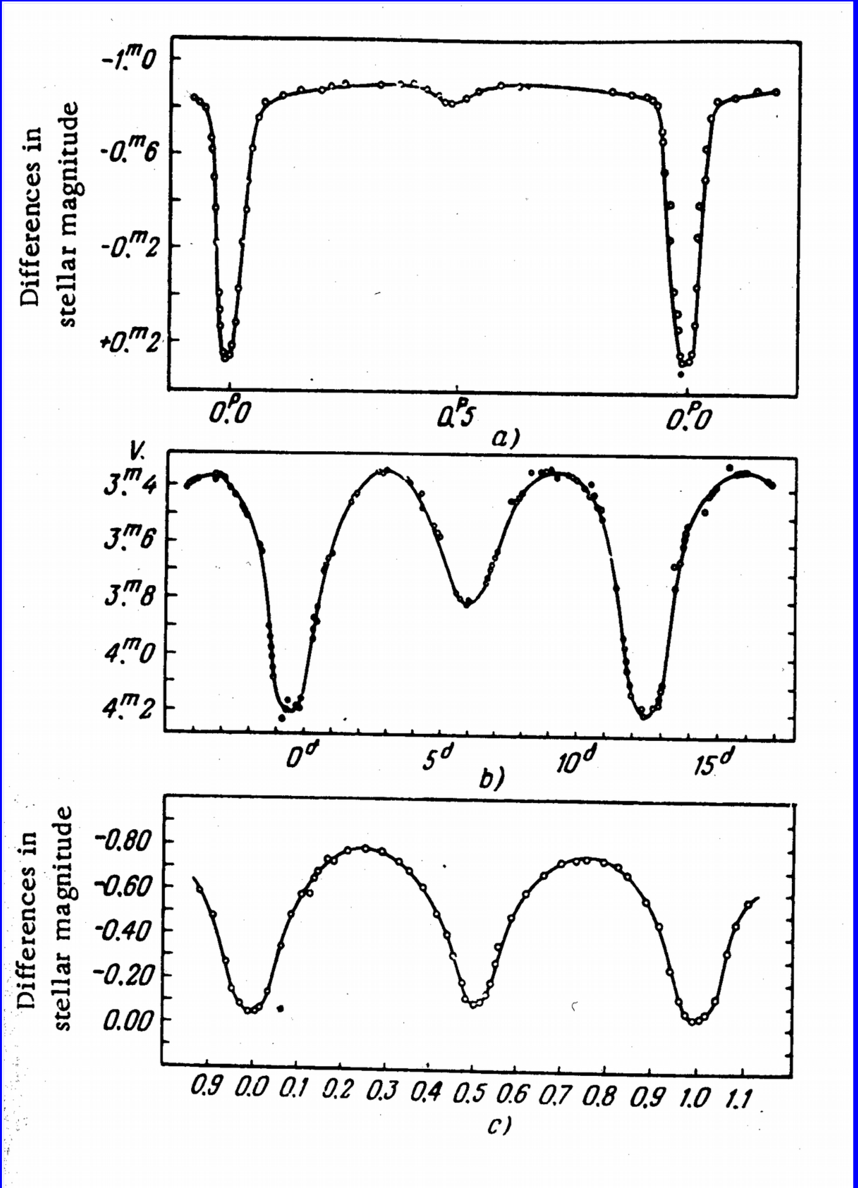
Properties

- HD 123732 listed as F8 in HD catalogue

∀ Δm = 0.16 mag

- b - y = 0.39
- V_{max} = 7.4 (transformed from *uvby* to Johnson UBV)
- Periodic variations with P = 9.48 hrs interpreted as orbital period
- Broad spectral lines ⇒ binary system with rapid rotation
- Eclipsing binary of W UMa type
- V759 Cen (Kukarkin et al 1972)

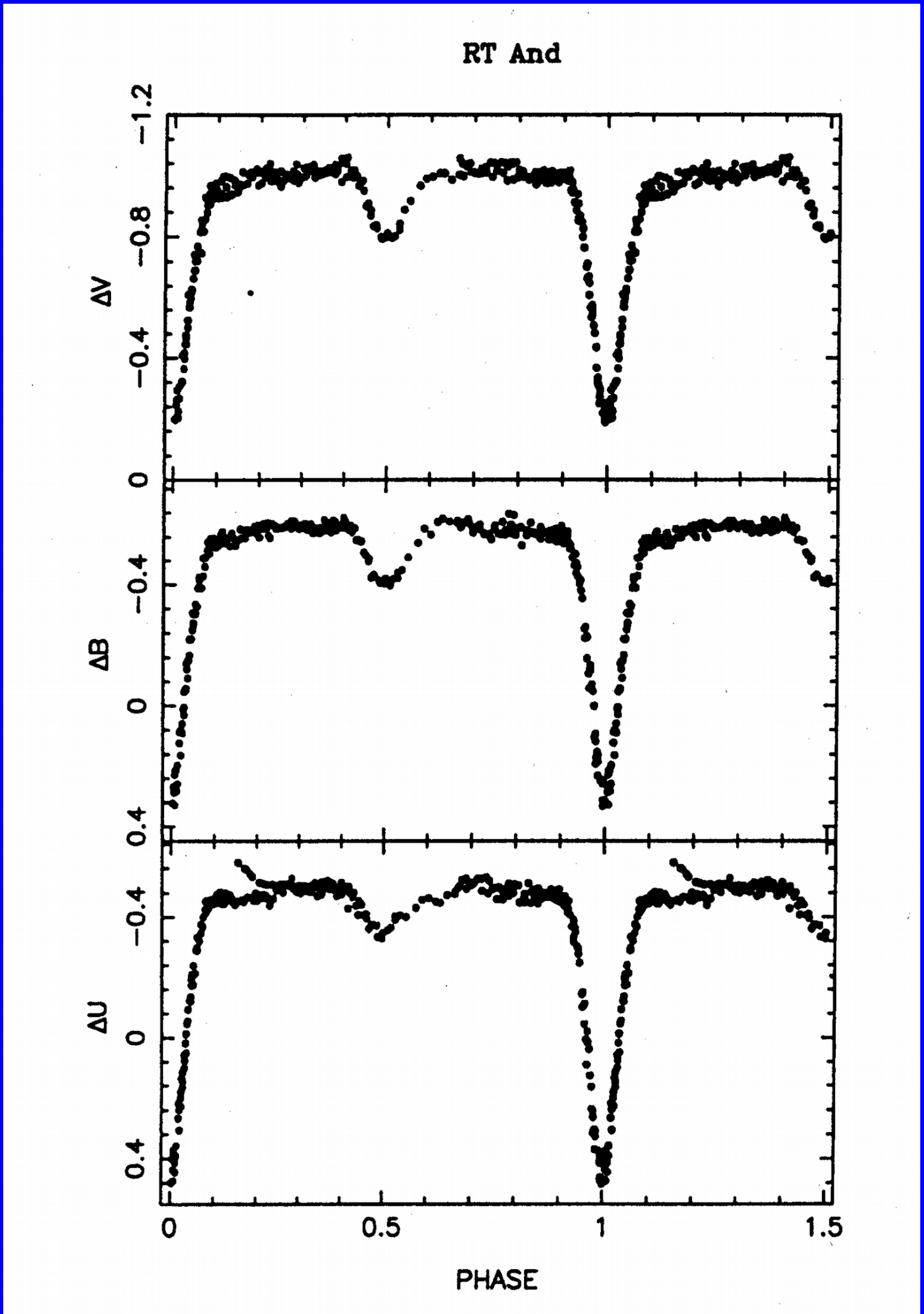
Eclipsing Binary Systems



EA

EB

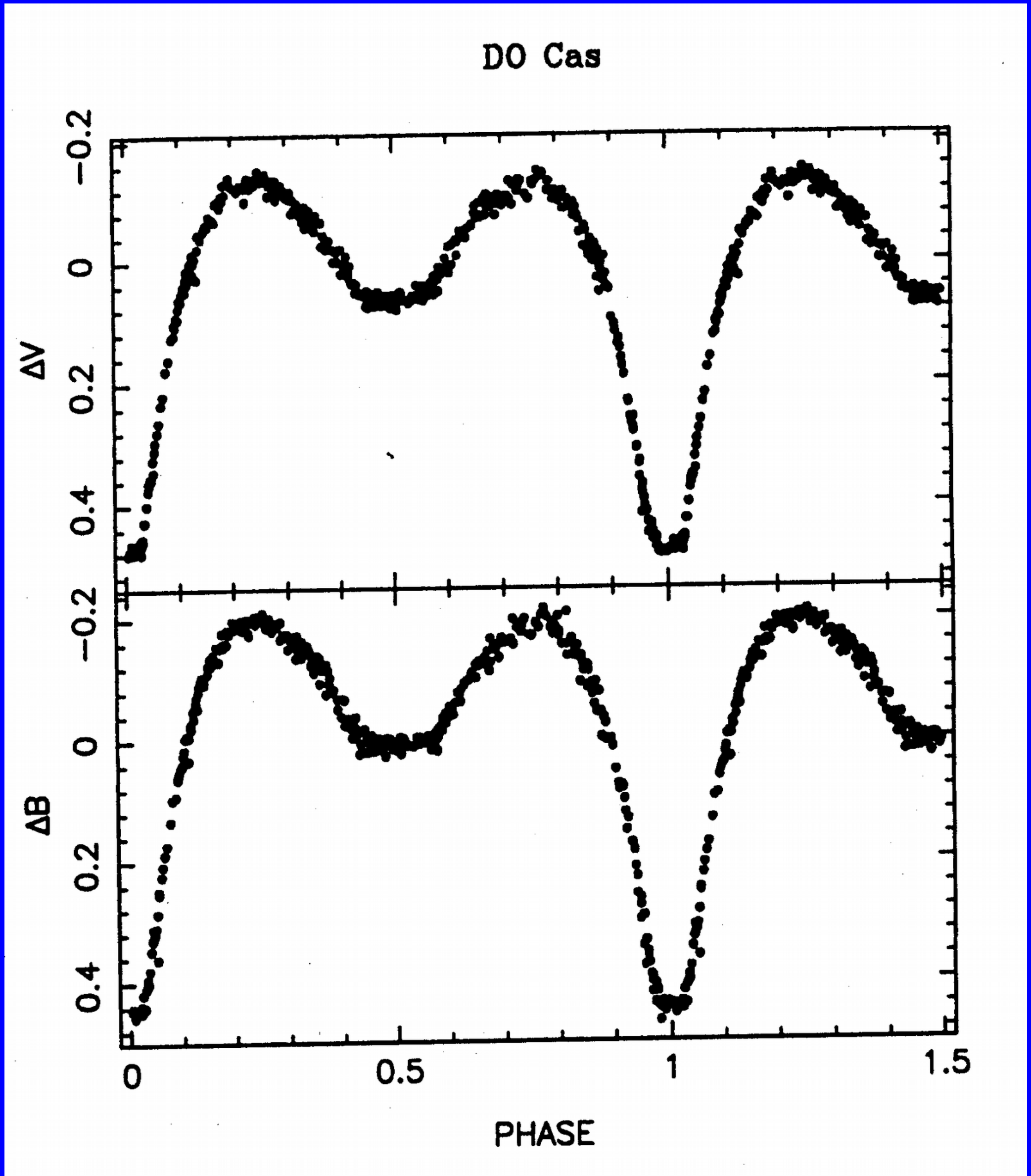
EW



Algol Binaries

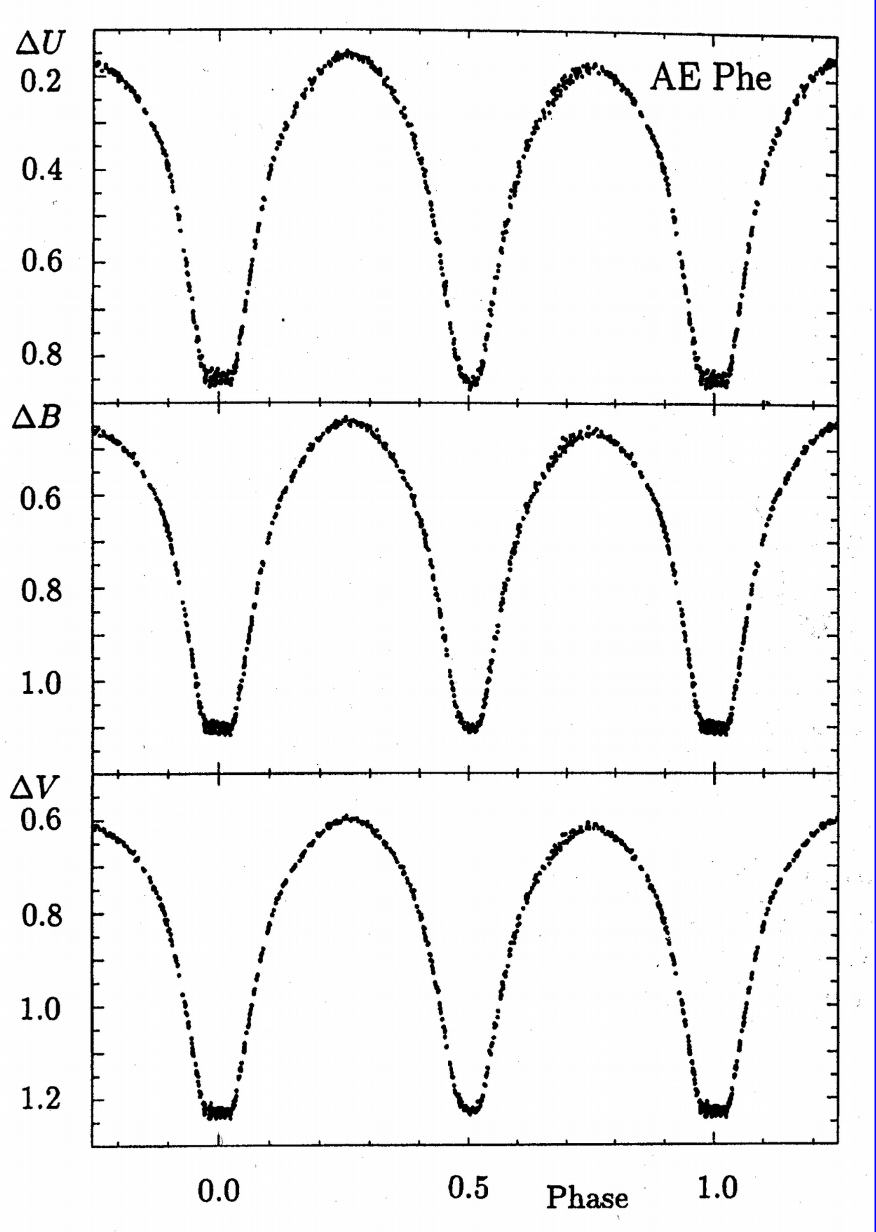
- EA systems
- Clearly defined eclipses, obvious start and end times
- Nearly constant light between eclipses
- Classification based on light curve, not on physical characteristics of stars

β Lyrae Eclipsing Binaries



- EB systems
- P_{orb} > 1 day
- spectral type A or B
- secondary eclipse has significantly different depth to primary.

W UMa Systems



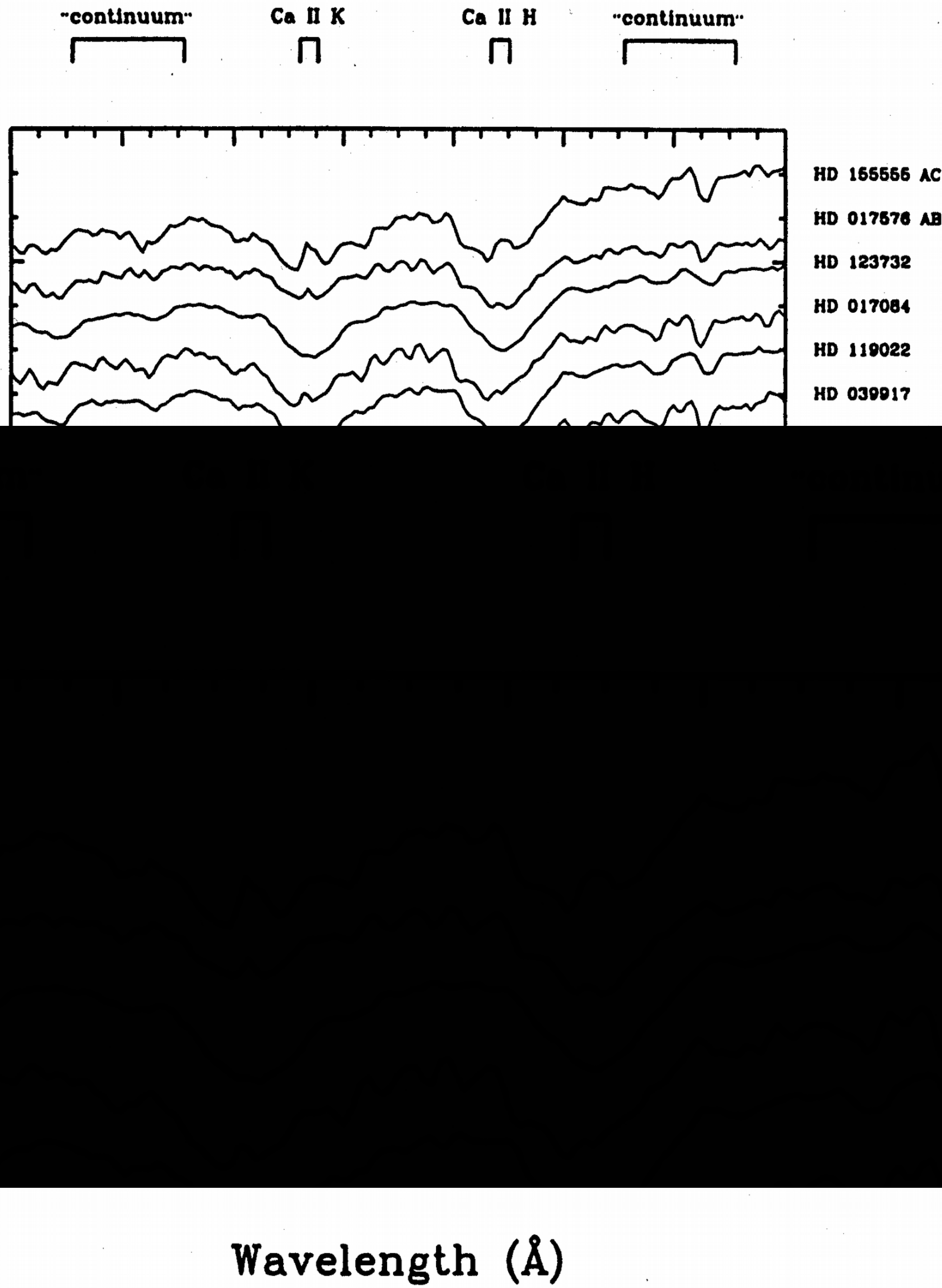
- $5^{hrs} < P_{orb} < 24^{hrs}$
- Mass ratio $M_1:M_2 \neq 1$
- Spectral type: late A to mid K dwarfs (class V)
- Spectral type and colour do not change during cycle
- Minima have mean amplitude of 0.75 mag and are of almost equal depth ▯min = 0.1 - 0.2 mag
- Light curve varies continu-ously between eclipses

Properties of V759 Cen

- Photometry: $7.563 \leq V \leq 7.66$

  $3.38 \leq M_V \leq 4.4$

  $0.534 \leq B - V \leq 0.61$
- Hipparcos: $\pi = 15.9 \pm 0.9 \Rightarrow d = 62.9$ pc = 205 ly
- Spectral type: F8 – G0
- Strength of H & K lines of Ca II ⇒ chromosphere active

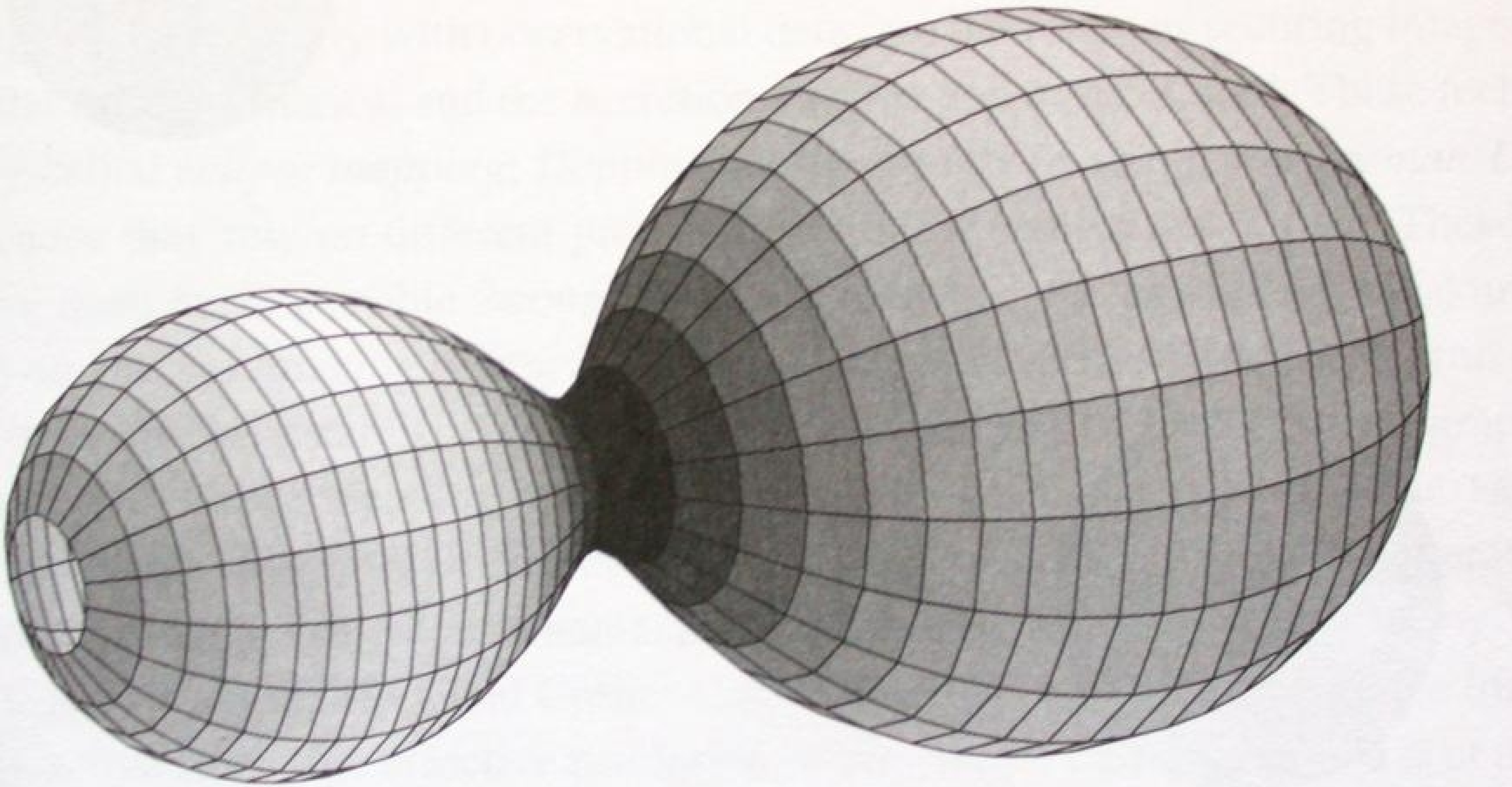

"continuum"
Ca II K
Ca II H
"continuum"
HD 155556 AC
HD 017576 AB
HD 123732
HD 017084
HD 119022
HD 039917
[redacted]
Wavelength (Å)

Period

- Sistero & Castore de Sistero (1976) made 231 UBV observations but mixed up primary and secondary eclipses when determining ephemeris
- Further observations by Sistero et al (1990) found 244 3089.2898 + 0.3939903 E using all available data (including Bond's)
- Statistical study by van 't Veer (1991) found +ve and -ve jumps randomly distributed between phases of constant period
- O - C residuals from Sistero et al (1990) comparable to estimated errors ⇒ V759 Cen shows no evidence of period jumps

Model of W UMa Systems

- Components are normal main-sequence stars
- Short period $\Rightarrow$ very close $\Rightarrow$ contact binary
- Common envelope formed around components, joined by thick neck
- Different masses $\Rightarrow$ transfer of material that contributes to luminosity
- Gravitational interaction deforms spherical stars into ellipsoidal shapes



Model

- Continuous light change due to eclipses and changing aspect of tidally distorted shape
- Lack of colour or spectral variation $\Rightarrow$ common envelope optically thick, and has uniform temperature
- Uniform temperature $\Rightarrow$ minima of equal depth
- PROBLEM: Mass ratio $\neq 1 \Rightarrow$ not barytropic
  How is energy transferred between stars?

Angular Momentum

- Closest known main-sequence binaries ⇒ least amount of ang mtm for MS stars
- Most binaries with P < 8 days have circular orbits and synchronised spins
- V759 Cen has 9.5 ^{hr} orbit & spin period
- Magnetic field due to differential spin ⇒ strong chromospheric emission

Evolution

- Single stars spin slower when they lose ang mtm
- Tidally locked binaries lose angular momentum by moving closer together
- Kepler's 3rd law $\Rightarrow$ spin faster
- W UMa systems probably descend from short period RS CVn systems through ang mtm loss via magnetised stellar winds
- Evolve into blue stragglers or rapidly rotating spotted giant stars (FK Comae) by merging

Problems

- Mass transfer would produce period jumps in only one direction, cyclic magn activity alternate positive/negative period changes
- Neither simple model supported
- 563 EW types listed in GCVS 4th ed
- 514 have reasonably well-defined periods
- Minor fraction have good light curves, even less have radial velocity curves

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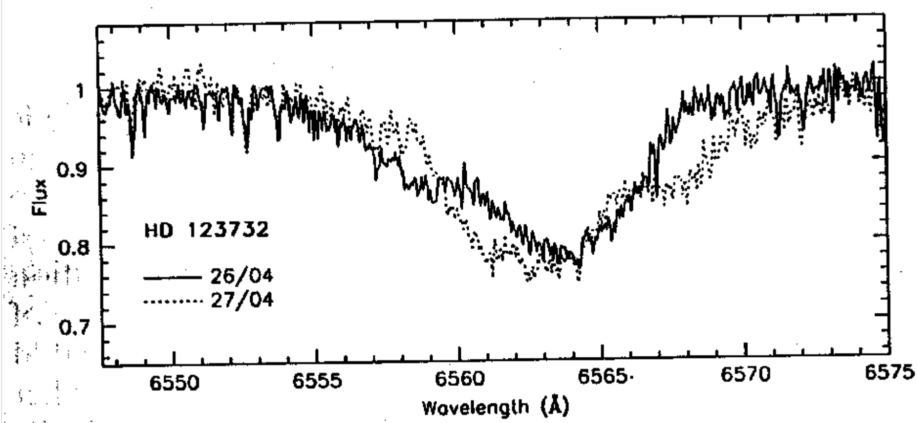

FIG. 11.—Unsmoothed spectra of the Hα region of HD 123732 acquired on consecutive nights, showing the broad- and double-lined nature of this W Ursae Majoris system.

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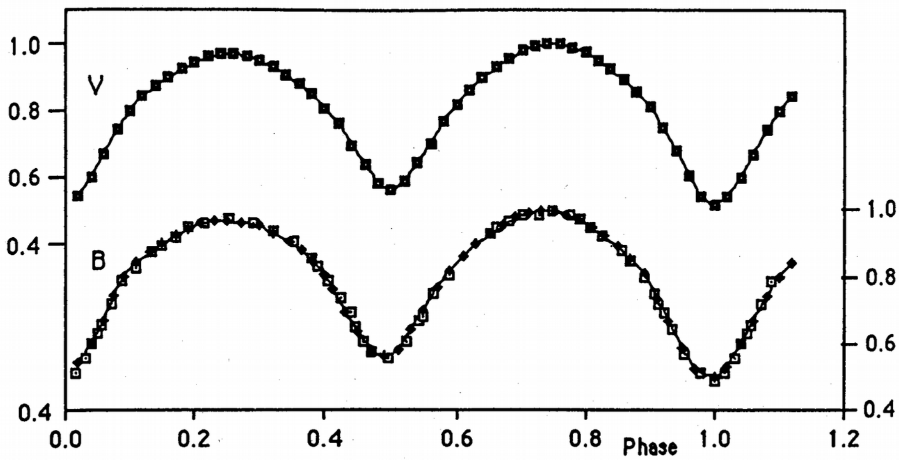
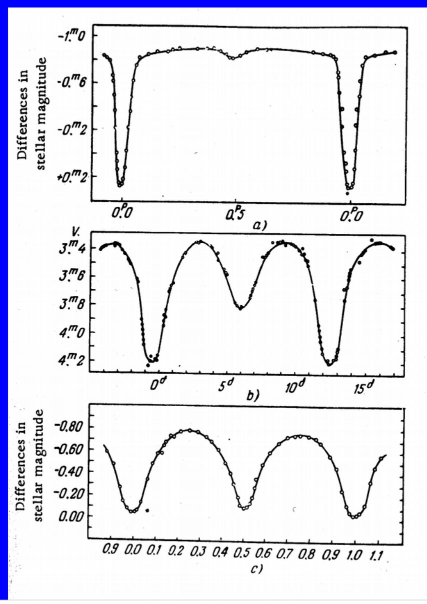


Figure 22: Light curves for a W-type W UMa system YY Eri (see Müyesseroglu *et al.* 1990). Note the virtual absence of color variations around the cycle.

Eclipsing Binary Systems



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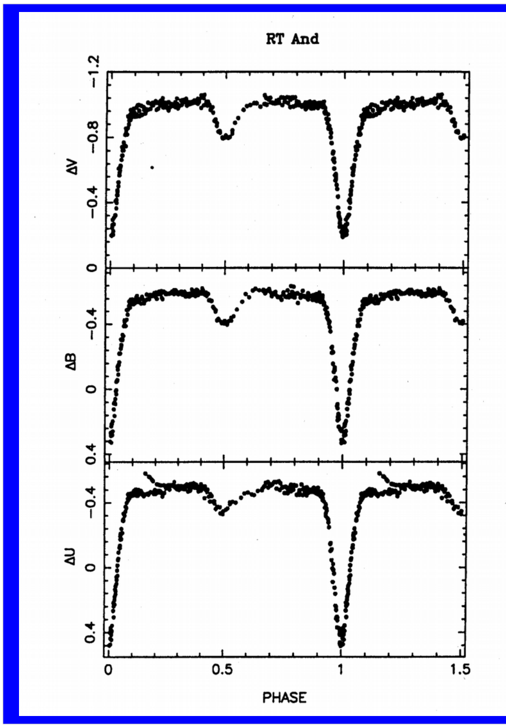

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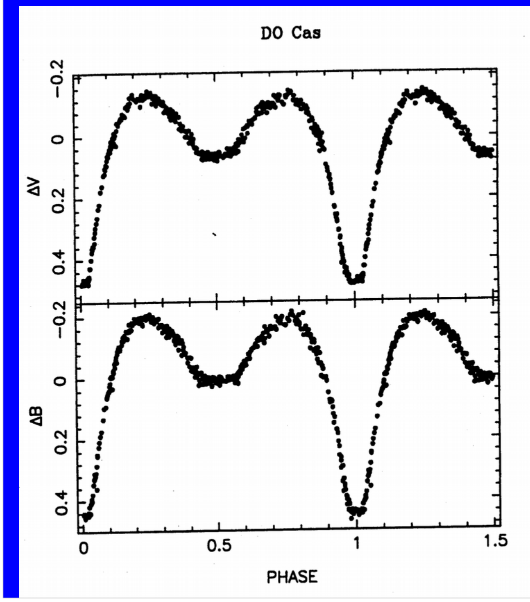

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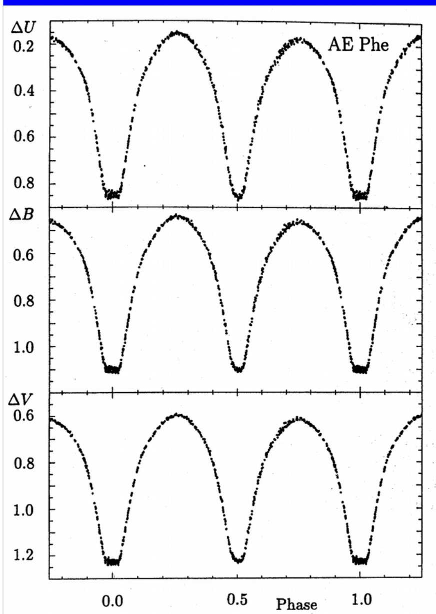

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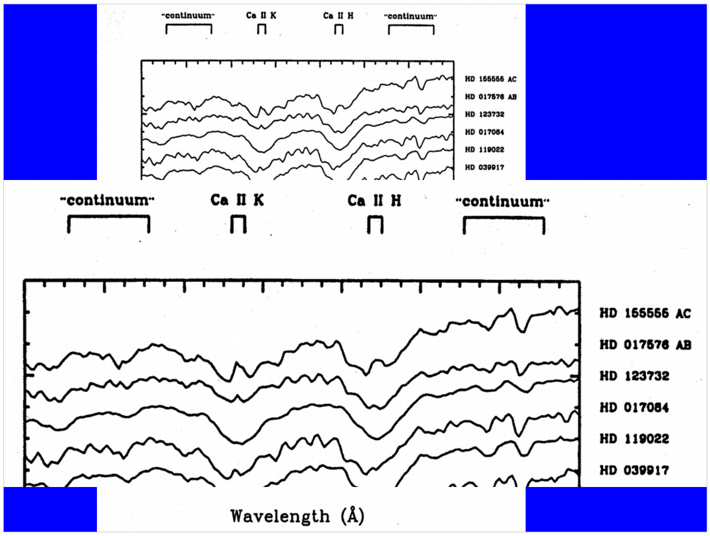
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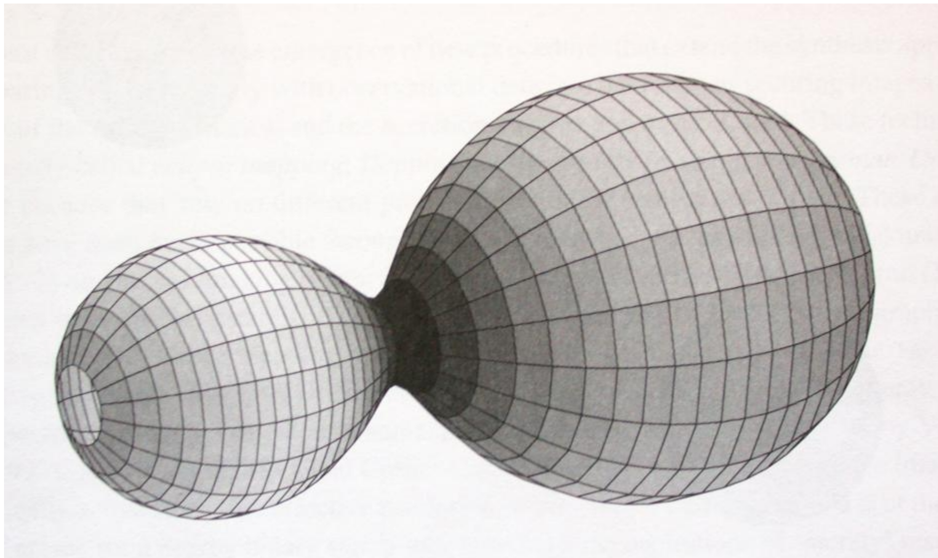

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