Modelling of W UMa-type Variable Stars

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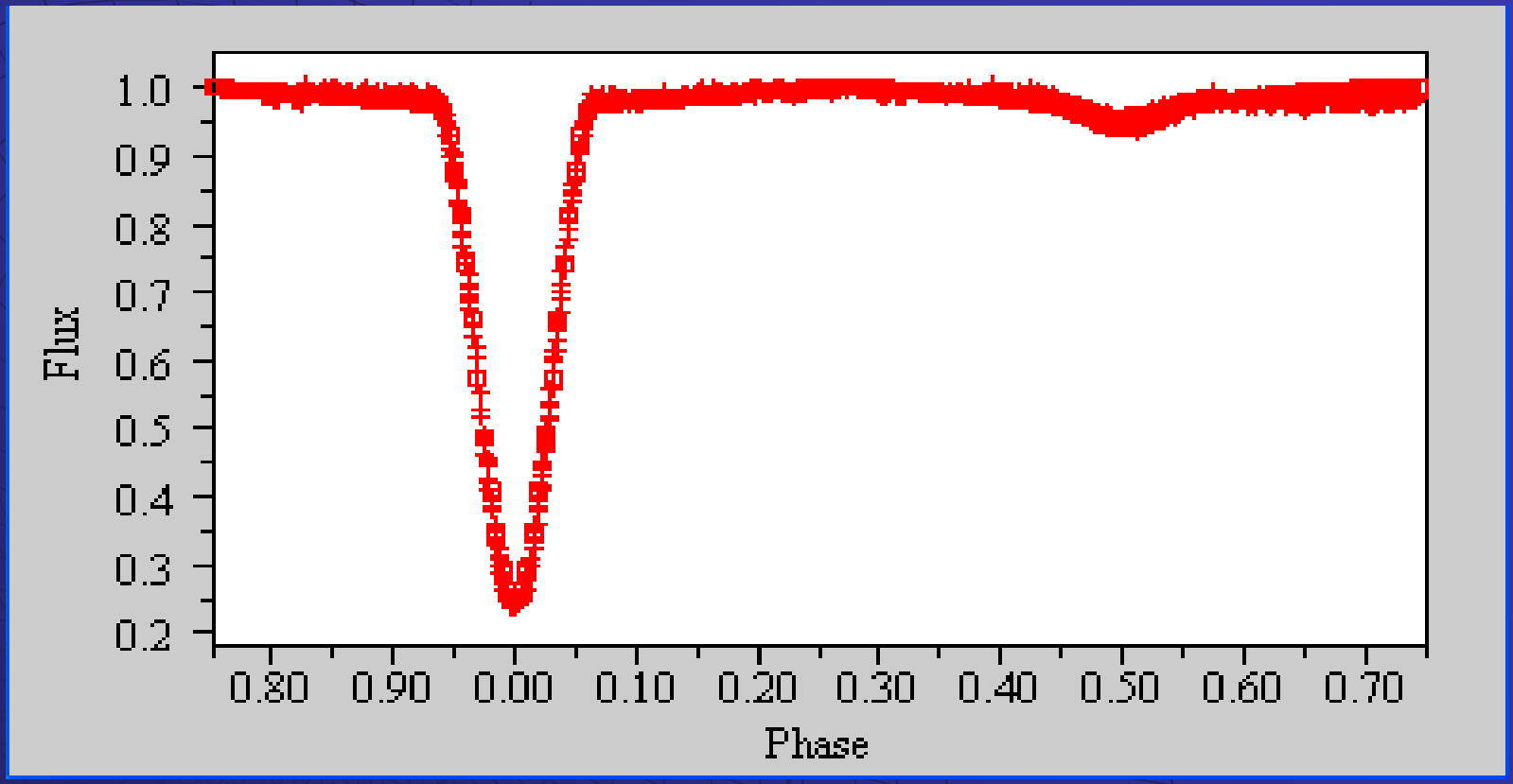
Outline

- Classification of Eclipsing Binaries
- Properties of W UMa-type Stars
- All Sky Automated Survey (ASAS)
- SuperWASP
- Data Modelling
- Flux Changes
- The Crossdresser
- Future Research
- Unanswered Questions

Eclipsing Binaries

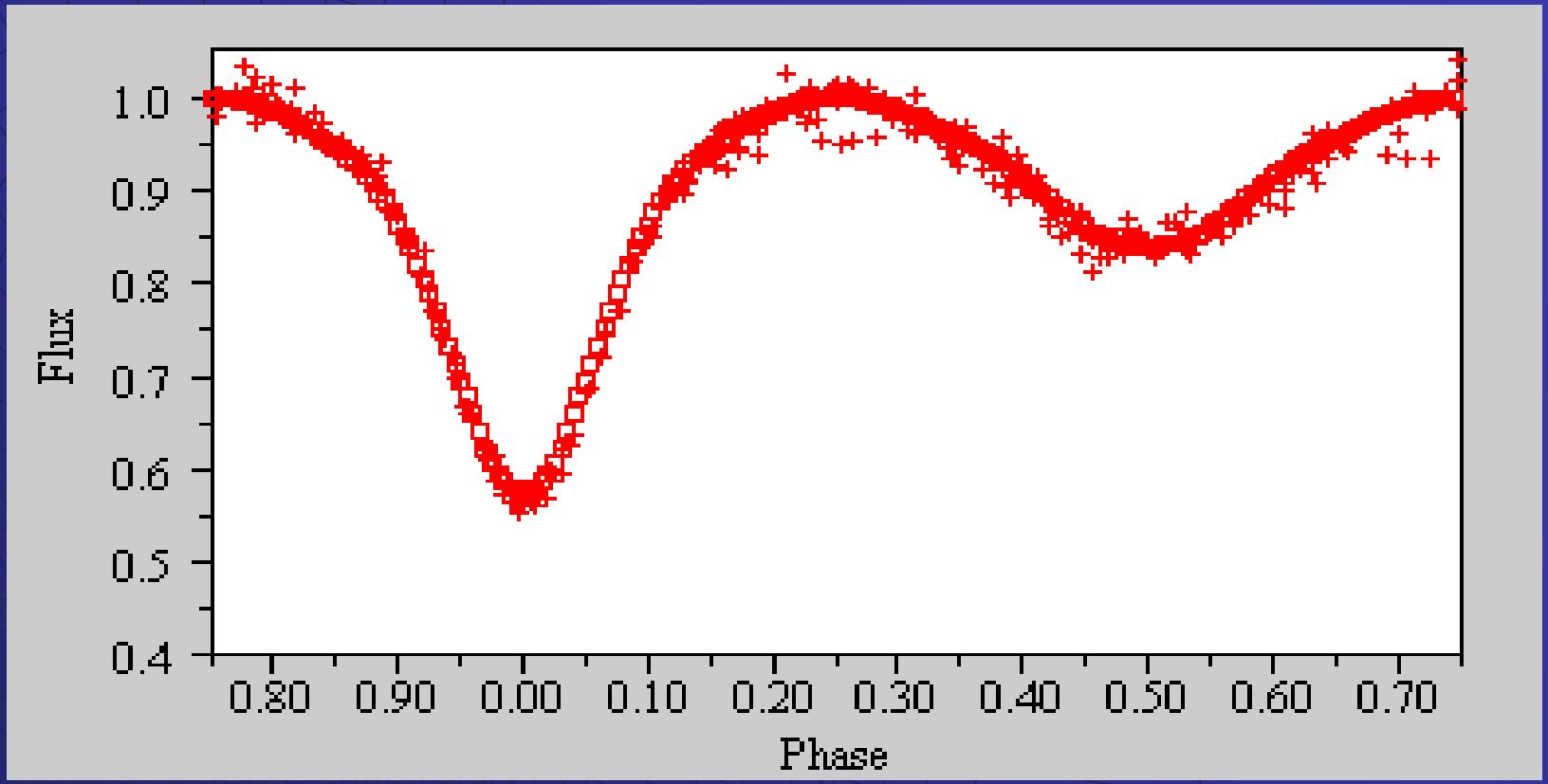
- Eclipsing binaries are extrinsic variable stars i.e. variations in light caused by the two component stars as they eclipse each other
- Initially classified according to observed light curve
- Three standard curves were identified and were designated EA, EB and EW light curves after their protostars

Classification of Eclipsing Binaries



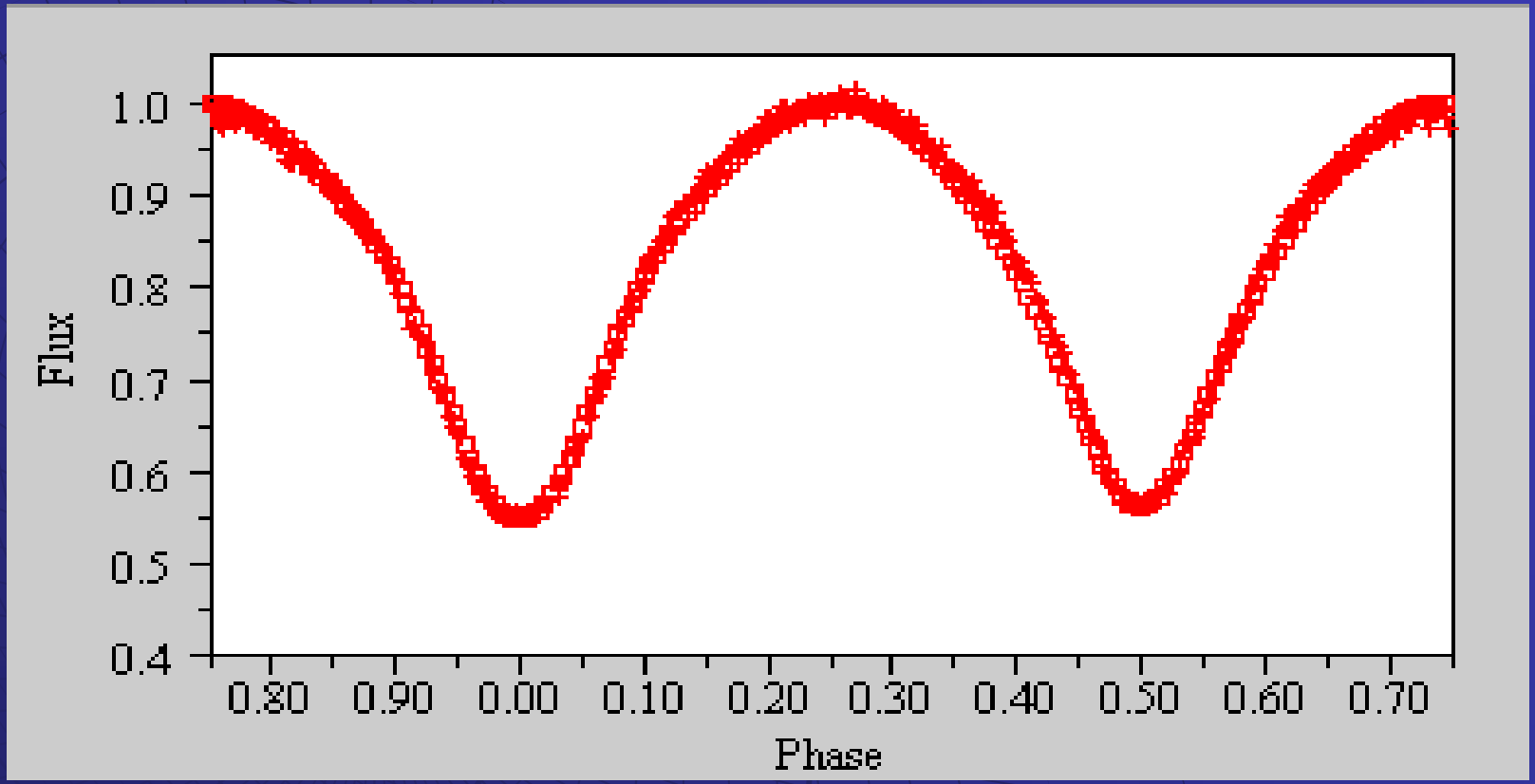
EA Light Curve

Classification of Eclipsing Binaries



EB Light Curve

Classification of Eclipsing Binaries

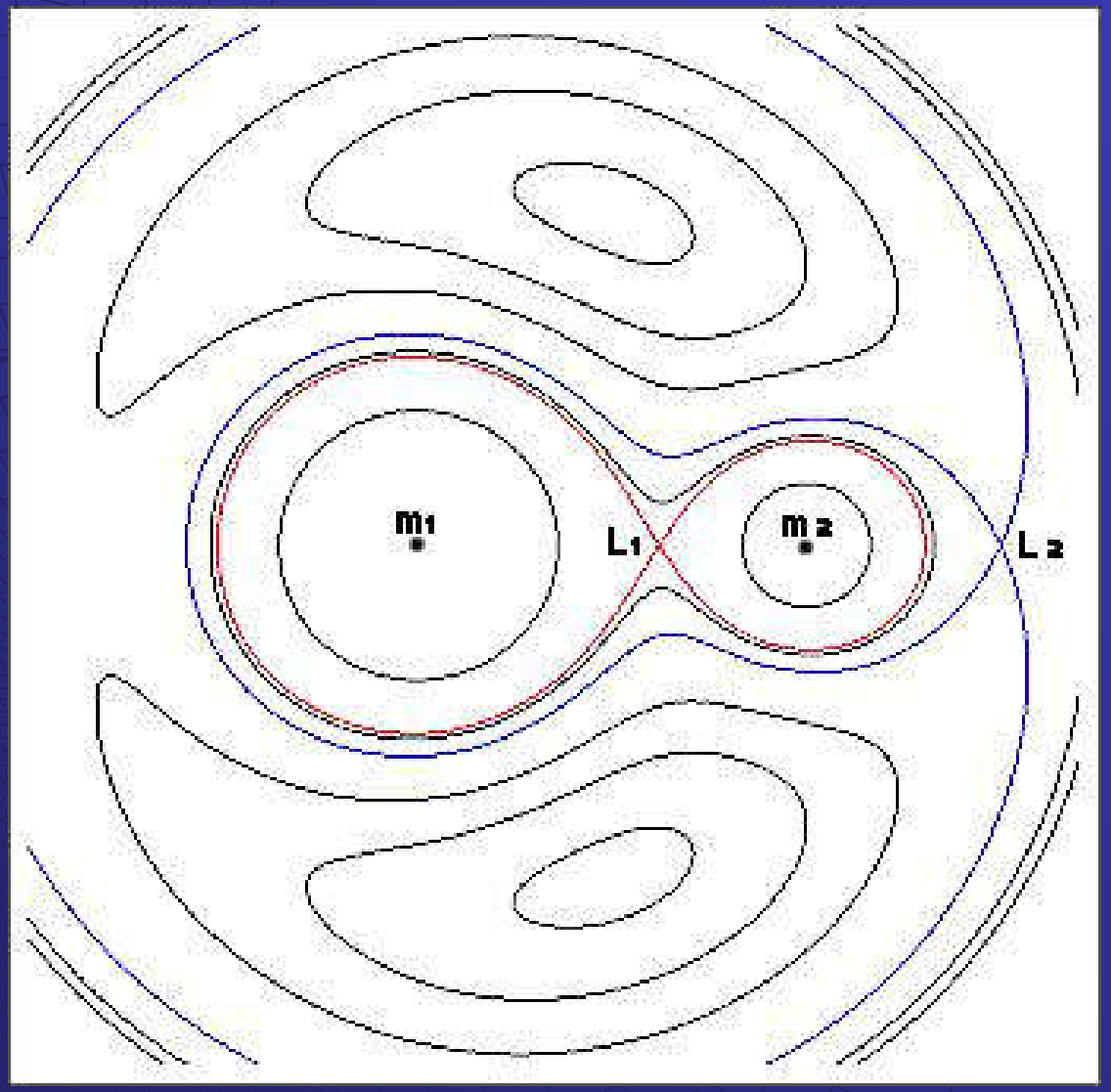


EW Light Curve

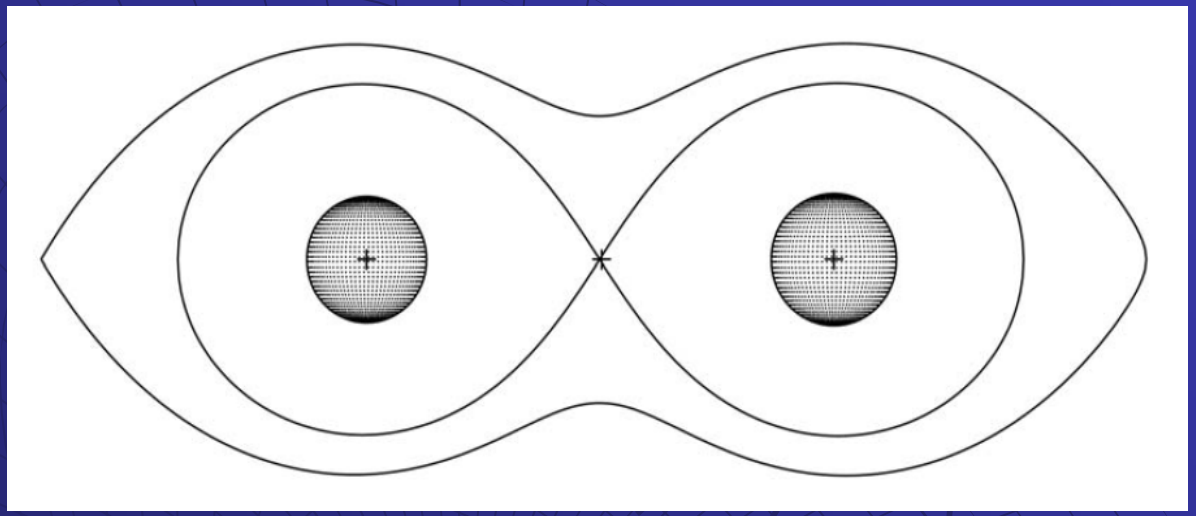
Classification of Eclipsing Binaries

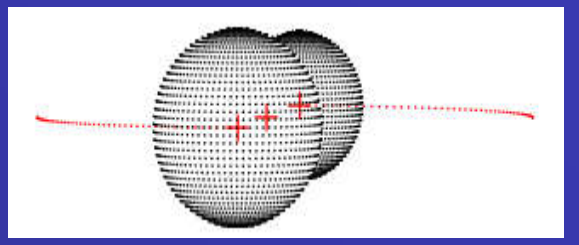
- Classification based on a physical property of the star systems called the Roche potentials
- Equipotential surface : surface where the sum of the rotational and gravitational potential energy is constant
- Equipotential surfaces of the two masses meet at several points

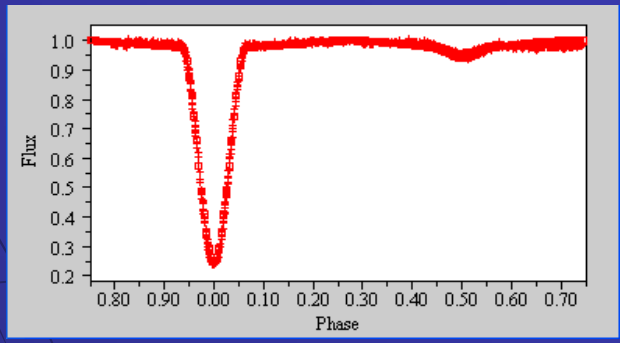
Classification of Eclipsing binaries

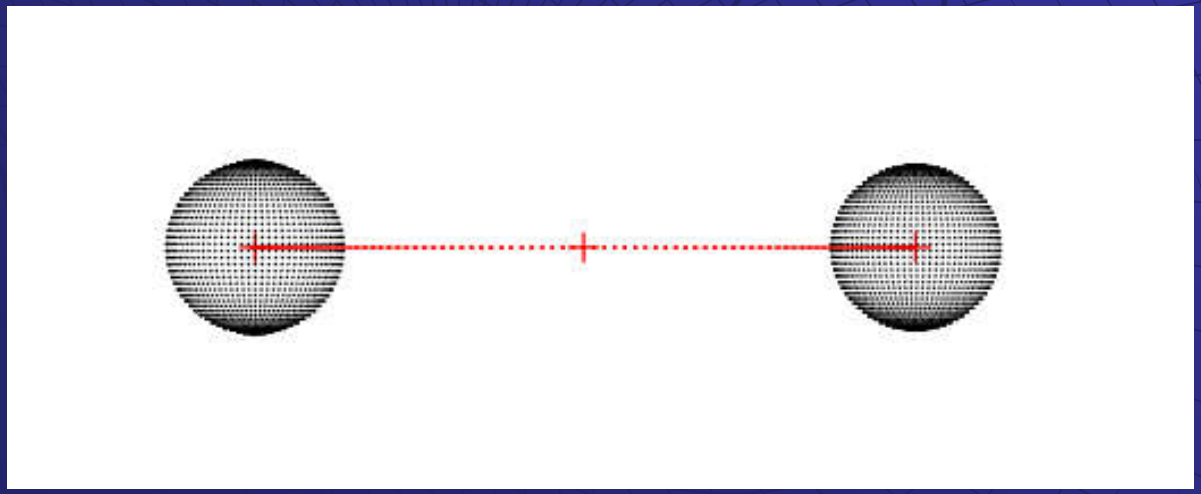


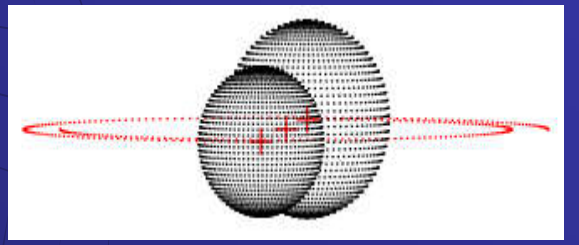
Detached System



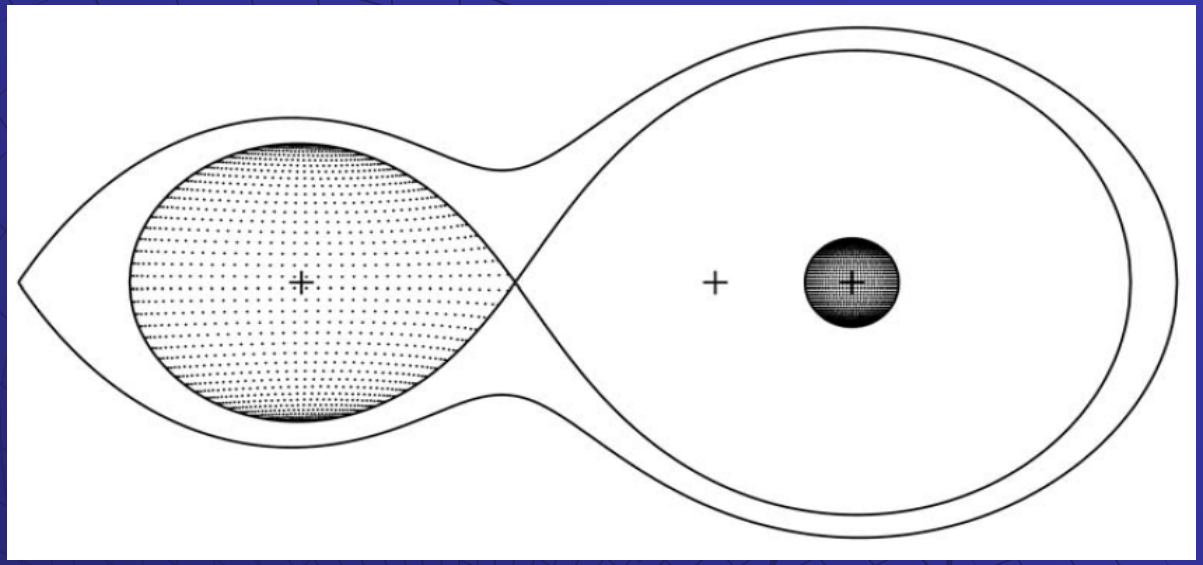


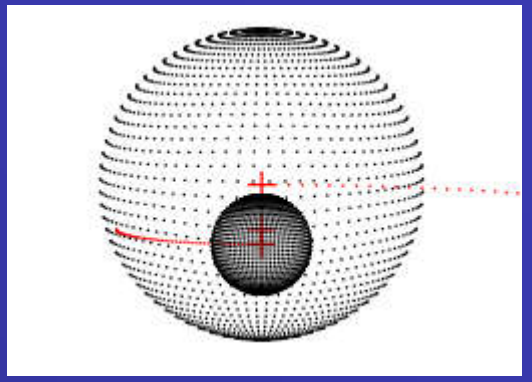


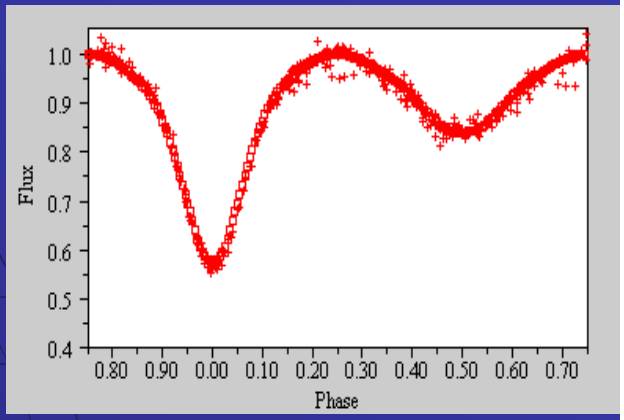


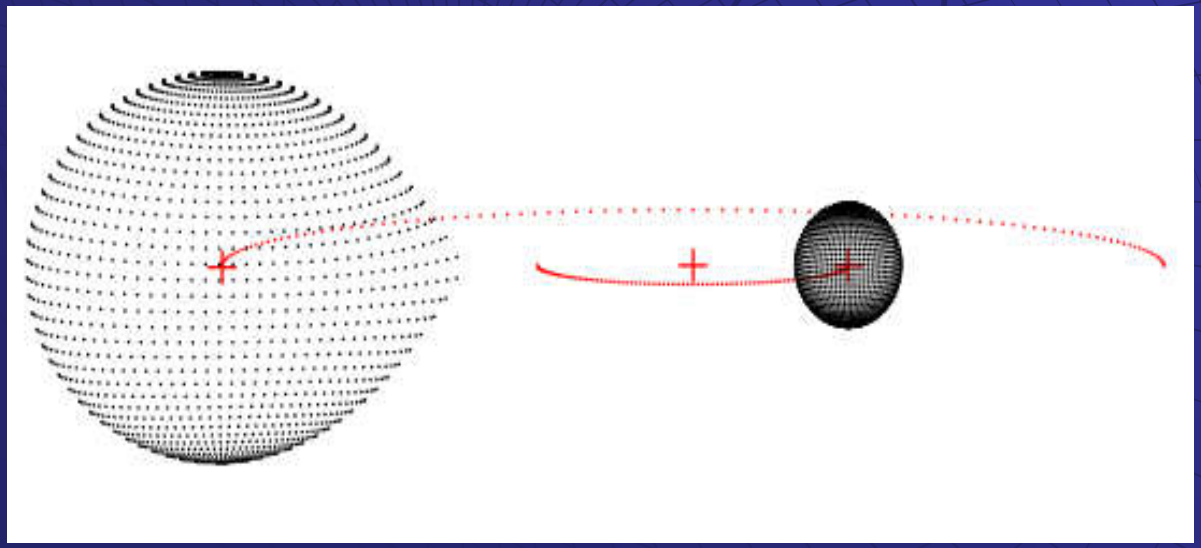


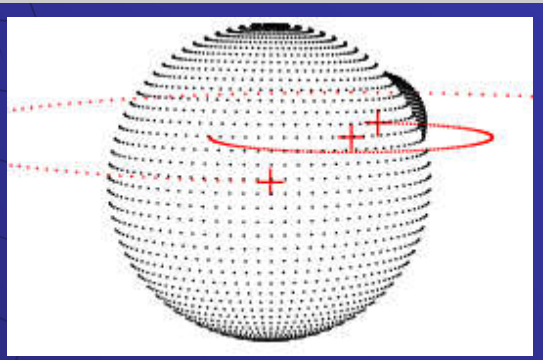
Semi-Detached System



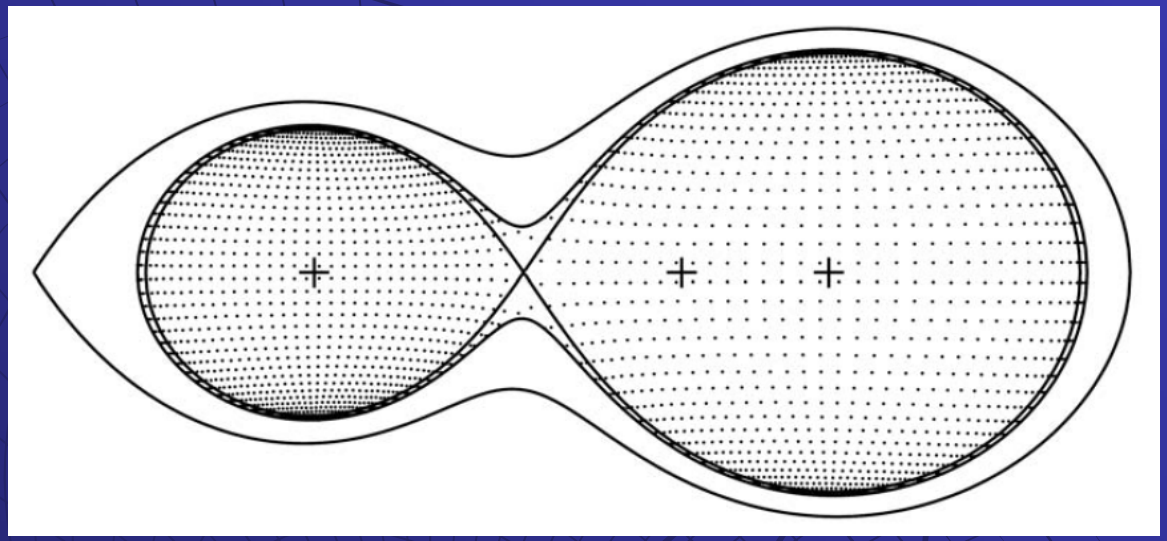


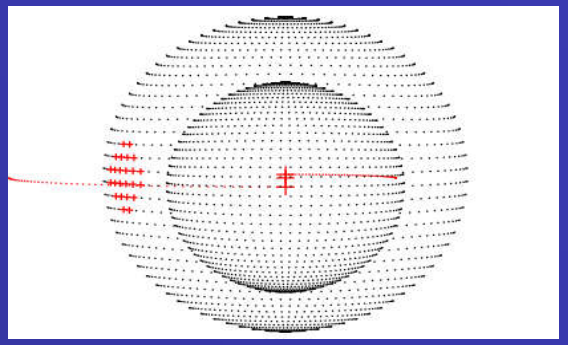


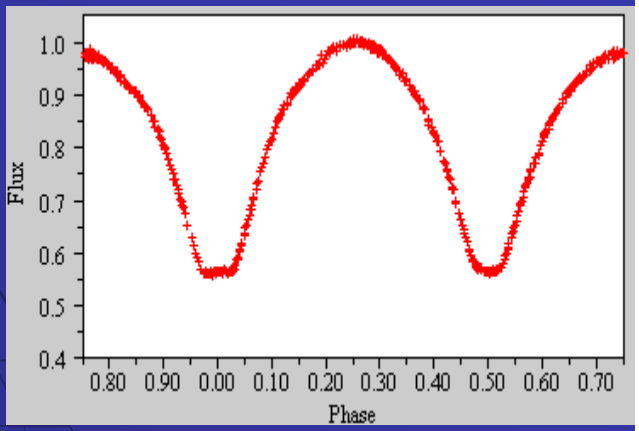


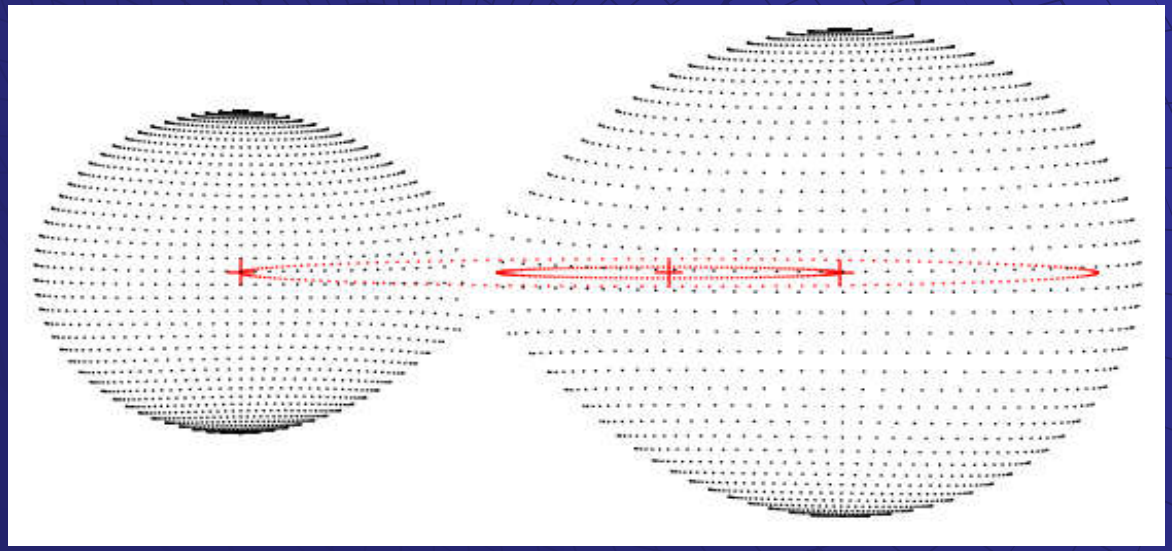


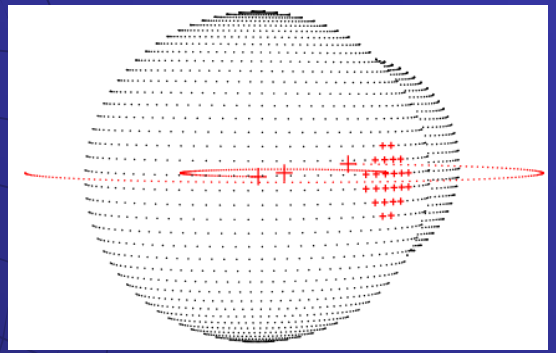
Over-Contact System





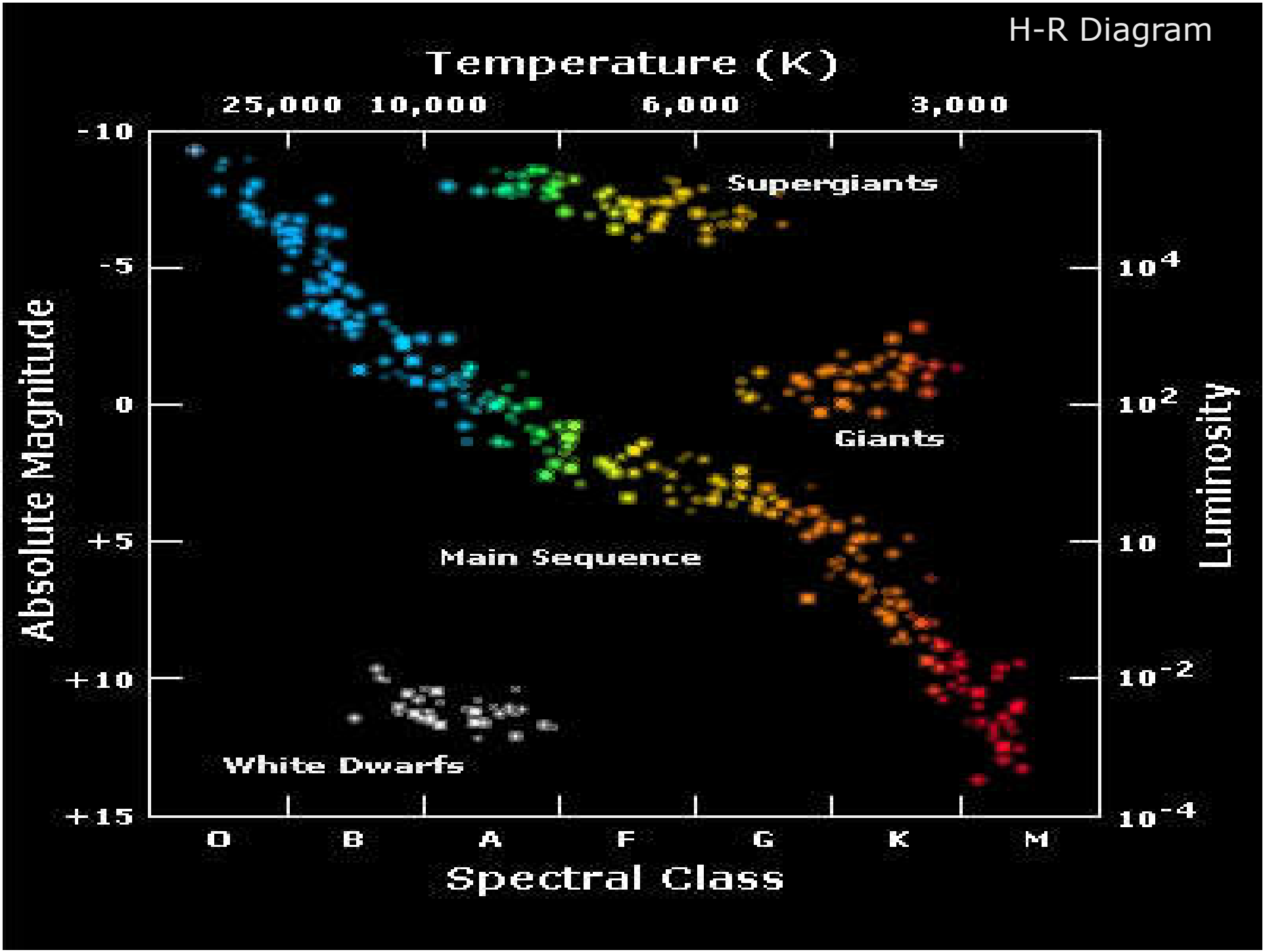






Properties of W UMa-type Stars

- Common Envelope
- Period < 1 day
- Spectral Range: A - K
- B-V constant over envelope
- ΔT approximately a few hundred degrees
- Subclasses : A-Type and W-Type


H-R Diagram
Temperature (K)
25,000
10,000
6,000
3,000
-10
-5
0
+5
+10
+15
Absolute Magnitude
Supergiants
Giants
Main Sequence
White Dwarfs
10^4
10^2
10
10^{-2}
10^{-4}
Luminosity
O
B
A
F
G
K
M
Spectral Class

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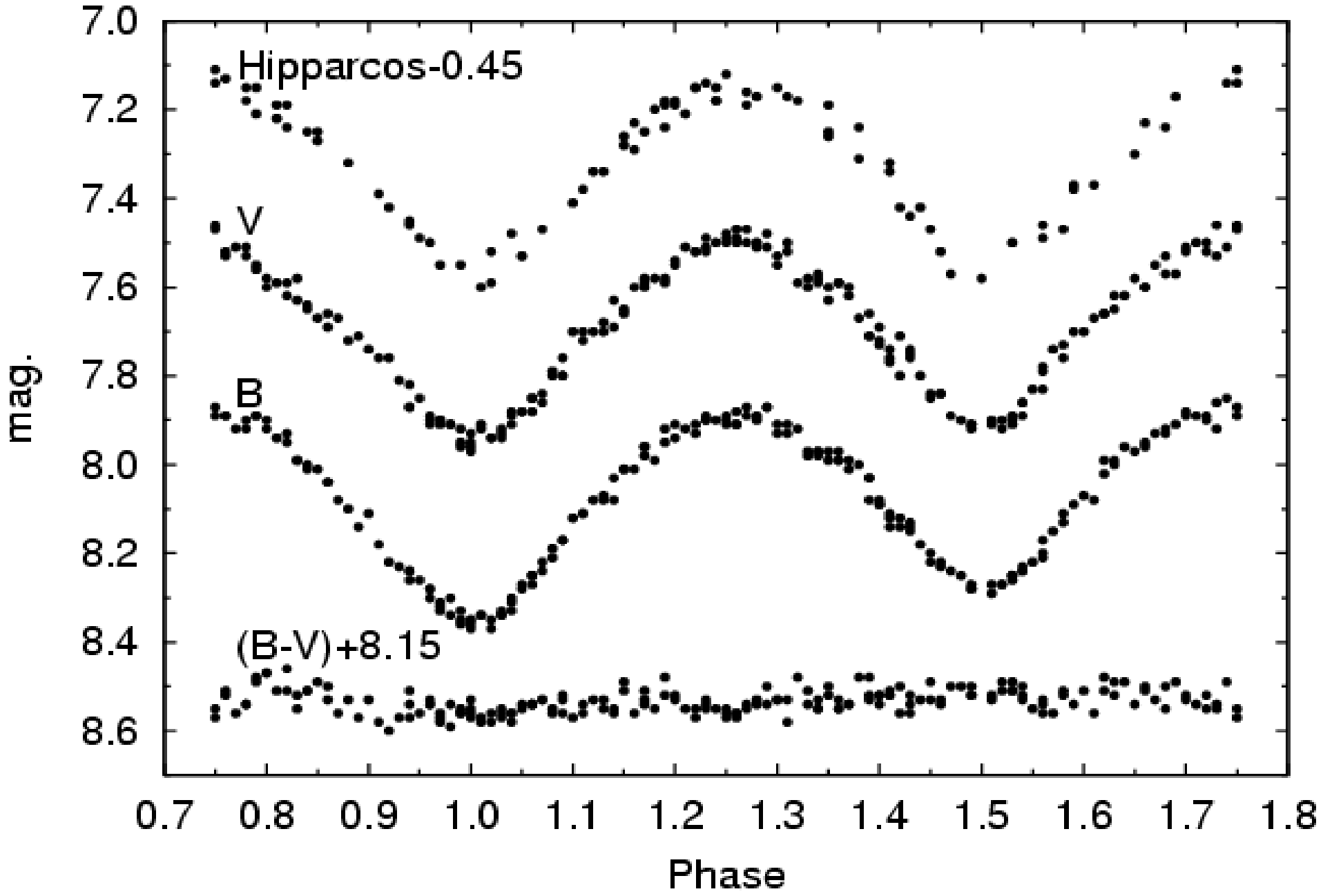
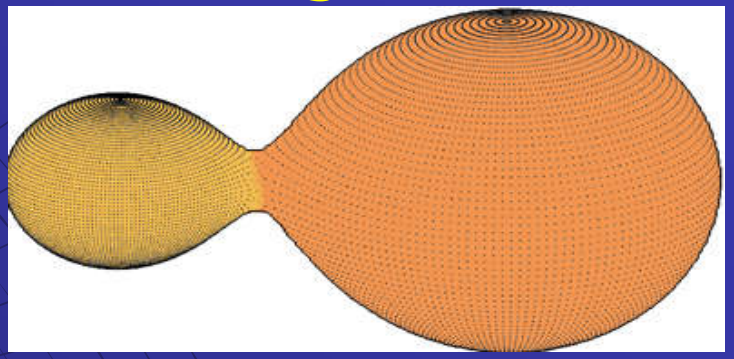

Hipparcos-0.45
V
B
(B-V)+8.15
mag.
Phase
7.0
7.2
7.4
7.6
7.8
8.0
8.2
8.4
8.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8

Properties of W UMa-type Stars

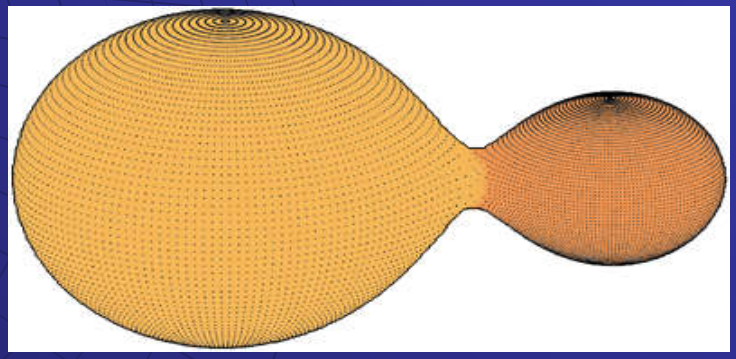
- Common Envelope
- Period < 1 day
- Spectral Range: A - K
- B-V constant over envelope
- ΔT approximately a few hundred degrees
- Subclasses : A-Type and W-Type

Subclasses

- A-Type
  - More massive component has higher temperature
  - Spectral Type A-F

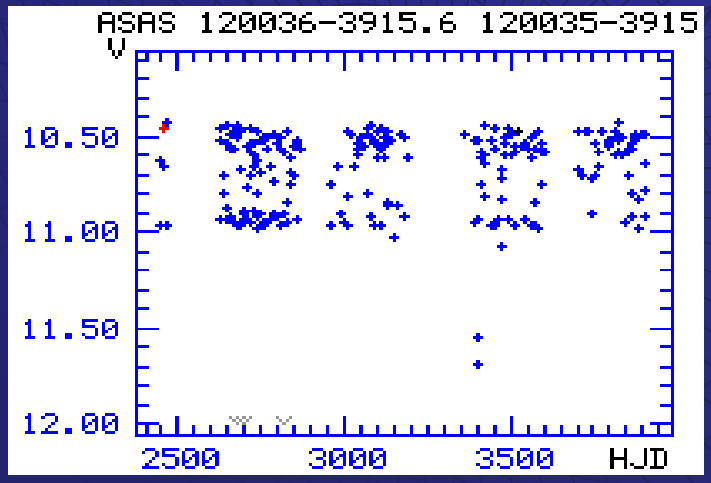


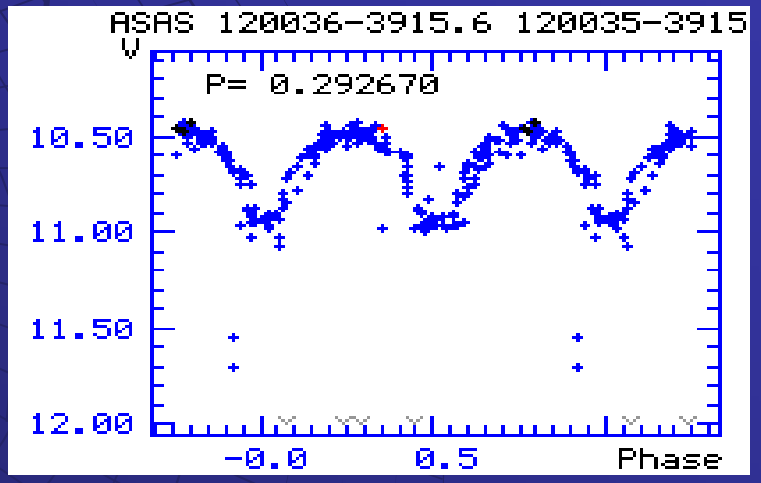
- W-Type
  - Less massive component has higher temperature
  - Spectral Type G-K



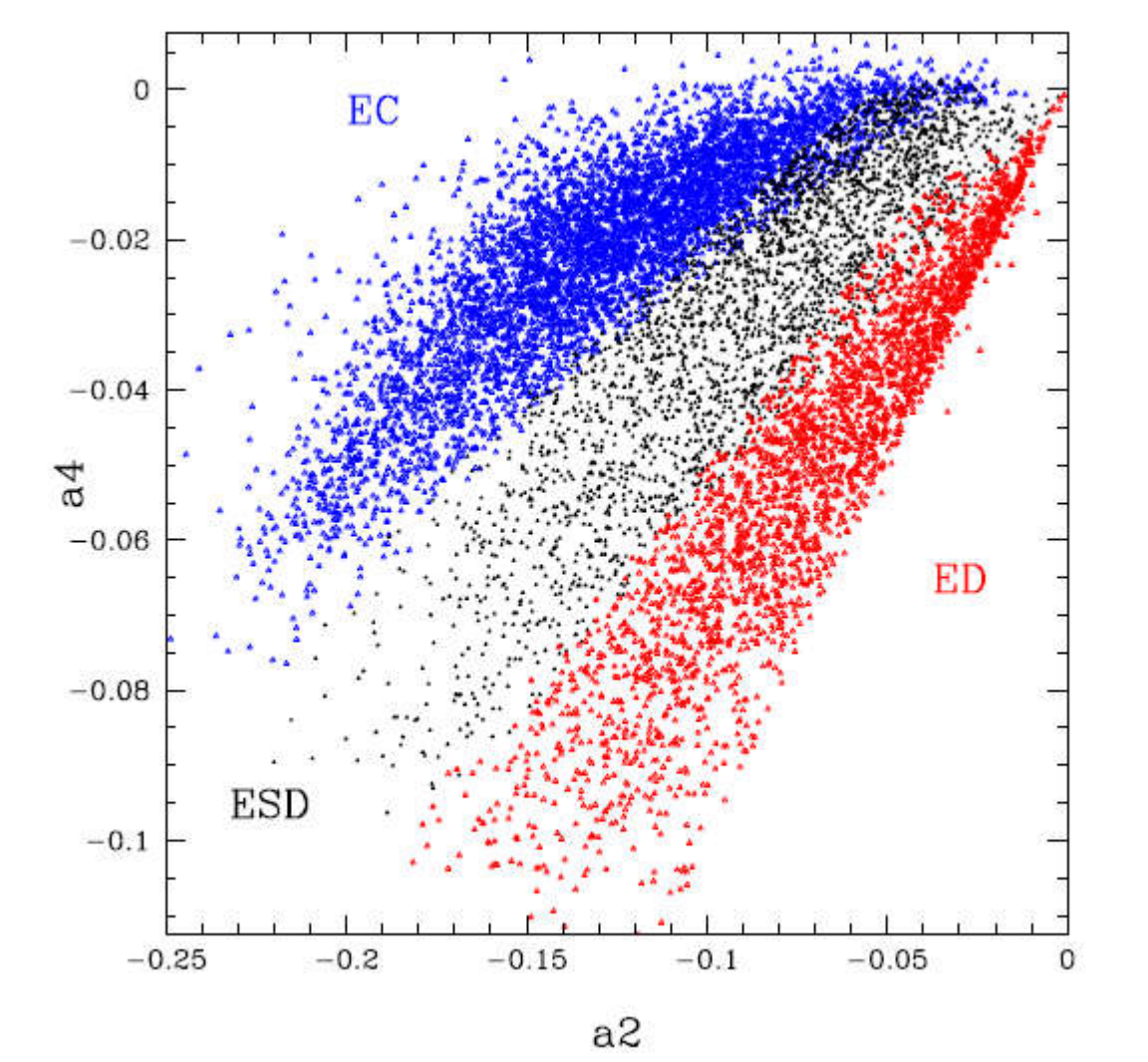
ASAS

- Las Campanas Observatory, Chile
- 7cm aperture telescope
- 50,000+ variable stars discovered
- Classification of stars done according to Fourier components
- EC, ESD, ED





$$V(t) = a_0 + \sum_{n=1}^{\infty} (a_n \cos n\omega t + b_n \sin n\omega t)$$

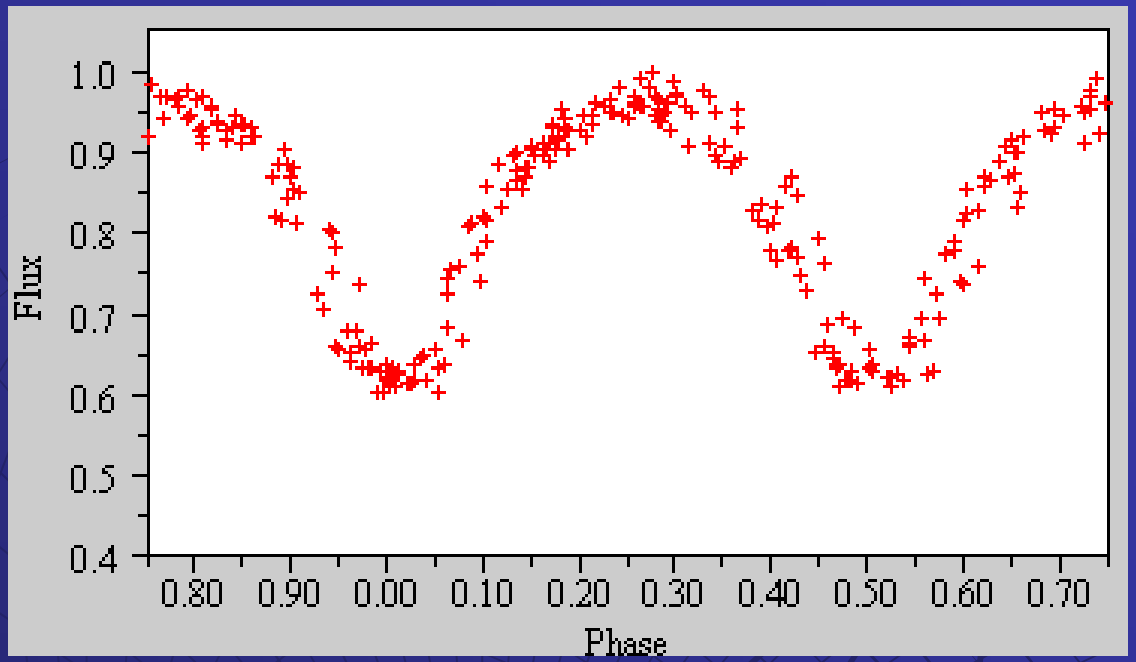


SuperWASP

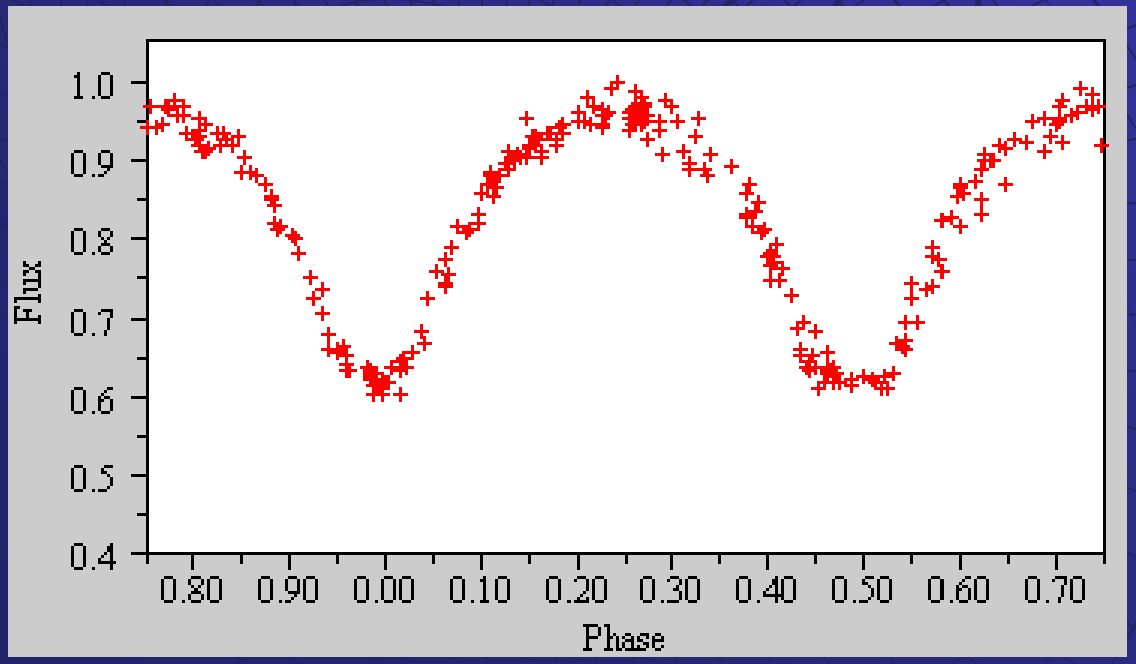
- Monitor sky for planetary transits
- Two robotic observatories:
  SuperWASP North: La Palma
  SuperWASP South: SAAO
- Eight wide angle cameras. Camera aperture 11.1cm

Data Modelling: ASAS

- Stars selected: period ≤ 0.4 days, brighter than 10^{th} mag
- Fold data using period
- Phase values: Fraction of the orbital cycle
- Phase-Magnitude Diagram



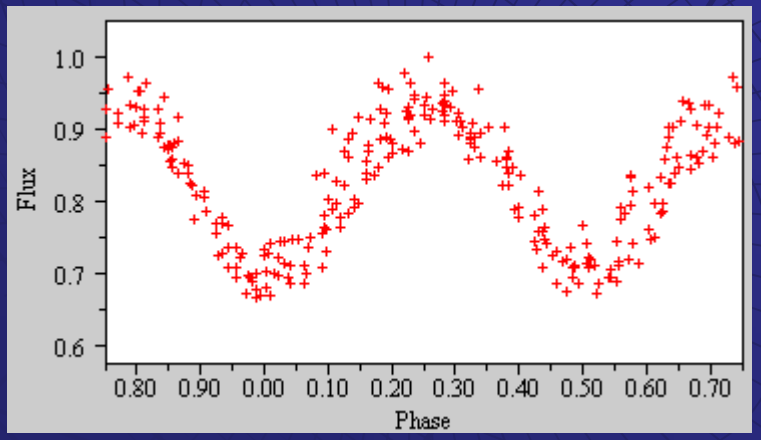
P = 0.292670 day



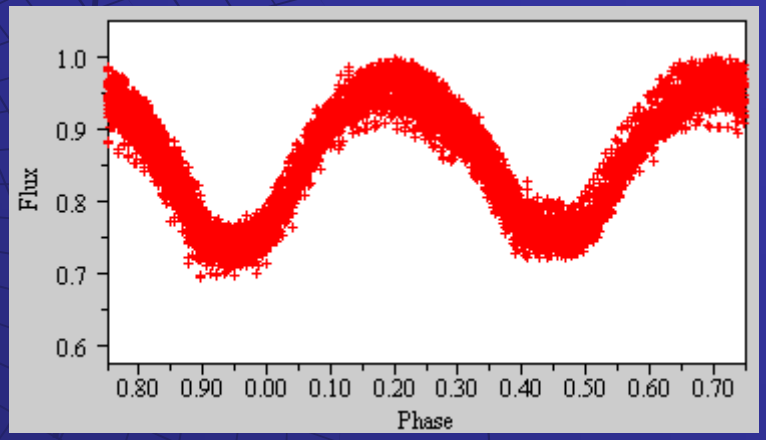
P = 0.292672 day

Data Modelling: WASP

- Same procedures used to obtain phase-magnitude diagrams
- More data to work with because observations are performed daily

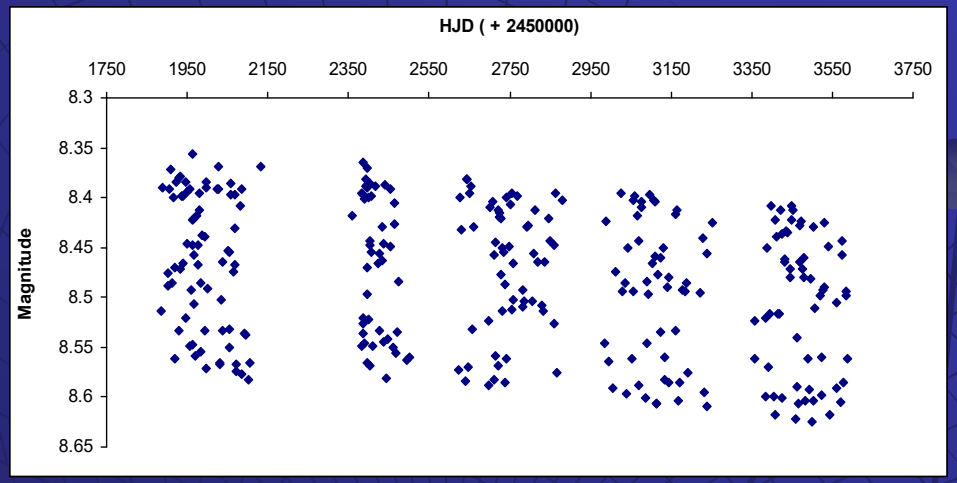


ASAS data



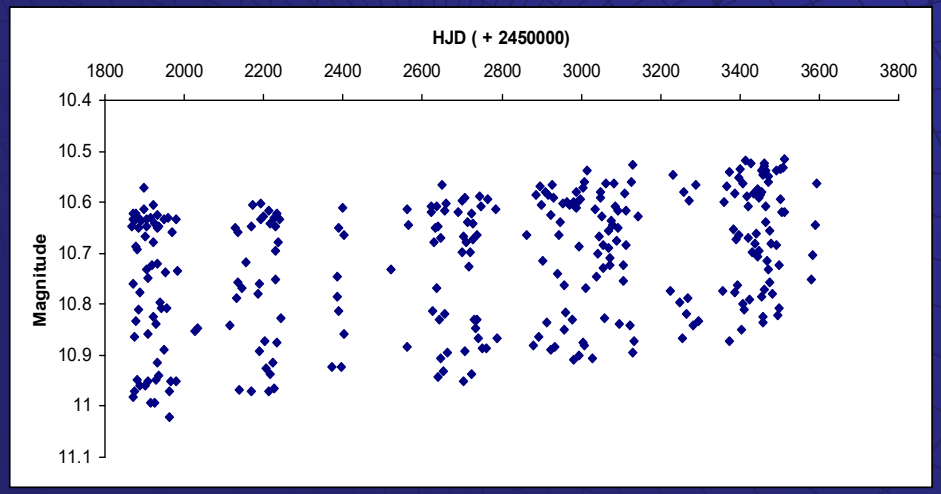
WASP data

Flux Changes



ASAS 133246-1745.5

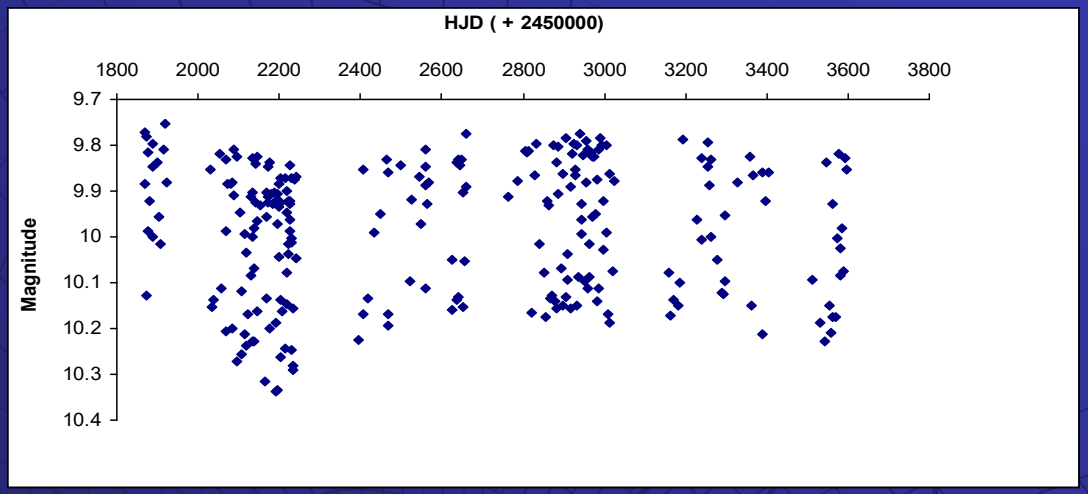
Decrease in flux



ASAS 062426-2044.9

Increase in flux

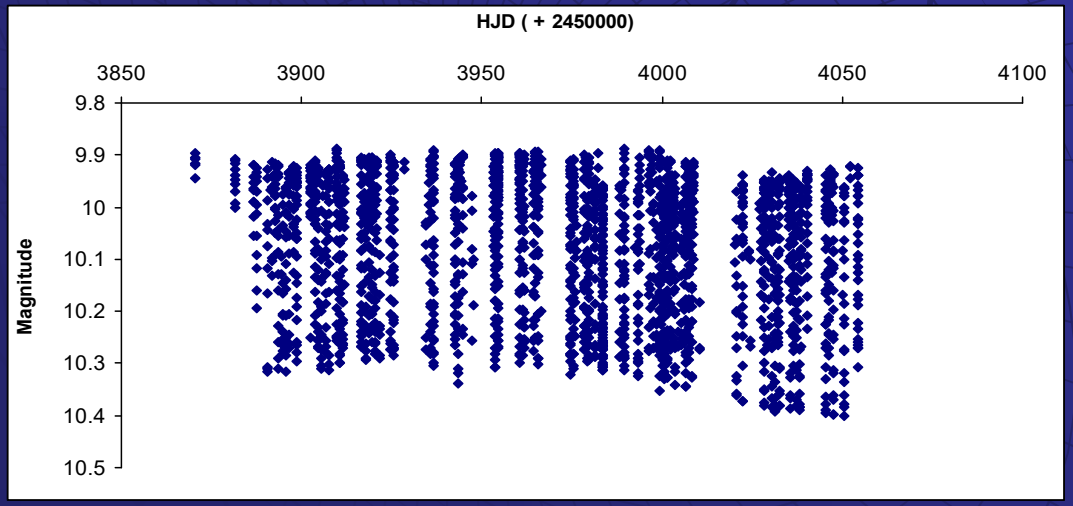
Flux Changes



ASAS 002328-2041.8

ASAS data

Combined increase & decrease

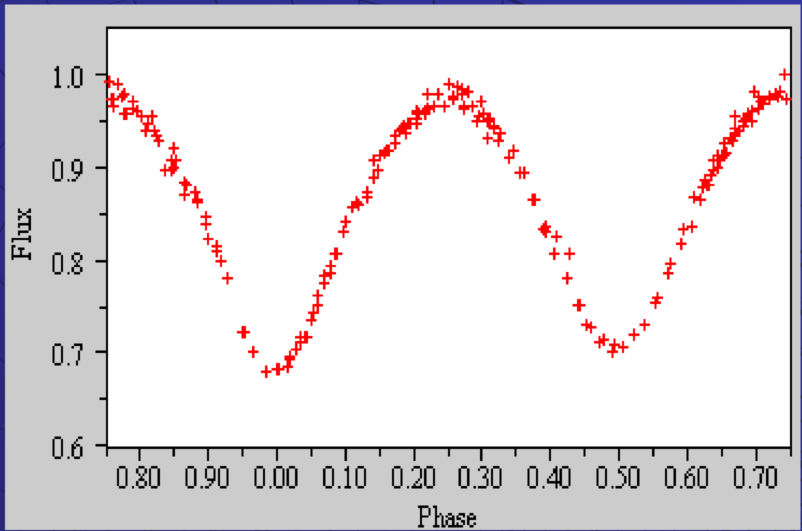


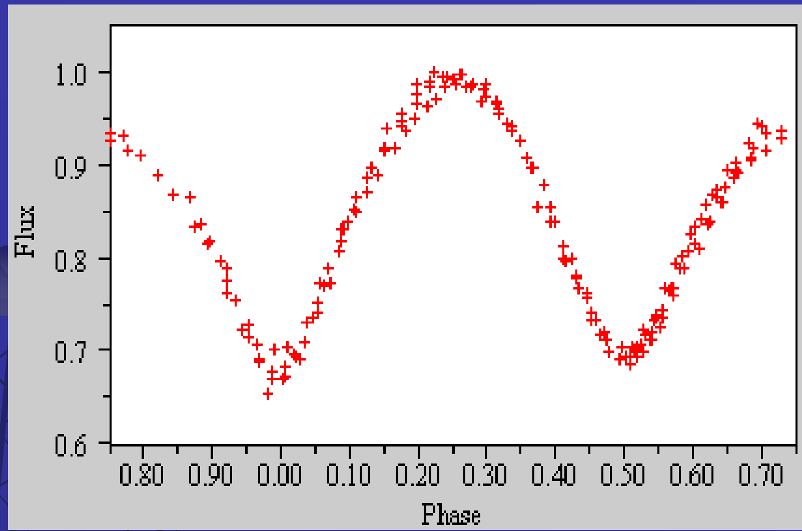
WASP data

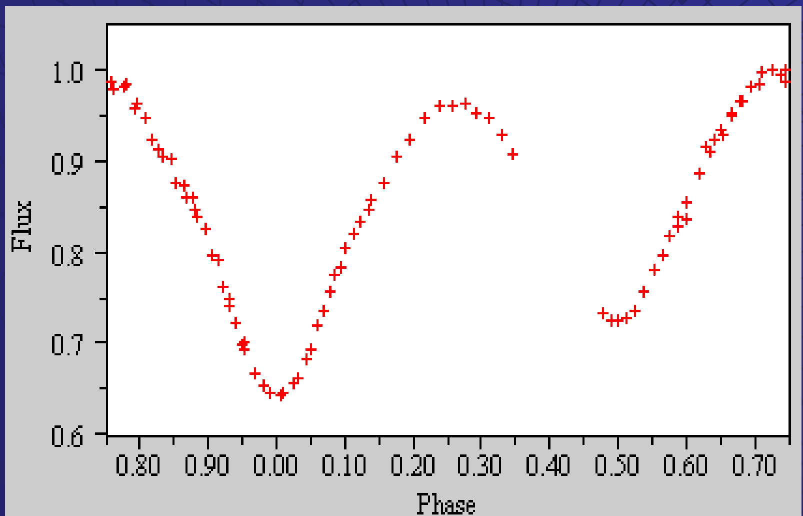
Hidden features: Interesting stars

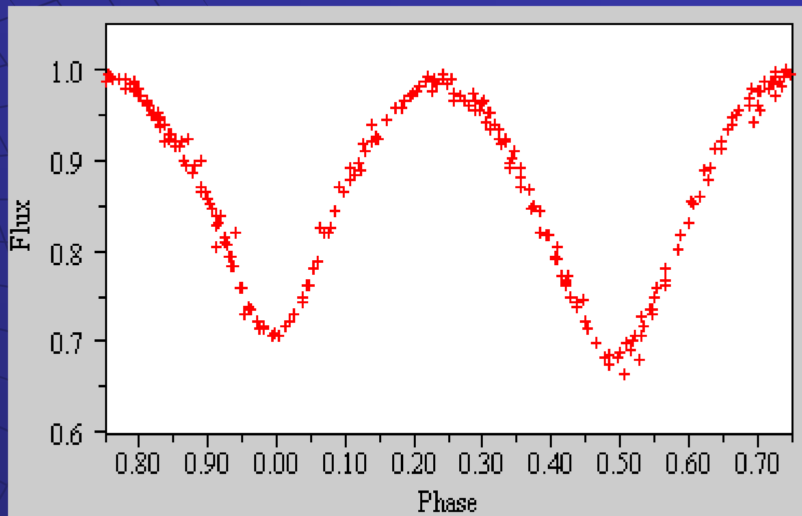
- Sometimes, certain features are hidden in the combined light curve
- Splitting the data into smaller intervals reveals many things

Interesting stars



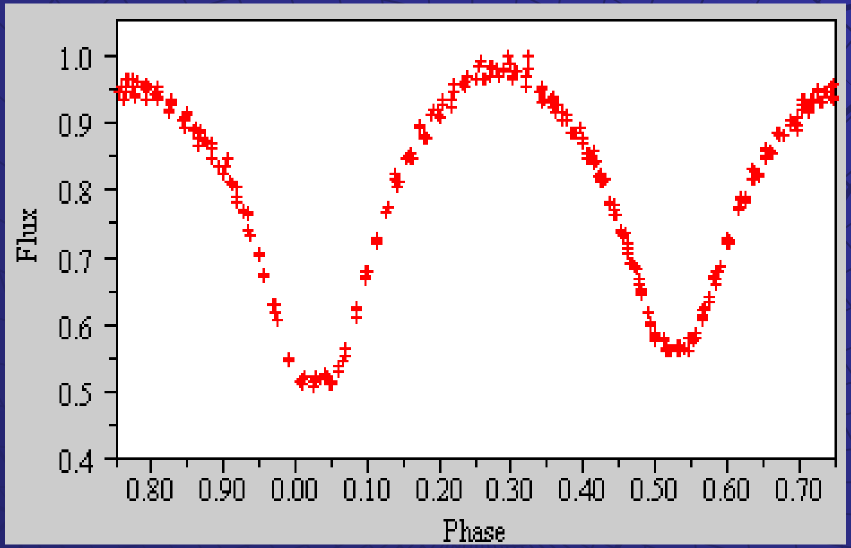


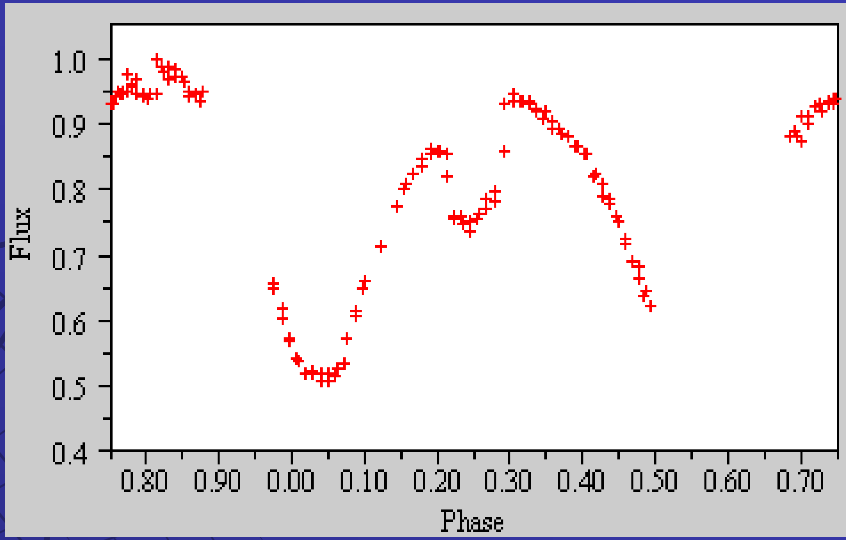


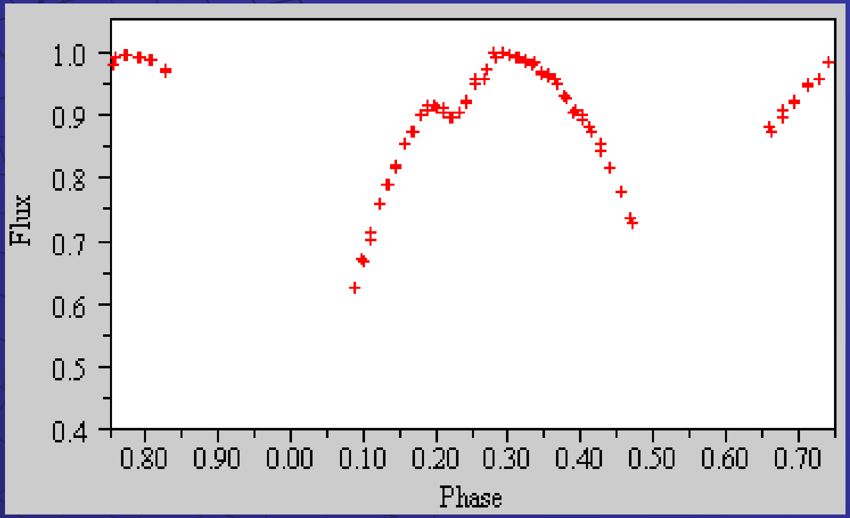


ASAS 002328-2041.8

Unexplained dips

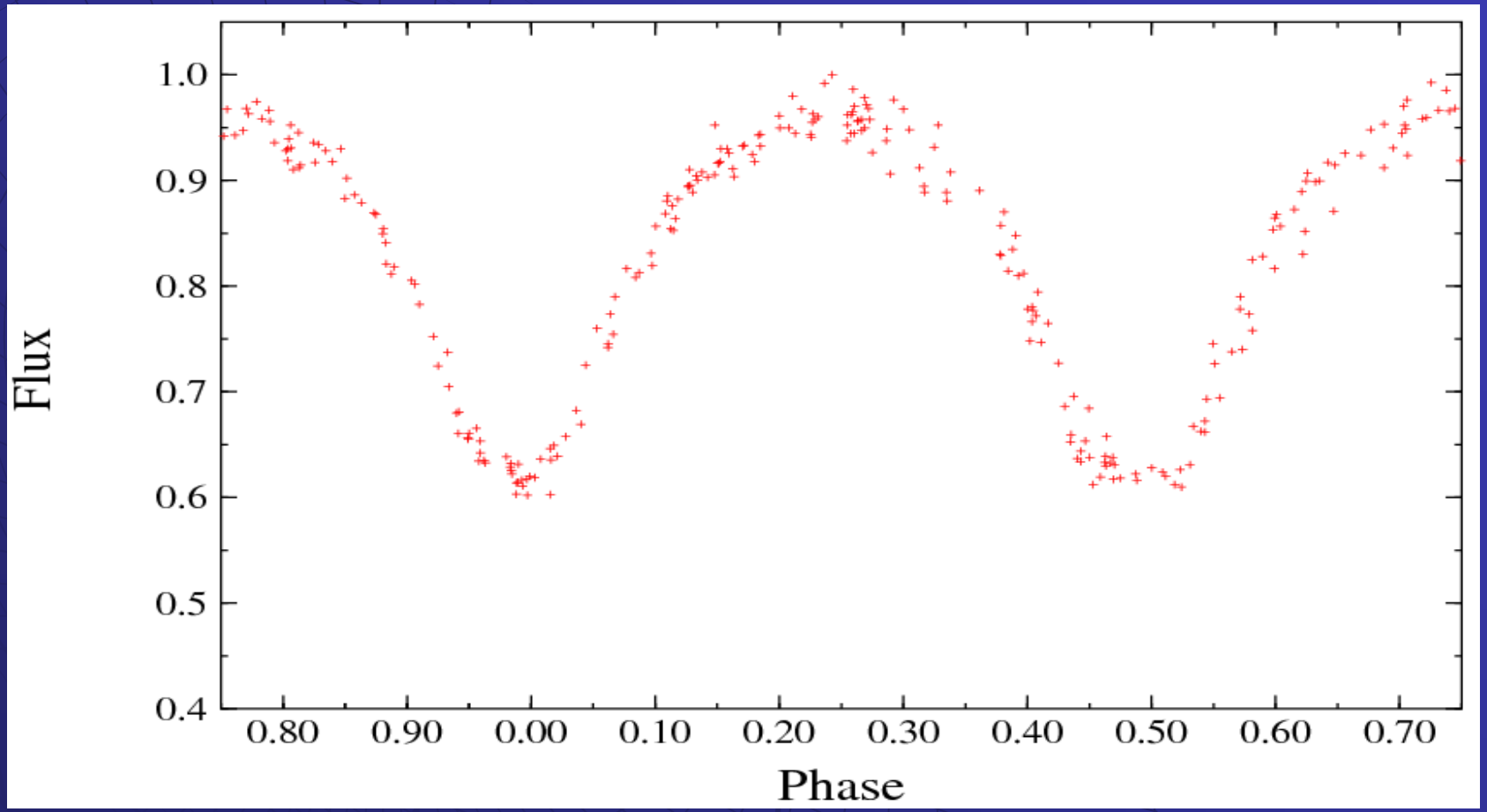






ASAS 150452-3757.7

ASAS 120036-3915.6



The Crossdresser

- Period – W-type
- Spectral type – W-type
- Mass ratio – A-type
- Temperature – Possibly A-type

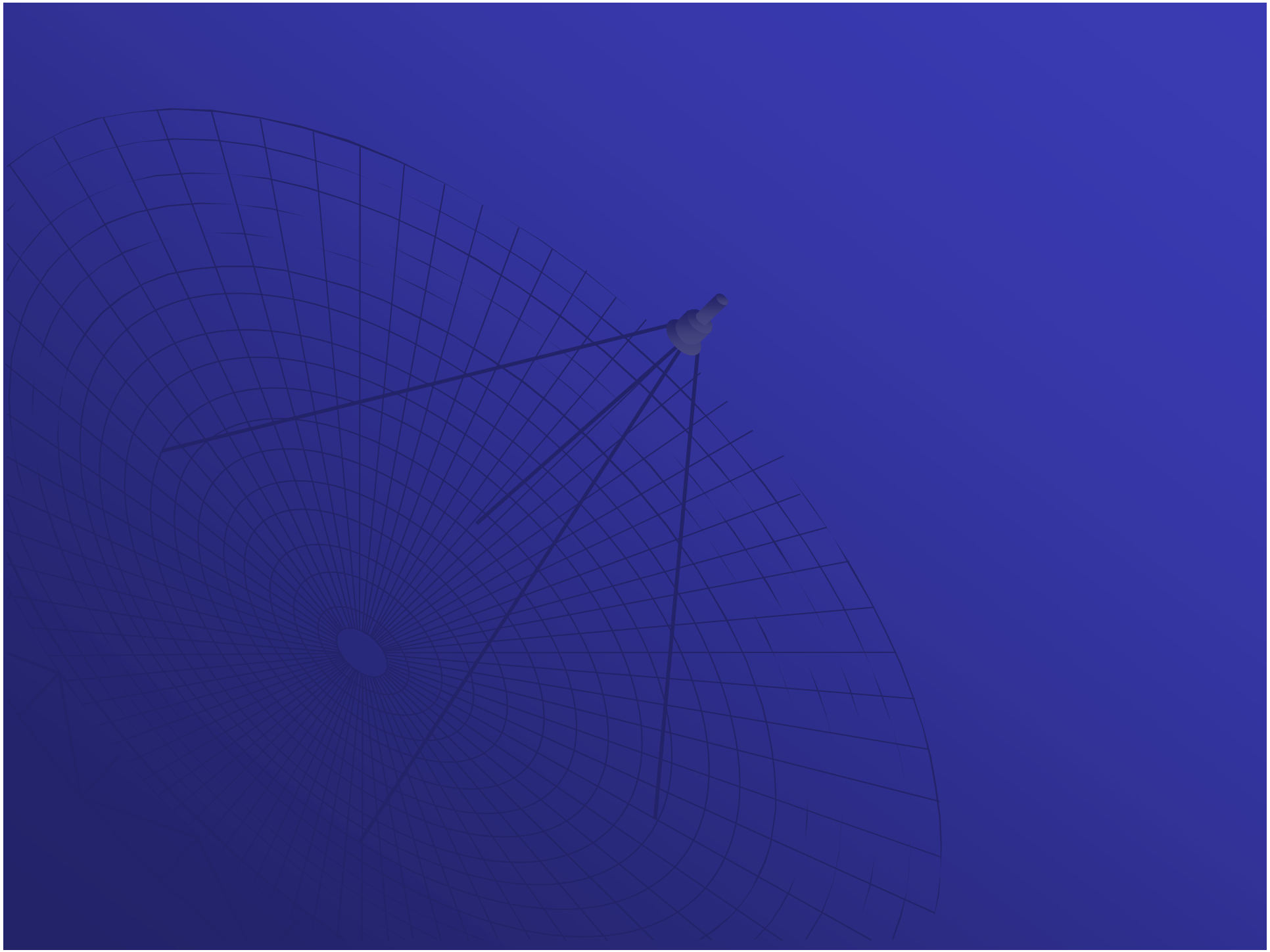
Unanswered Questions

- EW stars: How do they form and what do they become?
- Complex pattern of period changes
- Common Envelope: Uniform temperature. Why?

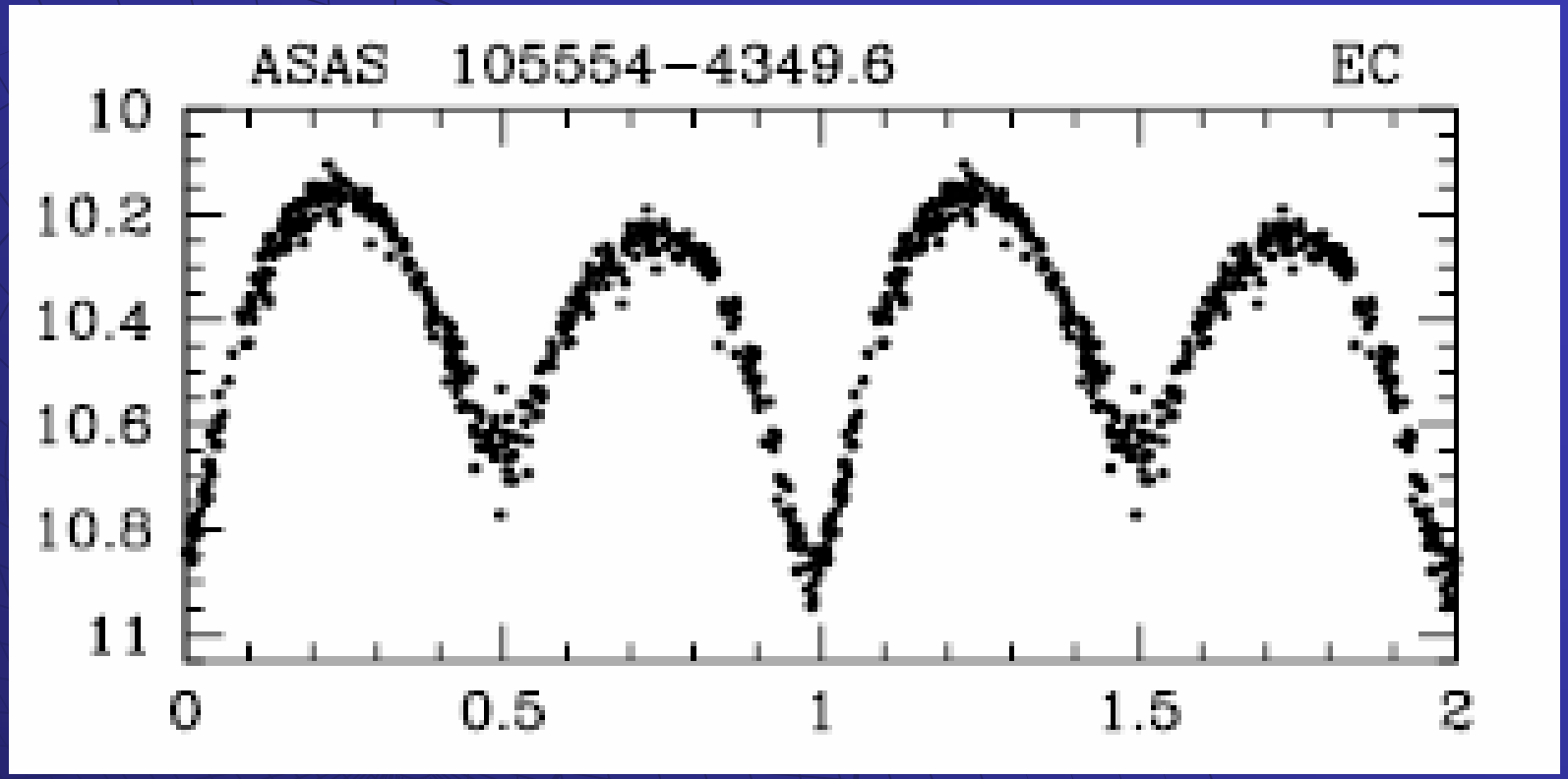
Future Research

- Period changes – O-C diagram
- APT observations
- Radial velocity measurements: Mass ratios
- Surveys for radio emission from spots

ASAS 120036-3915.6

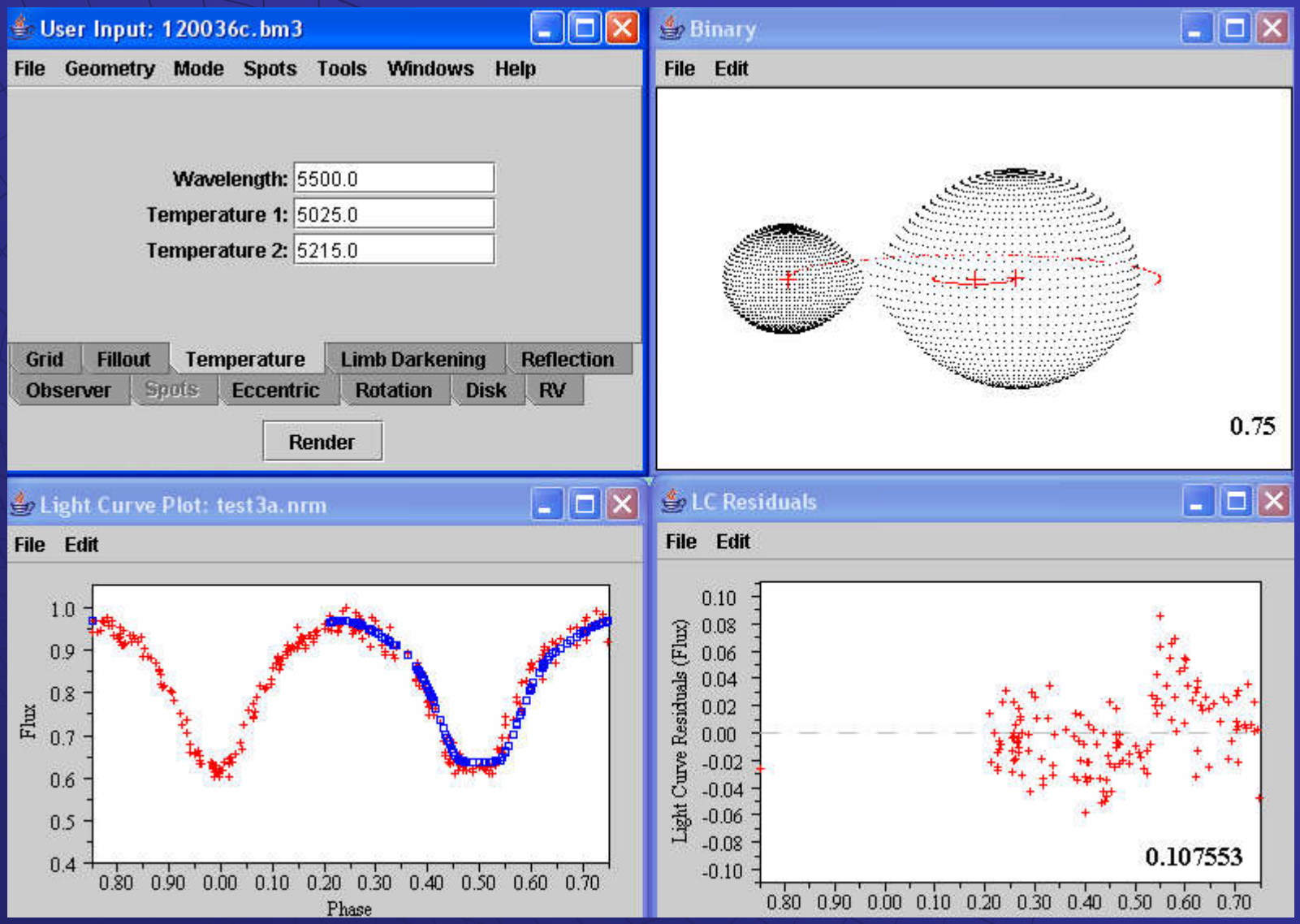


The O'Connell Effect



- Maxima Different Height
- Magnetic Activity: Spots

Data Modelling: Binary Maker 3.0



Total Eclipsing Systems