A Photometric/Spectroscopic Study of Eclipsing Binary AQ Ser

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Background

Close eclipsing binary stars:

- Close: Orbital periods are typically no longer than a few days
- Eclipsing: The plane of orbit coincides with our line of sight
- Binary stars occur with >50% frequency

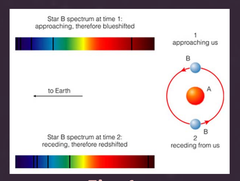

Fig. 1 shows the shift in spectral lines as the stars move towards or away from Earth. Fig. 2 shows the dip in light intensity when one star eclipses its companion.

Fig. 1

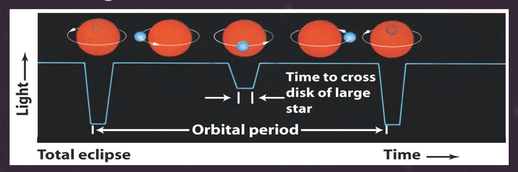

Fig. 2

Why study them?

- Unique properties (close, eclipsing) are optimal for determining the many fundamental properties of stars
- More properties, higher accuracy, less time
- Known properties can be tested against current stellar evolution models

Observations

Gathering images:

- URSA telescope
  - 10" Meade Schmidt-Cassegrain
  - SBIG ST-8 CCD camera
- Over 3000 images in 60 sec exposures
- April 2003 → May 2007
- 11 additional minima from literature

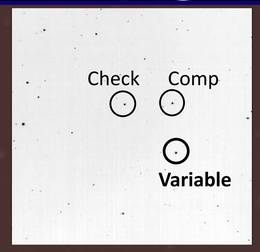

Fig. 3

Image of AQ Ser taken by the NFO telescope in New Mexico. Two comparison stars are used to guard against inaccuracies from dimness or changes in the sky. This is known as differential photometry.

Measuring the images:

- *Multi-measure*: Measures the magnitude of the variable and two comparison stars

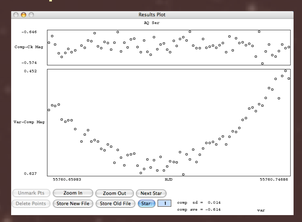

Fig. 4

The minimum shows that this is an eclipse. The random distribution of check-comp. magnitude increases confidence in the validity of the data points.

- *Multi-minima*: Determines exact dates of eclipses
- *Dates of minima*: Distinguish between primary and secondary minima; find period

Modeling

Light Curve:

- Generated by *Multi-minima*
- Stars have approximately the same radius and luminosity

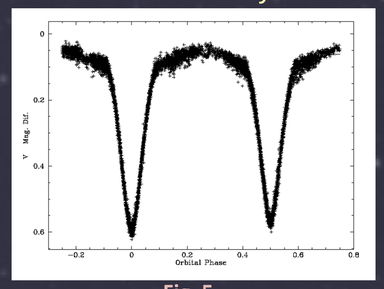

Fig. 5

JKTEBOP:

- Eclipsing Binary Orbit Program
- Some parameters vary, others constant
- Output: Physical properties of stars in ratio form

Radial-Velocity Curve:

- Plots each star's velocity relative to Earth by orbital phase
- Very circular orbit

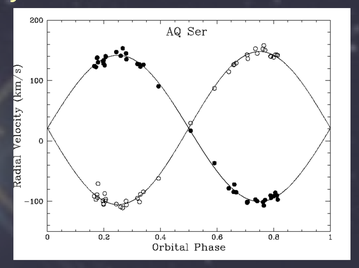

Fig. 6

GLSPL

- General Least Squares with Plotting
- Input: 41 radial velocity measurements from G. Torres
- Output: Orbital parameters (eccentricity, system velocity, etc.)

YY Models

- Shows evolutionary track of stars on a diagram similar to H-R diagram but with gravitational constant g replacing luminosity
- Stars are in post-main sequence!

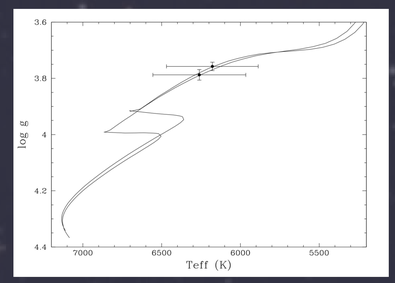

Fig. 7

Results

Absolute Properties:

- MRLCALC for initial properties
- Phoebe: More complete model than JKTEBOP, takes into account tidal distortion

	MRLCALC	PHOEBE
Mass(p)	1.305 (0.022)	1.308
Mass(s)	1.364 (0.024)	1.364
R(p)	2.415 (0.032)	2.428
R(s)	2.556 (0.022)	2.570
Log(g) p	3.787 (0.011)	3.784
Log(g) s	3.757 (0.007)	3.754
Log (L) p	0.908 (0.076)	0.969
Log(L) s	0.934 (0.075)	0.943

Ephemeris: Min 1 = 1.687n + 53499.541
Metallicity: 0.0085

Age of primary: 3.07 gyr
Age of secondary: 3.28 gyr
***Ages are within 6% agreement, satisfying the requirement of 10% from YY models, thus further confirming the theory.**

Interesting fact: AQ Ser stars are post-main sequence, which is very rare since it is a small fraction of a star's life cycle!

Acknowledgements

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