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A comparison between the orbital masses of early type binary stars and masses predicted by stellar evolution

ABSTRACT

The masses of early type single stars can be determined in three independent ways:

1. Comparison of the observed HRD-position of the star with evolutionary tracks.
2. Comparison of an observed photospheric spectrum with theoretical spectra using a non-LTE code.
3. Comparison of measured values of v_∞ from P Cygni profiles with values calculated theoretically from a radiatiatively driven wind theory.

The masses computed with the first method are about 40% larger than the results predicted by the second and third method (see e.g. Kudritzki et al., 1986; Simon et al., 1983)

In order to find the answer to this discrepancy, we consider a number of binary components, for which an independent orbital mass can be computed.

BINARY SYSTEMS

The number of binary systems, for which the three methods can be applied is limited because they have to fulfil several conditions:

The binaries contain nonevolved main sequence stars. The systems are detached and the primary component is of spectral type O or early B.

If the sytem is eclipsing, the luminosity (needed to use method 1) can be computed from the effective temperature and the radius (which is determined from light curve analysis). For other systems, the distance must be known.

We found 6 binaries which fulfil all these conditions: the four eclipsing systems CWCep, V453Cyg, V478Cyg and YCyg and the two systems HD93205 and HD217312.

For the eclipsing systems, the values (with their errors) of the orbital masses, luminosities and effective temperatures, are those determined by Popper (1980). Comparison with evolutionary tracks (Maeder, 1990) yields the mass range for the primary.

In table 1, the orbital masses of the primary of the 4 eclipsing binaries are compared with their masses, determined from evolutionary calculations.

Table 1:
column 1: name and HD number of the 4 eclipsing systems.
column 2: spectral type of the primary (Popper, 1980).
column 3: orbital mass range of the primary (Popper, 1980).
column 4: mass range of the primary, determined from comparison with evolutionary calculations.
The masses are given in $M_\odot$.

star	spectral type	orbital mass range	mass range from evolution
YCyg HD 198846	O9.8	16.2 - 17.2	13.80 - 17.25
V478 Cyg HD 193611	O9.8	14.9 - 16.3	15.58 - 18.03
V453 Cyg HD227696	B0.4	13.3 - 15.7	15.77 - 17.94
CWCep HD 218066	B0.4	11.6 - 12	12.4 - 15.54

For HD93205 and HD217312, the errors in luminosities and effective temperatures are not well known. Table 2 gives the mass of the primaries of these two systems, for which the orbital inclination angle is not known, so that we can only give a lower value for the orbital mass.

Table 2:
column 1: name and HD number.
column 2: spectral type of the primary (Humphreys, 1984).
column 3: orbital mass, from Batten (1989).
column 4: mass of the primary, determined from comparison with evolutionary calculations. The effective temperatures and luminosities are from Humphreys (1984).
The masses are given in $M_\odot$.

star	spectral type	orbital mass	mass from evolution
HD 93205	O9.8	≥ 57	≈ 60
NYCep HD 217312	B0.5	≥ 27	≈ 15

For four X-ray binaries with an O or B type component, we compared the orbital mass of this component with the mass determined from evolution (see table 3). The difference between the orbital and evolutionary mass of these four components is much less than 40%.

Table 3:
column 1: name of the X-ray binary.
column 2: spectral type (Joss, 1984).
column 3: orbital mass range of the primary (Joss, 1984).
column 4: mass of the primary, determined from comparison with evolutionary calculations.
The masses are given in $M_{\odot}$.

star	spectral type	orbital mass range	mass from evolution
SMC X-1	B0.5 I	13 - 21.5	≈ 14
Cen X-3	O6.5 IIIe	16.5 - 25	≈ 24.5
Vela X-1	B0.5 I	21.5 - 26.5	≈ 21
4U1538 - 52	B0I	12 - 30.5	≈ 20

CONCLUSIONS

The orbital masses are in good agreement with the masses, obtained from a comparison with evolutionary tracks, except for NYCep, where the orbital mass is much higher than the evolutionary mass.

A premilimiary conclusion may be that the masses, predicted by evolutionary computations are more reliable than those predicted from a non-LTE theory or from a radiatively driven wind theory.

FUTURE WORK

We will apply the second and third method on the binary components mentioned in tables 1 and 2.

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