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STELLAR MASSES DERIVED FROM THE BINARY HD 217312

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ABSTRACT

It is shown that the component stars of the binary HD 217312 have masses of 27 ± 2 and $13 \pm 1\ \mathfrak{M}_\odot$. The absolute bolometric magnitudes of the two stars are -6.2 ± 0.4 and -5.2 ± 0.4, respectively.

Subject headings: associations — eclipsing binaries — mass-luminosity relation — stars, individual

HD 217312 is an early-type double-lined spectroscopic binary which is a member of the III Cephei association. These facts, together with recent discoveries that it is also an eclipsing system, make HD 217312 of some importance since they permit relatively accurate masses and absolute magnitudes to be derived which help define the as yet rather poorly established upper end of the mass-luminosity relation.

Heard and Fernie (1968) have given a detailed analysis of the system as a spectroscopic binary, deriving $\mathfrak{M}_1 \sin^3 i = 27 \pm 2$ and $\mathfrak{M}_2 \sin^3 i = 13 \pm 1\ \mathfrak{M}_\odot$. From fairly extensive photometric observations they concluded that the system is not an eclipsing one. Subsequently, however, Madore and Percy (1973) and Rao (1972) found that the system does eclipse, the eclipse being only about 0.1 mag deep and lasting only for a few hours in the 15-day cycle. Although the light-curve is not yet well enough known to derive the inclination and radii, it is the purpose of this note to show that the fact of eclipses being present at all is sufficient to establish the masses to within the errors given by the spectroscopic orbit.

Simple geometry shows that the minimum inclination for eclipses to occur is given by

$$\cot i = (R_1 + R_2)/D ,$$

where R_1 and R_2 are the radii of the stars and D is their projected separation at the time of eclipse. The spectroscopic orbit gives $D = 68 \pm 3\ R_\odot$, while the radii, derived from the absolute magnitudes discussed below and effective temperatures of 26,000° appropriate to the stars each having a spectral type of B0.5 V, are $R_1 = 7 \pm 2$ and $R_2 = 5 \pm 1\ R_\odot$. These errors include an uncertainty of 1500° in the effective temperatures and of 0.4 mag in the absolute magnitudes. The resulting minimum inclination ranges between 77° and 82°; even for the lower figure $\sin^3 i = 0.925$, so that $\mathfrak{M}_1 = 29$ and $\mathfrak{M}_2 = 14\ \mathfrak{M}_\odot$, which are not significantly different from the minimum masses given by Heard and Fernie. In fact, the eclipse is more than just grazing, and a simple calculation shows that the most likely inclination for an eclipse depth of about 0.1 mag is around 85°. In this case the minimum masses are increased by only a few tenths of a solar mass. It is concluded that the most likely masses for these stars are 27 ± 2 and $13 \pm 1\ \mathfrak{M}_\odot$.

The absolute magnitudes of the two stars can be found from their membership in the III Cephei association (Garrison 1970). It may be noted that although the ratio of total to selective interstellar absorption in this association is controversial (Garrison 1970), this does not enter into the assigned absolute magnitudes. The latter are essentially assigned on the basis of the position in the H-R diagram of HD 217312 relative to the other association members. The absolute magnitudes are $M_{V_1} = -3.6$ and $M_{V_2} = -2.6$, employing the luminosity ratio found by Heard and Fernie. The likely uncertainty in these magnitudes is about ± 0.3 mag.

An alternative estimate of the absolute magnitude, at least of the primary, may be had by considering the probable evolutionary state of the system. III Cephei is one of the youngest of associations (Garrison 1970), and one might therefore suppose that the two stars of HD 217312 are both still on the zero-age main sequence (ZAMS). Adopting Garrison's spectral type of B0.5 V for the primary (see below), which corresponds to $(B - V)_0 = -0.29$, the ZAMS absolute visual magnitude is then -3.0. This is slightly fainter than the value derived above, but leads to a radius which is only 1 $R_\odot$ smaller than the previously derived value: an insignificant difference. If anything, it leads to a value of i still closer to 90°, and so strengthens the conclusion regarding the masses, but at the same time the diminished luminosity would slightly degrade the positions of the stars in the mass-luminosity plane (see fig. 1).

Heard and Fernie, from relatively high-dispersion spectrograms, assigned a spectral type of B0 IV to each star. Garrison, from classification-dispersion plates on which only the primary spectrum was visible, assigned a type of B0.5 V. Harris (1963), Morton and Adams (1968), and Morton (1969) are in reasonable agreement that the bolometric correction for this spectral type is -2.6 ± 0.2 mag. The absolute bolometric magnitudes of the two stars are therefore -6.2 ± 0.4 and -5.2 ± 0.4.

Figure 1 shows the brighter end of the mass-luminosity relation with the position of the two HD 217312 stars indicated by crosses, the remaining points on the diagram being taken from the compilation by McCluskey and Kondo (1972).

In conclusion, reference should be made to the disquieting result found by Heard and Fernie, *viz.*, that the component stars of HD 217312 appear to have significantly different systemic velocities: $\gamma_1 = -15 \pm 2 \text{ km s}^{-1}$, $\gamma_2 = +17 \pm 6 \text{ km s}^{-1}$. This phenomenon is known also in a number of other systems (see, e.g., Wilson 1940; Abhyankar 1959; Peery 1966), but almost invariably in these other cases there is additional evidence that the system is peculiar, particularly that gas-streaming effects are present. In HD 217312, however, there is no evidence at all for gas-streaming, and none is to be expected in so well-detached a system. Even at the minimum projected

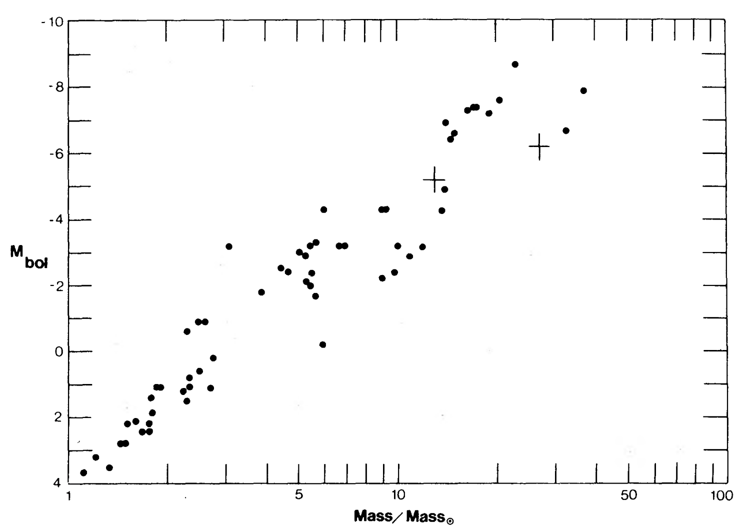

FIG. 1.—The brighter end of the mass-luminosity relation. The positions of the HD 217312 stars are shown by crosses, the sizes of which indicate the uncertainties in absolute magnitude and mass. The remaining points are from McCluskey and Kondo (1972).

separation of 45 $R_\odot$, the primary star fills only about 4 percent of the volume of its Roche lobe. For the same reason reflection effects are unlikely to be significant. Nevertheless, whatever causes the phenomenon may also, in some unsuspected manner, cause a distortion of one or both of the velocity curves, in which case the masses derived here might be erroneous.

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