THE DISTANCES TO RR LYRAE VARIABLES

Rodney V. Jones and Bruce W. Carney

University of North Carolina

David W. Latham and Robert L. Kurucz

Harvard-Smithsonian Center for Astrophysics

Of all the different methods employed to estimate the mean absolute magnitude of RR Lyrae variables, only an analysis of the Baade-Wesselink type can determine this quantity directly. The distance to a globular cluster can therefore be measured by determining $<M_V>_{RR}$ for that cluster instead of being forced to assume that $<M_V>_{RR}$ is the same as that of the nearby field variables. This is important in that the field stars may have a different luminosity than cluster variables. In addition, since $<M_V>_{RR}$ should depend on the composition (especially helium) and history of mass loss of these stars, this quantity may vary from cluster to cluster.

Direct measures of the distances to the nearer globular clusters are now feasible with the Baade-Wesselink method due to the implementation of efficient spectrographs and detectors such as the digital speedometer on the MMT (Latham 1985; Wyatt 1985). We have successfully applied a version of this technique, the surface brightness method, to the nearby field variables X Ari ([Fe/H] ~ -2.2) and SW Dra ([Fe/H] ~ -0.7) utilizing simultaneous optical and infrared photometry and radial velocities with typical accuracies of 1 km sec^{-1} (Jones et al. 1986 a,b), and plan to extend the investigation to the nearer globular clusters such as M5.

Carney and Latham (1984) discovered a phasing problem in their analysis of VY Ser such that the phase of the radial velocities or the photometry had to be shifted in order for the Baade-Wesselink method to work. This problem also occurred for X Ari and SW Dra if optical color indices such as B-V or b-y were used to compute the effective temperatures needed for this type of analysis. The problem vanished when the V-K index was employed to calculate T_{eff}, and it was discovered that the optical colors yielded temperatures that were consistently

J. E. Grindlay and A. G. Davis Philip (eds.),
The Harlow-Shapley Symposium on Globular Cluster Systems in Galaxies, 589–590.

https://doi.org/10.1017/S0074180900043217 Published online by Cambridge University Press

hotter than those derived from V-K during the expansion phase of the pulsation cycle due to an excess of flux in the optical region, causing a distortion in the computed angular diameters which led to the apparent phase shift. The cause of this excess flux has not yet been determined, but it seems to be associated with the shock wave phenomenon.

We derived $\langle M_V \rangle = +0\overset{m}{.}88 \pm 0\overset{m}{.}15$ for X Ari and $\langle M_V \rangle = +0\overset{m}{.}94 \pm 0\overset{m}{.}15$ for SW Dra utilizing the V-K index and restricting the phase interval to exclude the shock waves. Since the major sources of error in the absolute magnitudes are systematic and affect both stars equally, the error in the magnitude difference is smaller, such that X Ari is only $0\overset{m}{.}06 \pm 0\overset{m}{.}10$ brighter than SW Dra despite the large difference in metallicity, $\Delta[Fe/H] = 1.5$. Sandage (1982) predicts that such a metallicity difference should produce a magnitude difference of $0\overset{m}{.}5$, and his period-luminosity-amplitude relation indicates that X Ari should be $0\overset{m}{.}27$ or $0\overset{m}{.}19$ brighter, depending on whether or not there is a metallicity dependence on horizontal branch star masses. Our results contradict these predictions; however, the Sandage relations were derived assuming that the stars were near their zero-age horizontal branch luminosities, which may not be valid here, since we cannot exclude the possibility that SW Dra is a well-evolved star that is not crossing the instability strip for the first time. The only sure way to adequately test the Sandage relations is to determine $\langle M_V \rangle_{RR}$ for globular cluster variables directly.

If the results for X Ari and SW Dra are valid for globular clusters of the appropriate metallicity, then the age of metal-poor clusters such as M15 and M92 derived from the luminosity of the main-sequence turnoff is 20×10^9 years for a helium abundance of $Y = 0.2$, with a slight dependence upon the helium abundance, while the age of metal-rich clusters such as 47 Tuc is 14×10^9 years for the same helium abundance. These results indicate that the metal-rich old disk clusters formed much later than the metal-poor halo clusters, but such a conclusion can be firmly established only by direct analysis of cluster variables.

REFERENCES

Carney, B. W. and Latham, D. W. 1984 Astrophys. J. 278, 241.

Jones, R. V., Carney, B. W., Latham, D. W. and Kurucz, R. L. 1986a Astrophys. J., in press.

Jones, R. V., Carney, B. W., Latham, D. W. and Kurucz, R. L. 1986b Astrophys. J., in press.

Latham, D. W. 1985 in IAU Colloquium No. 88, Stellar Radial Velocities, A. G. D. Philip and D. W. Latham, eds., L. Davis Press, Schenectady, p. 21.

Sandage, A. 1982 Astrophys. J. 252, 553.

Latham, D. W. 1985 in IAU Colloquium No. 88, Stellar Radial Velocities, A. G. D. Philip and D. W. Latham, eds., L. Davis Press, Schenectady, p. 123.