DISTANCES AND RADII OF CLASSICAL CEPHEIDS

T.G. Barnes III
The University of Texas at Austin, Austin, Texas 78712 USA

T.J. Moffett
Purdue University, West Lafayette, Indiana 47907 USA

We have used new BVRI photometry and radial velocities of a selection of bright classical Cepheids to determine their distances and radii through the surface brightness method. The improved photometry permitted, through the visual surface brightness relation, high-quality angular-diameter values for each Cepheid throughout its pulsation. The simultaneous radial velocities permitted the linear displacement curve to be phase-locked to the angular diameter variation. The results are individual distances and radii with considerably smaller uncertainty than could be obtained previously.

Introduction

Pulsating variables, especially Cepheids, play a major role in distance determinations, both within and external to our Galaxy. At present the Cepheid distance scale is based principally upon the cluster Cepheids, although statistical parallax analyses add a valuable check. The cluster distance scale is based, of necessity, on a small number of stars and the method relies heavily on the adopted ZAMS, which in turn depends strongly on the adopted Hyades distance.

Barnes et al. (1977) introduced an alternate method for determining individual distances to Cepheids which is based upon the visual surface brightness-color index relation. The distances so determined are completely independent of all other astrophysical distance scales. They also showed that the method is nearly geometric in the sense that even large errors in the interstellar extinction have a negligible effect upon the distances.

The results given in the above paper, which were based upon photometry and radial velocities from the literature, agreed with the Cepheid distance scale given by Fernie & Hube (1968), although the scatter was large. Contributing to the scatter were uncertainty in the Cepheid surface brightnesses, the uncertain phase-matching between the radial velocities and the photometry, and the errors of the photometry.

In the present work, we have addressed each of these sources of uncertainty. The method developed by Barnes (1980) is used to calibrate a visual surface brightness-color index relation from the Cepheids

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themselves. The BVRI photometry of Moffett & Barnes (1984) for 112 Cepheids provides a high-quality photometric data set. Radial velocities obtained simultaneously with the photometry enable secure phase-matching for 88 of these Cepheids. We summarize here our results for the first 20 Cepheids studied.

Cepheid Surfaces Brightnesses

We have followed exactly the method given by Barnes (1980) to establish a relation between the visual surface brightness parameter, F_V, and the Johnson (V-R) color index. Our data sets were the BVRI photometry of Moffett & Barnes (1984) and our unpublished radial velocities (Barnes & Moffett 1984).

In this method the photometry and radial velocities are combined to compute F_V throughout the pulsation cycle to within an unknown additive constant. The variation of F_V with (V-R) is thus determined. In every case F_V is found to vary linearly with (V-R). The mean slope for the 20 Cepheids so far analyzed is -0.362 ± 0.005 (s.e.m.) in superb agreement with Barnes' (1980) value of -0.363 ± 0.011 (s.e.m.)

To obtain the zero point of the F_V - (V-R) relation we make use of the angular diameters published by Parsons (1970) and Parsons & Bouw (1971). Parsons computed these by fitting Cepheid model atmosphere fluxes to observed fluxes in the blackbody six-color system. Knowledge of the mean angular diameter and mean V magnitude then specifies the mean F_V. A plot of F_V against mean (V-R) shows a linear distribution which agrees in slope with the independently determined value of -0.362. Adopting this value, the model atmosphere results were used only to determine the zero point of the F_V - (V-R) relation, 3.956 ± 0.003 (s.e.m.) Not surprisingly this is the same result found in the previous work, although the uncertainty is reduced by half.

Distances and Radii for Cepheids

Having established the visual surface brightness as a function of (V-R), it is a simple procedure to determine the angular diameter of the Cepheid throughout the pulsation cycle. Figure 1 shows a representative result. The smooth curve is the integrated radial velocity curve, corrected by a factor of 1.31 to pulsational velocity. With distance and mean radius as free parameters, it has been fit to the photometrically determined angular diameters.

We have carried out this analysis on 20 bright Cepheids with periods in the range 2 days to 45 days. The radii so obtained are in good agreement with Baade-Wesselink results of Balona (1977). Our results average 0.05 ± 0.02 larger in log R/R. than Balona's. The distances we obtain yield a distance scale 0.26 mag + 0.17 mag larger in the distance modulus than the Fernie & Hube (1968) and Sandage & Tammann (1969) scales.

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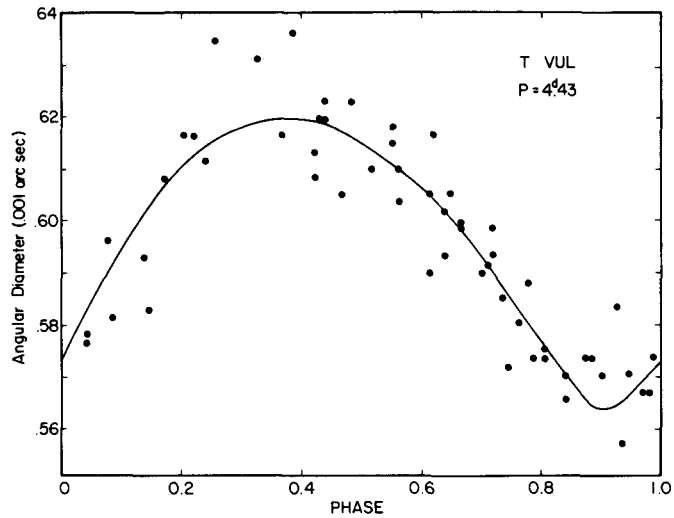
Figure 1. Angular Diameter Variation of T Vul



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