POPULATION II CEPHEIDS

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Abstract. A review of Cepheids in globular clusters finds 46 stars that are highly probable members of 21 clusters, all of intermediate to low metallicity with blue horizontal branches. In order to separate Type II Cepheids in the field from classical Cepheids, an analysis is made of the distribution of all Cepheids: 144 are sufficiently far from the galactic plane to be considered Type II. Their properties are compared with the cluster Cepheids. Some recent studies are reviewed that are improving our understanding of low-mass Cepheids.

INTRODUCTION

The distinction between young, massive, classical Cepheids and old, low-mass, Population II Cepheids has been recognized for more than three decades. Cepheids in globular clusters have been carefully studied and compared with field Cepheids near the sun. A simple (and in some respects traditional) view of the Cepheids in our Galaxy leaves them divided cleanly into the two types with no overlap. This view is based on the idea that stars in our Galaxy with intermediate masses (1 to 2 $M_{\odot}$) are sufficiently metal-rich to avoid making loops through the instability strip and becoming Cepheids in appreciable numbers during their helium burning evolution. It is supported by the absence of Cepheids in metal-rich globular clusters.

As in most research, however, further study reveals complications. The old, low-mass, field Cepheids include some metal-poor analogs to those in globular clusters, but many come from a metal-rich, old-disk population, for which the term "Type II" seems more appropriate than "Population II". These old-disk stars and the Anomalous Cepheids in dwarf spheroidal galaxies challenge our simple picture of two types of Cepheids. Type II Cepheids are often separated into long-period W Vir stars and short-period BL Her stars (with the division at a period of about 10 days). This separation is useful because the evolutionary state of the two groups is different, and these terms will be used occasionally throughout this paper. Various aspects of these stars have been reviewed previously (Joy 1949; Arp 1955; Payne-Gaposchkin 1956; Plaut 1965; Kukarkin 1975; Wallerstein & Cox 1984). This paper will discuss the present state of both the cluster and field Type II Cepheids, as well as current research that is shedding new light on this late stage of evolution for old stars.

CEPHEIDS IN GLOBULAR CLUSTERS

The list of known Cepheids in globular clusters continues to grow slowly. The presently known members are listed in Table 1, including 23 BL Her stars and 23 W Vir and/or RV Tauri stars. This list is based on the data from Sawyer Hogg (1973), updated by numerous more recent papers. References can be found in Clement et al. (1984a) and Harris et al. (1983). The magnitudes marked as approximate are based on B or pg magnitudes and colours estimated from the P-C relation, so they cannot be considered reliable. In addition, the following stars are possible cluster Cepheids, but will require further study: NGC 3201-V65 (probable eclipsing field star), NGC 4833-V9 (probable SR), NGC 6093-V2 (uncertain type), NGC 6293-V2 and NGC 6522-V8 (probable field Cepheids), NGC 6626-V21 (possible field Cepheid), NGC 6626-V22 (possible field RR Lyrae, but uncertain period), and NGC 7492-V4 (probable red variable). However, the following stars are probably not cluster Cepheids: NGC 362-V8 and V10 (Cepheids in the SMC), NGC 5024-V24 and NGC 6626-V9 (RR Lyrae stars).

Included in Table 1 are the 6 known cluster stars that show the RV Tauri characteristic of alternating deep and shallow minima. These are

Table 1. Cepheids in Globular Clusters

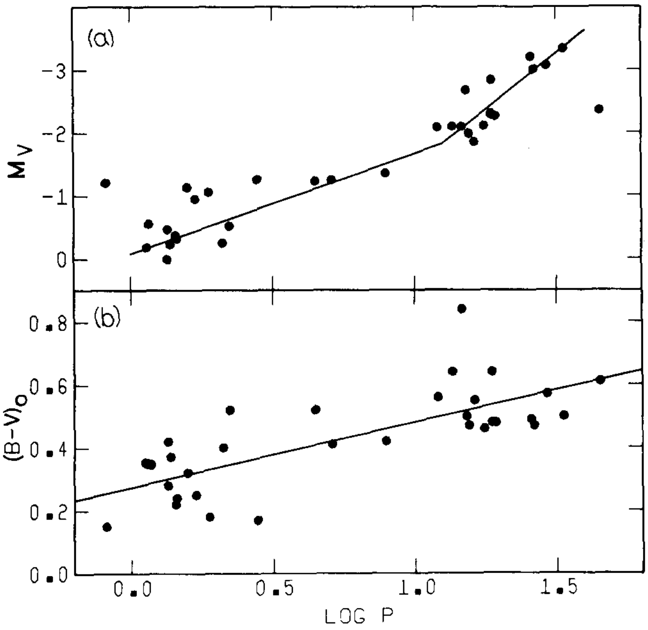
CLUSTER	STAR	PERIOD	‹V›	‹B›-‹V›
NGC 2419	V18	1.58	18.8	0.35
NGC 5139 (w Cen)	V1*	29.34	10.85	0.68
	V29	14.73	11.82	0.95
	V43	1.16	13.36	0.46
	V48	4.47	12.69	0.63
	V60	1.35	13.45	0.39
	V61	2.23	13.40	0.63
	V92	1.35	13.93	0.53
NGC 5272 (M3)	V154	15.29	12.32	0.51
NGC 5466	V19	0.82	14.75	0.20
NGC 5904 (M5)	V42*	25.74	11.3	0.52
	V84*	26.42	11.5	0.50
NGC 6093 (M80)	V1	16.30	13.42	0.76
NGC 6205 (M13)	V1	1.45	14.0	0.26
	V2	5.11	13.1	0.43
	V6	2.11	14.1	0.42
NGC 6218 (M12)	V1	15.51	12.0:	...
NGC 6229	V8	14.85	15.65:	...
NGC 6254 (M10)	V2	18.73	11.76	0.74
	V3	7.91	12.69	0.68
NGC 6273 (M19)	V1	16.92	13.0:	...
	V2	14.14	13.3:	...
	V3	16.5	12.9:	...
	V4	2.43	14.1:	...
NGC 6284	V1	4.48	15.2:	...
	V4	2.82	15.4:	...
NGC 6333 (M9)	V_	short	...	...
NGC 6402 (M14)	V1	18.73	14.06	1.22
	V2	2.79	15.64	0.75
	V7	13.60	14.80	1.22
	V17	12.08	14.81	1.14
	V76	1.89	15.84	0.76
NGC 6626 (M28)	V4	13.46	13.5:	...
	V17*	46.0	12.5:	...
NGC 6656 (M22)	V11	1.69	12.6	0.8
NGC 6715 (M54)	V1	1.35	17.0:	...
NGC 6752	V1	1.38	12.97	0.40
NGC 6779 (M56)	V1	1.51	15.3:	...
	V6*	45.01	13.24	0.83
NGC 7078 (M15)	V1	1.44	14.89	0.34
	V72	1.14	15.08	0.47
	V86	17.11	13.7:	...
NGC 7089 (M2)	V1	15.58	13.46	0.53
	V5	17.61	13.34	0.52
	V6	19.30	13.18	0.54
	V11*	33.6	12.11	0.56

*Shows RV Tauri characteristics.

included for two reasons. The identification of a star as an RV Tauri star rather than a Cepheid can be difficult, because detecting the alternating minima sometimes requires more complete and accurate observations than are available. In fact V1 in NGC 5139 and V42 in NGC 5904 have been called both types. Second, there is probably no qualitative difference between the evolutionary state of RV Tauri stars in clusters and other long-period Cepheids (although the situation for field RV Tauri stars is more complicated). Both types have pulsation driven by the same mechanism (the opacity of the hydrogen and helium ionization zones), and some models of long-period Cepheids display RV Tauri behavior (Bridger 1984). Both types lie together in the instability strip, in contrast to yellow semiregulars (SRd stars), which have lower luminosities, and red semiregulars, irregulars, and long-period variables, all of which are cooler (Rosino 1978, Wehlau & Sawyer Hogg 1977, Lloyd Evans 1977). The periods listed in Table 1 are the times between successive minima.

Rosino (1978), Lloyd Evans (1983a), and others have pointed out the usefulness of infrared colours and magnitudes for studying cluster variables. However, the UBV system remains the only system for which data are available for many of these stars. The P-L and P-C relations

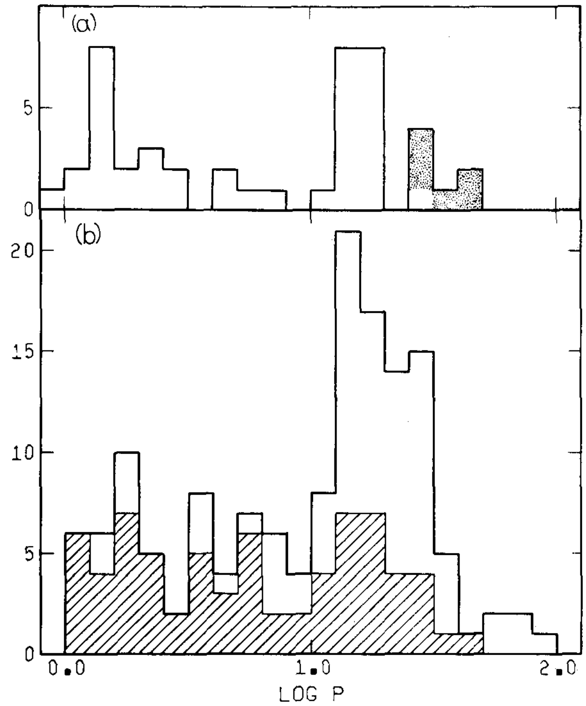
Figure 1. The period-luminosity relation (a) and the period-colour relation (b) for the cluster Cepheids from Table 1 with measured V magnitudes and B-V colours. The line in the P-L plot is taken from Harris (1981). The line in the P-C plot is a least-squares fit to the data: $(B-V)_o = 0.275 + 0.206 \log P$.



are shown in Figure 1, using distances and reddenings taken from Harris and Racine (1979). The mean deviations from the lines are 0.21 in V and 0.08 in B-V, and they probably include a significant contribution from observational errors for these faint, often crowded, variable stars. These deviations are not very large, to my eye (compared to similar plots for classical Cepheids by Feast at this conference, for example), and show that these relations *can* be used to determine distances and reddenings to globular cluster Cepheids without introducing excessive errors. The P-C relation in B-V for Type II Cepheids in the field has a larger scatter than appears in Figure 1 (Demers & Harris 1974), related to the larger range of abundances among the field stars. However, data presently available in V-K, R-I, and T_1-T_2 indicate that the use of red or infrared colours reduces the scatter. Further work is needed on field stars to determine whether the instability strip for Type II Cepheids is much wider in temperature than it is for classical Cepheids.

The distribution of periods is shown in Figure 2(a). The bimodal distribution noted by Kraft (1972) is obvious, with the gap around P = 8 to 10 days separating BL Her stars from W Vir stars. However, Clement *et al.* (1984b) suggest that instead the gap at P = 4 days should be used

Figure 2. (a) The distribution of periods for the cluster Cepheids from Table 1. Stars with RV Tauri characteristics are shown shaded. (b) The distribution for field Type II Cepheids. The cross-hatched region shows stars within a cylinder of radius 5 kpc centred on the sun.

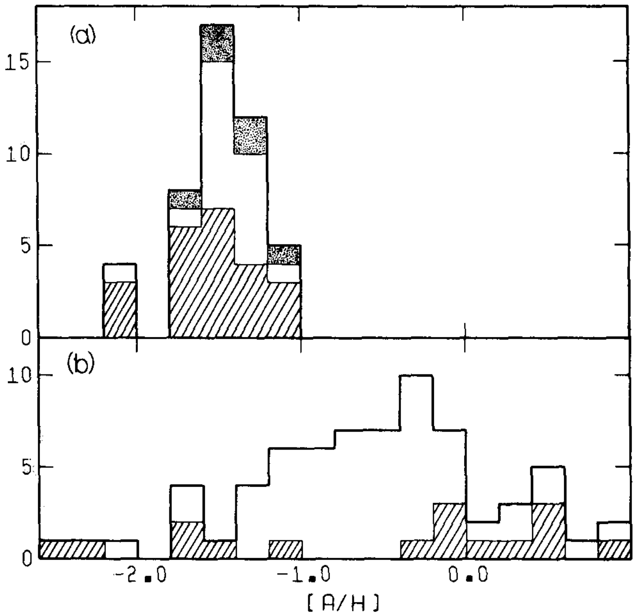


as the upper limit defining the BL Her class. Similar period distributions are found for subsamples of metal-poor or intermediate metallicity clusters.

Cepheids appear only in clusters with blue horizontal branches, a fact demonstrated by Wallerstein (1970) and supported with today's more complete data. More generally, UV-bright stars are most frequent in clusters with blue horizontal branches (Harris et al. 1983), and Cepheids are simply the UV-bright stars that happen to be passing through the instability strip. BL Her stars, in particular, may be most frequent in clusters such as M15 that have an extended blue tail on the horizontal branch. The metal abundance [A/H] of clusters containing Cepheids is generally low. The abundance distribution is shown in Figure 3(a), where the abundances are taken to be those of the parent clusters from Pilachowski (1984). (Use of a different source such as Zinn makes little difference for these clusters.) The spread of abundances in ω Cen makes the values for its Cepheids more uncertain than for others.

The evolution of globular cluster stars into Cepheids is generally understood (Schwarzschild & Harm 1970; Strom et al. 1970; Newell 1973; Zinn 1974; Gingold 1976). Stars from the blue end of the horizontal branch evolve through the instability strip with M_V = 0 to -1 and P = 1 to 5 days. Stars evolving up the asymptotic giant branch make loops into the instability strip (with M_V = -2 to -3 and P = 15 to 30 days)

Figure 3. The histogram of metal abundances for (a) cluster and (b) field Type II Cepheids. RV Tauri stars are shaded and BL Her stars are cross-hatched.



due to helium shell flashes and the final transition toward becoming a white dwarf. The bimodal distribution of periods seen in Figure 2 is predicted, but the distribution of periods, particularly for long periods, differs from that predicted (Gingold 1976). One factor that might help to explain the discrepancy is mass loss by AGB stars, limiting the luminosity attained by W Vir stars.

FIELD CEPHEIDS

Separation of Classical and Type II Cepheids

Classifying individual Cepheids that are not members of clusters as Type I or Type II is, at best, difficult. The problem arises because Type II Cepheids not only have smaller masses than classical Cepheids, but also smaller radii, so their surface gravities at a given period are almost identical; they likewise have similar temperatures at a given period, so most spectroscopic indicators cannot distinguish the two types. Some Type II Cepheids are metal-poor and have weak-lined spectra, but metallicity is a characteristic we want to measure, so it should not be used to define our sample. Classification methods must use a criterion sensitive to mass or radius. Several have been devised, based on different observational characteristics: Type II Cepheids sometimes exhibit open loops in color-color plots (Mianes 1963; Kwee 1967; Nikolov & Kunchev 1969) or color-magnitude plots (Warren & Harvey 1976); they often are bluer at maximum light (Walraven *et al.* 1958); they are more prone to variations in period or phase jitter (Hoffleit 1976; Szabados 1983); for periods of 13 to 28 days, they almost always show strong hydrogen emission lines during rising light (Joy 1949; Wallerstein 1958; Harris & Wallerstein 1984); they often have distinctive bumps in their light curves, and so show a Hertzsprung progression different from classical Cepheids (Petit 1960; Plaut 1965; Stobie 1973; Warren & Harvey 1976; Szabados 1977). Unfortunately, a comparison of results from these methods shows considerable disagreement for various reasons. For example, the presence of a hot main-sequence companion can cause a classical Cepheid to execute loops, mimicking a Type II Cepheid (Madore 1977). If good photometric data is available, the light curve shape is perhaps the most useful criterion for periods of 1 to 3 days and 12 to 20 days, and the agreement of observed and model light curves (Carson & Stothers 1982; Bridger 1984) adds confidence in this method of classification. However, for other periods for metal-rich Cepheids, there is at present no reliable way of separating the two types. When more accurate velocity curves and temperature indicators are available for many Cepheids, direct determinations of their radii through the Baade-Wesselink method will allow better identification of the Type II's.

A different approach to separating Type II Cepheids relies on their larger distances from the Galactic plane. Fernie (1968) found that classical Cepheids are distributed exponentially from the galactic plane with a scale height of only 70 pc. Hence any Cepheids farther than about 500 pc from the plane are very likely Type II. (The distances can first be estimated assuming the P-L relation for classical Cepheids. Then for the more distant stars, now assumed to be Type II, the distances are recalculated with the fainter Type II P-L relation, giving distances from the plane larger than about 200 pc.) This method was used by Smith et al. (1978) to identify BL Her stars. However, it may not always give a correct result. Runaway OB stars defy the exponential distribution, so some runaway Cepheids might be expected. Note, however, that runaway OB stars are rare and OB stars outnumber Cepheids in the Galaxy by almost two orders of magnitude, so runaway Cepheids should be very rare. Might the classical Cepheid disk be thicker toward the galactic center? Probably not, because the young disk of HI and molecular clouds is not thicker there, and because scattering out of the disk (perhaps by molecular clouds) is probably not effective during the short (typically 10^8 years) Cepheid lifetimes. At very large distances away from the galactic center, this approach should take into account the increasing thickness and warp of the galactic disk, but in practice these effects are usually negligible.

I have carried out a new analysis of the distribution of Cepheids using this approach. Working from a tape of the General Catalogue of Variable Stars, edited to include the Third Supplement (1976), I find 771 Cepheids, including 5 Cepheids with periods near one day classified as RR Lyraes. Removing Magellanic Cepheids, some non-Cepheids, and some without determined periods leaves 708 stars. Reddenings and distances are calculated from the P-C and P-L relations of Fernie & McGonegal (1983) for the 450 stars with measured B-V colours. (B-V is used rather than some other colour only because it is available for most stars.) Fernie (1968) had only 212 stars with measured colours, and the improved reliability of these reddenings constitutes the major improvement over Fernie's study. Reddenings are taken from Fernie & Hube (1968) for 80 more Cepheids, estimated from nearby field stars. Finally, reddenings are taken from Burstein & Heiles (1982) for 35 stars with $|b| > 10°$ from observed HI column densities. Therefore 553 Cepheids are included in the analysis.

The distribution of $|z|$ distances in this sample is peaked close to the Galactic plane. (Half are within 150 pc of the plane.) Before using the data to find the distribution of classical Cepheids, we must limit the sample to a region near the sun where the incompleteness caused by dust absorption is not too great. Using a cylinder of radius 2 kpc centred on the sun, we obtain a density in the central plane $N_o = 69$ kpc^{-3}, and a scale height $h = 71$ pc. These data are shown in Figure 4. Similar results are obtained for a cylinder of radius 3 kpc ($N_o = 57$ kpc^{-3}, $h = 69$ pc). These are least-squares fits to the stars with $|z| <$ 350 pc. Relatively few Type II Cepheids will be contaminating this restricted sample. The scale height found here for classical Cepheids agrees very well with the value (70 ± 10 pc) found by Fernie.

A total of 144 Cepheids are calculated to lie beyond $|z| = 600$ pc, and these are all presumably Type II Cepheids. (In the GCVS, 14 are classified as Cδ, 81 as CW or CW?, and 49 as Cep or Cep?.) Their reddenings and distances have been recomputed using the P-C and P-L relations in Figure 1. After restricting the sample to a cylinder of radius 5 kpc centred on the sun, the distribution of $|z|$ distances is shown in Figure 5. The first bin is very incomplete, of course, because stars with small |z| have gone into the classical Cepheid group. The distribution is probably not exponential (probably due to the mixture of old-disk and halo stars), but the number of stars is too small to draw a firm conclusion. The line drawn by eye in Figure 5 has N_o = 1.5 kpc^{-3}, h = 500 pc. This estimate of N_o should be considered a lower limit because of incompleteness for these faint stars; comparison with counts in smaller cylinders suggests that N_o = 2.2 kpc^{-3} is more realistic.

These distributions in |z| for classical and Type II Cepheids suggest several conclusions: Classical Cepheids outnumber Type II Cepheids in the Galactic plane near the sun by about 30 to 1. Type II Cepheids dominate at |z| > 300 pc. When projected onto the Galactic plane, the densities in the solar neighborhood of classical and Type II Cepheids are 9.8 kpc^{-3} and 2.2 kpc^{-3}, respectively. We do not know if these relative numbers are also valid near the Galactic centre and toward the anticentre. The above estimate for N_o for Type II Cepheids derived statistically is consistent with the numbers of individual stars identified in the solar neighborhood (Harris 1981). The relative numbers of Type II Cepheids and RR Lyraes appear to differ in clusters, in the halo field, and in the solar neighborhood (Harris & Wallerstein 1984), probably due to real population differences.

Figure 4. The distribution in 50 pc bins of Cepheids within a cylinder of radius 2 kpc centred on the sun.

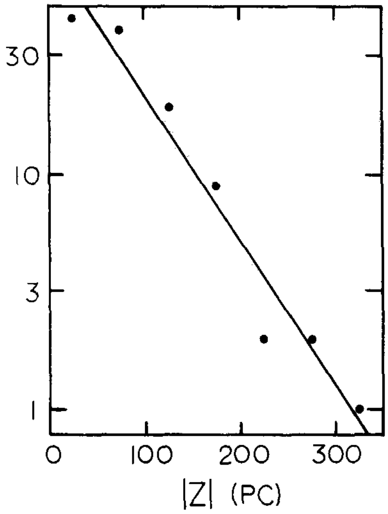
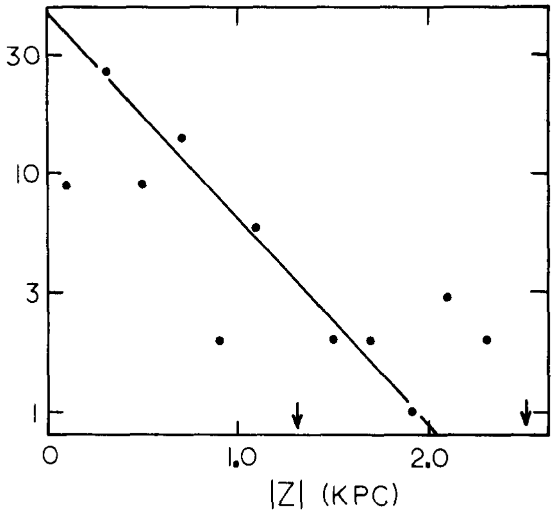


Figure 5. The distribution in 200 pc bins of Type II Cepheids within a cylinder of radius 5 kpc.



Properties of Field Type II Cepheids

The period distribution for the 144 field Type II Cepheids is shown in Figure 2(b). To minimize biases caused by selection effects, we should restrict the sample to a limited volume. The cross-hatched histogram in Figure 2(b) shows the bimodal distribution seen in cluster Cepheids in Figure 2(a), but the short-period peak is not as prominent in the field star sample as in clusters. This may be due to a selection effect (because short-period stars are fainter and discovered less completely), but I suspect that it shows a real difference. Probably the field population does not have a horizontal branch as extremely blue as the mean for clusters, and so contributes relatively fewer BL Her stars. Also the metal-rich field Cepheids (not present in clusters) may tend to fill in the 6- to 12-day range of periods. An earlier plot by Kraft (1972) included stars already classified as Type II, probably biasing his sample toward those periods where the light curve is a good discriminator of Cepheid type. Kraft's result that long-period Cepheids dominate in the nuclear bulge is supported here: over 80% of stars in this sample of Type II Cepheids that lie within 15° of the Galactic centre have periods longer than 10 days. Some of this excess must be due to greater completeness for brighter stars, but some of the excess is probably real.

Until recently, abundances of only five Type II Cepheids have been measured using high-resolution spectroscopy (Rodgers & Bell 1963; Barker et al. 1971; Anderson & Kraft 1971; Caldwell & Butler 1978; Cottrell 1979; Wallerstein et al. 1979), too few to draw conclusions about their origins. Recently, however, the abundances of 70 field Cepheids have been measured by Harris (1981) and Harris & Wallerstein (1984) using the Washington system, a broad-band system efficient for a survey project of this type. Similar studies are now in progress by McNamara, Kwee and Diethelm, and others using other observing systems (and these narrow-band or spectroscopic systems offer potential advantages over a broad-band system), but it is too early to tell if the Washington-system results will be confirmed. The abundance histogram for all observed field stars is shown in Figure 3(b). It differs markedly from the histogram for cluster Cepheids in Figure 3(a), and it demonstrates that the solar abundance of BL Her is not unusual.

The radial velocities of field Type II Cepheids have been analyzed by Harris & Wallerstein (1984) improving earlier studies based on small samples (Woolley 1966; Plaut 1965). Their kinematic properties correlate with their abundances in the sense that metal poor stars have a low velocity of rotation around the Galaxy and a high velocity dispersion, while metal-rich stars have mostly normal, circular motions. The kinematics of the metal-rich Type II Cepheids are consistant with their origin in the old-disk, confirming this result already suggested from their spatial distribution and their abundances.

Radial velocity curves have been used to determine radii for seven field Type II Cepheids using the Baade-Wesselink method: BL Her (Abt & Hardie 1960), κ Pav (Rodgers & Bell 1963), W Vir and TW Cap (Bohm Vitense 1974), XX Vir (Wallerstein & Brugel 1979), AU Peg (Harris et al. 1984), and SW Tau (Burki 1984). The distances and luminosities derived for these stars are consistent with the P-L relation for cluster Cepheids in Figure 1. However, these results are not very precise for several stars. Better quality velocity curves should be obtained for more stars, particularly the metal-rich Type II Cepheids, to check their luminosities.

FURTHER INVESTIGATIONS

Cepheids should change their pulsation periods by about 40% as a result of changing their radii as they evolve through the instability strip. The changes for Type II Cepheids are predicted by evolutionary models to occur in about 10^3 to 10^5 years, depending on the model. These changes are sufficiently rapid to be detectable with presently available observations covering about 80 years, allowing a check on the applicability and correctness of the models. Unfortunately, W Vir stars have quite unstable periods, often exhibiting apparently random changes larger than are seen in classical Cepheids (Coutts 1973; Szabados 1983). The cause of these period fluctuations is not known, but the fluctuations are large enough that so far they appear to have masked the systematic changes that might be present due to evolution.

BL Her stars show less extreme random period changes, however, and the studies by Wehlau & Bohlender (1982) and Wehlau & Sawyer Hogg (1984) have detected changes that are probably caused by evolution. Among 13 Cepheids with periods from 1 to 5 days in six globular clusters, ten had increasing periods and three had constant periods, but none showed decreasing periods, suggesting that most of these stars are evolving through the instability strip toward cooler temperatures. The rates of period change observed were from 0.4 to 18 days/10^6 years. Changes of this size are predicted by the evolutionary tracks of Gingold (1976) and Sweigart and Gross (quoted by Wehlau & Bohlender), supporting the proposal that the changes are indeed caused by evolution. If so, the six stars with fast changes (of the order of 10 days/10^6 years) are probably in their first crossing of the instability strip, while the seven stars with slow changes (less than 1 day/10^6 years) are probably in their third crossing. By combining observed period changes with evolutionary models, we can map the part of the horizontal branch that pumps the BL Her-star domain.

Pulsation models for BL Her stars constructed for a variety of masses, periods, and luminosities have successfully reproduced many of the features observed in the light and velocity curves (Carson & Stothers 1982; Hodson et al. 1982; Cox & Kidman 1984). For example, the bump around minimum light that distinguishes 1.2- to 2.4-day BL Her stars from classical Cepheids is seen in the model light curves. The most important result of the models is that the masses of all the BL Her stars may be close to 0.6 $M_\odot$. There is some evidence that metal-rich BL Her stars are less luminous than metal-poor ones (by perhaps 0.3 magnitudes), but have nearly the same mass. Considerable structure appears in the light curves of some stars when accurate observations are obtained with good phase coverage, so accurate light curves for a large sample of stars combined with the models is likely to provide further constraints on M, L, Y and Z. The same remarks apply to W Vir stars for which recent models also indicate masses close to 0.6 $M_\odot$ (Bridger 1983, 1984).

The study of Type II Cepheids has revealed some with unusual properties. For example, CC Lyr and ST Pup may be unusually hot for their periods, while AU Peg is unusually cool. Several are carbon stars (Lloyd Evans 1983b) and show erratic behavior, the most notable being RU Cam. Detailed analyses of temperature and abundances have been carried out for only a few stars and are needed for more. Three Type II Cepheids, AU Peg, TX Del, and IX Cas, all metal-rich Cepheids with periods in the 6-12 day gap, are now known to have close binary companions that have likely influenced their evolution by mass transfer (Harris *et al*. 1984; Harris, in preparation). This may provide an explanation of how some of these stars have evolved into the instability strip, since evolutionary tracks do not predict such Cepheids. However, other similar Cepheids have not shown, with presently available data, velocity variations indicating a binary companion, so it is not yet clear whether some other explanation is needed for their existence.

One explanation for the presence of metal-rich old-disk stars in the instability strip is large mass loss during hydrogen-shell burning evolution. This produces unusually blue stars on the horizontal branch, and might give rise to both BL Her and W Vir stars. Large mass loss can also explain the presence of metal-rich RR Lyrae stars in the solar neighborhood (Taam *et al*. 1976). However, the cause of the mass loss in old-disk field stars and its absence in metal-rich globular cluster stars remains to be explained.

Outside our Galaxy, the Magellanic Clouds are the only systems with much data on Type II Cepheids available. Twenty are known in the LMC: HV2351, 5598, 5690, 13063, 13064, 13065 (Hodge & Wright 1969; Wright & Hodge 1971; Connolly 1975; Butler 1978), and fourteen other stars (Payne-Gaposchkin 1971). Four are known in the SMC: HV206, 1828, and 12901 (Payne-Gaposchkin & Gaposchkin 1966) and probably Star 48 (Wesselink & Shuttleworth 1965). The magnitudes to which the variable star searches at Harvard are considered to be complete suggest that these lists are largely complete outside of crowded regions for Type II Cepheids with $P > 15$ days, but that virtually all of the BL Her stars in the Magellanic Clouds remain undiscovered. Only a few small areas have been searched for RR Lyrae stars at fainter magnitudes. In some cases variables have been found which might include Type II Cepheids, but they have not been investigated further. The stars with $P = 1$ to 3 days found in the SMC by Wesselink and Shuttleworth (1965) probably represent the short-period, low-mass end of the sequence of classical Cepheids. Cepheids with $M \sim 2\ M_\odot$ and $P \sim 1$ day are predicted to occur in large numbers in a metal-poor population (Becker *et al*. 1977). Stars with $P <$ 1 day but brighter than the RR Lyraes in the SMC (Wesselink & Shuttleworth 1965; Graham 1975; Butler *et al*. 1982) and the LMC (Connolly 1984) may include classical Cepheids, Anomalous Cepheids, normal Type II Cepheids, and foreground RR Lyraes. The status of most of these short-period variables is not yet clear.

Anomalous Cepheids in the dwarf spheroidal galaxies (anomalously bright BL Her stars) have received a great deal of attention during the last decade (Wallerstein & Cox 1984, and references therein). The only Anomalous Cepheid known in our Galaxy, V19 in NGC 5466 (Zinn & Dahn 1976), stands out in Figure 1, but we should remember that others may exist among field Type II Cepheids and RR Lyraes. Anomalous Cepheids are more massive than either the majority of the stars in the dwarf spheriodals or the normal BL Her stars found in Galactic globular clusters. Possible explanations for their presence are that they are younger than the RR Lyraes in these galaxies, that they have gained mass by exchange from a binary companion, or that they result from a coalescence of two stars in a binary system. The apparent lack of normal Type II Cepheids in these galaxies probably can be understood as a small numbers effect: most of these galaxies have red horizontal branches and so should produce almost no Type II Cepheids, while Sculptor and Ursa Minor (with blue horizontal branches) have not yet had a sufficient number of variables investigated. Many variables remain to be investigated in several dwarf spheroidals (van Agt 1973), and Demers is studying Fornax variables. I hope that all types of variables will be pursued to allow comparison of their relative numbers and properties.

I wish to thank George Wallerstein for developing my interest in Type II Cepheids and for numerous conversations on their various aspects. Much of this research has been supported by the Natural Sciences and Engineering Research Council of Canada at the Dominion Astrophysical Observatory and at McMaster through a grant to William Harris, to whom I am most grateful.

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