fashion by Munch [19]. AQ Pup has two fainter companions approximately 15″ and 25″ distant which could be individually observed both photo-electrically and spectroscopically under favourable conditions.

Eggen [20] has recently pointed out that δ Cep and α UMi may be members of the α Persei group. Attention should also be called to the fact that a considerable number of cepheids have distant, possibly physical, companions and there are some cepheids that are close visual binaries. Probably the most precise technique for determining absolute magnitudes and spectral types of early type stars is Strömgren's [21] photo-electric technique using narrow-band colour filters. This method has obvious application both to cluster companions and single companions of cepheids and could perhaps be extended, with profit, to the cepheids themselves.

In conclusion, the study of companions of cepheids is only in its beginning, but would seem to be richly rewarding.

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2. PHOTO-ELECTRIC OBSERVATIONS OF MAGELLANIC CLOUD CEPHEIDS

S. C. B. GASCOIGNE

(Communicated by B. J. Bok)

Photo-electric observations of cepheids in the Magellanic Clouds were begun with Dr G. E. Kron in 1951, with the objects of learning something about the colours and the scatter in the $P-L$ relation of the Cloud cepheids, and hence also of those in the Galaxy, the tacit assumption being that these two groups of stars are members of the same family and have the same intrinsic properties. It became clear at once that this assumption would need justification, the Cloud cepheids being bluer than those in the Galaxy to an extent difficult to explain by reddening of the galactic cepheids. Since then much of the interest of the work has centred around the problem of what differences, if any, exist between the Cloud

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cepheids on the one hand, and those in the Galaxy on the other. A major complication arises from the fact that even if the population I galactic cepheids could be separated without ambiguity from those in population II, the population I stars would still constitute a far from homogeneous group [1]. This makes it difficult to decide just what is meant by 'difference' in the sense in which the word is used above.

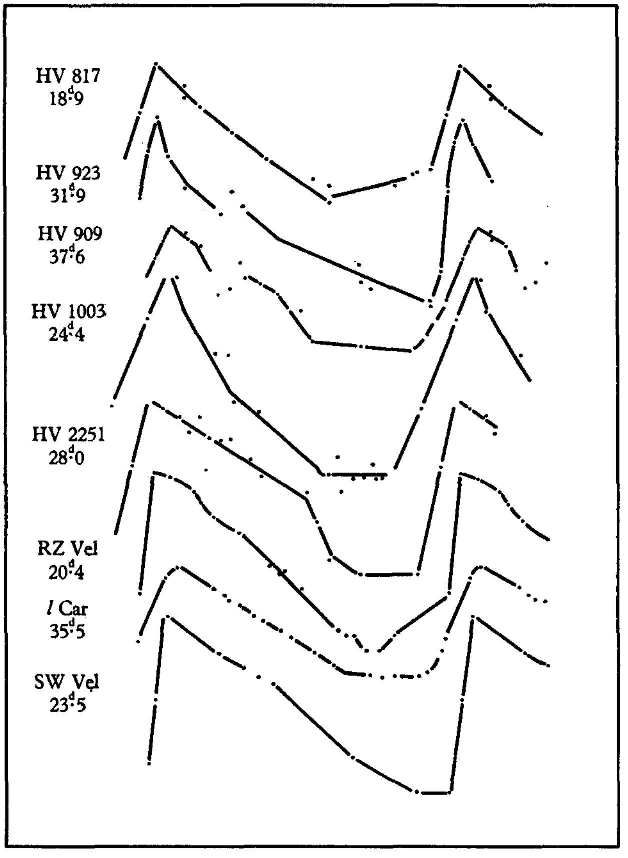

Fig. 3. *V* light-curves for the SMC cepheids HV 817 and 923; the LMC cepheids HV 909, 1003 and 2251; and the galactic cepheids RZ Vel, *l* Car and SW Vel. The periods in days are indicated.

The programme has proceeded more slowly than had been hoped, and to date reasonably complete light-curves have been obtained only for twenty-three cepheids in the two Clouds. Eighteen of the twenty-three have periods longer than twenty days. This restriction is due to the fact that almost all the observations have been made with the 30-inch reflector, which is not equipped with offset guiding.

The observations have been referred to standard sequences in each Cloud, and these have been measured by a number of people (Gascoigne and Kron, van Wijk, Hogg, Cox and Hallam, Arp, Bok), in almost all cases with good agreement.

Fig. 3 shows some typical data, light-curves of two SMC cepheids (HV 817 and 923), three LMC cepheids (HV 909, 1003 and 2251), and three galactic cepheids, all with comparable periods. It can be seen that these light-curves are, generally speaking, very similar. Those for HV 909 and the galactic cepheid *l* Car are almost identical in shape. There is evidence in a number of cases for a sharp dip, or perhaps instability, immediately after maximum. Eggen found a similar feature in SV Vul (45^d1) [2]. Some of the Cloud cepheids have very sharp maxima, which makes it difficult to determine their light and colour ranges. In such cases we have kept our estimates of these ranges conservative.

Fig. 4 shows how, for longer periods, the amplitudes of the LMC cepheids are generally greater, and those of the SMC cepheids smaller, than the amplitudes of the galactic cepheids. This is true both in light and colour. An interesting point is provided by HV 1492, an SMC cepheid of period 6^d65 ($\log P = 0{\cdot}799$). The observations of this star are incomplete, and the true amplitudes are almost certainly greater than those indicated in the figure, and hence greater than those of galactic cepheids of corresponding period.

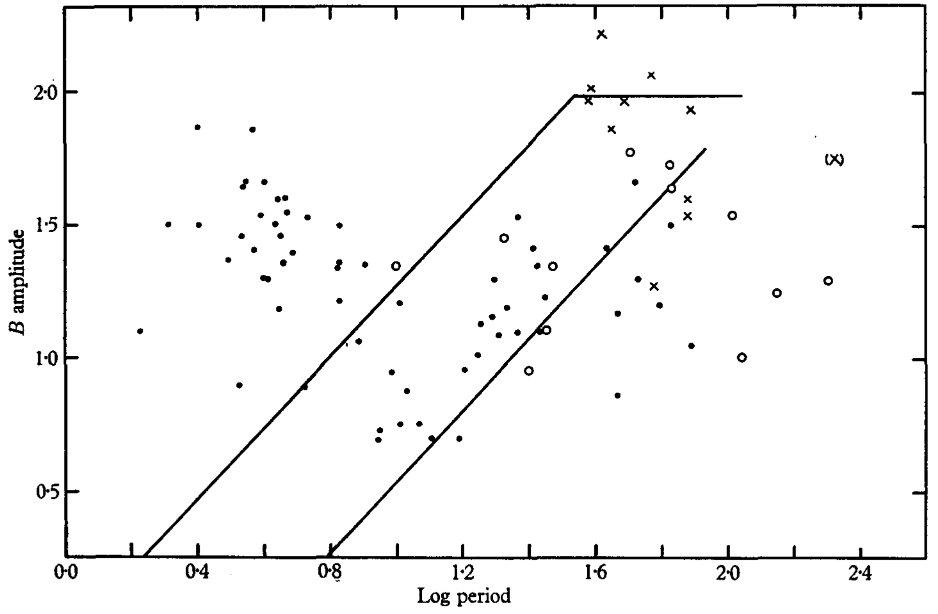

Fig. 4. Period-amplitude relation for Magellanic Cloud cepheids. Arp's data for SMC cepheids are represented by points, Gascoigne's by open circles, and Gascoigne's LMC cepheids by crosses. The amplitudes for almost all galactic cepheids lie within the full lines (Eggen, Gascoigne and Burr). A few longer period cepheids have amplitudes below and to the right of these lines.

We have data on three cepheids with periods greater than a hundred days. We find, with Gaposchkin, that HV 2447 in the LMC, period 119 days, is irregular. But both HV 821 in the SMC (127 days) and HV 883 in the LMC (134 days) seem to be true cepheids in that their light-curves are periodic. No galactic cepheids are known with periods as long as these.

Fig. 5 includes plots of mean B for our twenty-three cepheids against $\log P$ (SMC open circles, LMC crosses. The points and line represent Arp's data for the SMC). The data are consistent with Arp's slope of $2{\cdot}2 \log P$, and the scatter about the same, but our SMC cepheids come out about $0^m{\cdot}4$ brighter than his. Arp's stars are in the north following part of the Cloud, ours on the preceding side. The difference certainly does not arise in the standard sequences, where we agree very well, and for the one cepheid we have in common our mean B's agree to $0^m{\cdot}06$. Our LMC cepheids lie about $0^m{\cdot}7$ above Arp's line; this seems more likely to mean that the LMC cepheids are brighter, rather than nearer those in the SMC [3].

Finally there is the point that the Cloud cepheids are so much bluer than those in the Galaxy. I have nothing to add here to a paper by Eggen and myself [4], in which we endeavoured to show that the colours of the Cloud cepheids were also reasonable values for galactic cepheids. Since then Feast has shown that the spectra of some LMC cepheids are very similar to those in the Galaxy [5], and Irwin has just told you that cepheids in galactic clusters seem somewhat redder than those in the Clouds. Kron has evidence, from six-colour observations of super-giants, which supports this. Arp found that most of his SMC cepheids were a little redder than ours; the difference, though small, seems real. All that seems clear is that we are still a long way from a solution to this problem. We are not even sure how much reddening occurs between the Galaxy and the Clouds, or within the Clouds themselves.

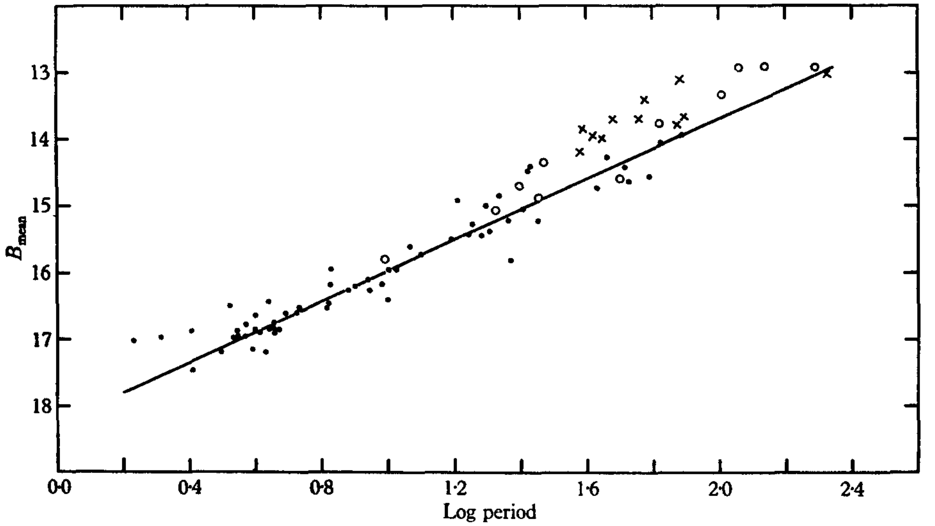

Fig. 5. Period-luminosity relation for Magellanic Cloud cepheids. Coding as in Fig. 4. The mean line, drawn from Arp's data only, has the equation: $B_{mean} = 17{\cdot}8 - 2{\cdot}2 \log P$.

To summarize, for periods greater than about ten days there are at present no well-established differences between the Cloud and galactic cepheids, except quite possibly in intrinsic colour. For the shorter period cepheids in the SMC the situation is very different; for those in the LMC existing observations do not allow a decision, but it should not be long before better ones have been obtained. There is now a good relative $P-L$ relation for the SMC, and within a few years we can expect absolute $P-L$ relations for both the SMC, LMC and galactic cepheids. These will at least indicate what the limitations are on the use of cepheids as extra-galactic distance indicators.

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