43. THE GALACTIC DISTRIBUTION OF YOUNG CEPHEIDS

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Abstract. The distribution of long-period Population I cepheids is studied. An age comparison of cepheids and galactic clusters shows that cepheids with periods >11.25 d, corresponding to ages of $\lesssim 30 \times 10^6$ yr, should be almost as good spiral arm tracers as galactic clusters with earliest types b 2-3. The distances of cepheids are determined from a revised period-luminosity-colour relation and from colour excesses, for the determination of which a new, purely photometric method is given. The resulting distribution of cepheids shows a good correlation with the spiral arms, as traced by young clusters.

1. Introduction

Spiral arm tracers have to fulfill two requirements: they must be young enough to be typical for the spiral arm population and it must be possible to determine reliable distances for them. Next to the young galactic clusters and H II regions the Population I cepheids with long periods seem most suitable for this purpose. As for the clusters and exciting stars of H II regions the theory of stellar evolution provides age estimates for the cepheids, and their distances can well be determined from the period-luminosity-colour (*P-L-C*) relation.

It is then of great interest to decide whether galactic clusters and H II regions on the one side and cepheids on the other side of comparable age define the same spiral arms. The contrary would be most severe: it would mean that there are separate places for stellar formation for different kinds of objects. It would seem easiest to solve the problem in extragalactic spirals whether the loci of young galactic clusters and young cepheids coincide. However, at present there are no complete surveys of cepheids in nearby spirals (M 31, M 33) available. The detection of cepheids in more distant galaxies is so badly hampered by the discovery chance that a meaningful discussion of their distribution is impossible. It remains only the possibility to study the distribution of galactic cepheids and to compare it with the spiral arms as defined by galactic clusters and H II regions.

The study of the galactic distribution of cepheids has not yet led to clear results, mainly due to the paucity of long period cepheids. Their space density within 1500 pc from the sun is roughly ten times lower than that of young galactic clusters, and their small number does not allow to outline spiral arms with any certainty. Therefore the question whether they are confined to spiral arms can only be settled, if their location is compared with more frequent spiral arm tracers as the young galactic clusters and H II regions are (Becker, 1963; Becker and Fenkart, 1963). Kraft and Schmidt (1963) have found a vague correlation between bright cepheids and OB-associations, and Kraft (1963) a reasonable correspondance between bright cepheids and young clusters, which was confirmed by Schmidt-Kaler (1964) and by Tammann (1968) on the basis of an extended observational material. However, Fernie (1968) has recently

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denied this correlation; and he has found – not discriminating against cepheids with shorter periods – even an anti-correlation for cepheids with early B stars, galactic clusters, and H II regions.

Becker's (1969a) updated list of cluster and H II region distances and additional observations for long period cepheids as well as a new calibration of the slope and the zero point of the *P-L-C* relation (Sandage and Tammann, 1969) and a better understanding of the age of cepheids as a function of period (Kippenhahn and Smith, 1969) make a new intercomparison desirable.

2. The Age of Cepheids

Kippenhahn and Smith (1969) have found from cepheids in galactic clusters an empirical relation between age and period. The relation predicts with surprising probability the age of a cepheid, in spite of the fact that the massive cepheids cross the instability strip several times and hence have different ages at a given period. The spread of age is offset by the fact, that the crossing times are quite different, and that the second crossing is by far the slowest. A least square solution of the data by Kippenhahn and Smith and giving proper weight to the individual crossing times leads to (Tammann, 1969a)

$$\log t(\text{in } 10^7 \text{ yr}) = 1.16 - 0.651 \log P \text{ (in d)}. \tag{1}$$

The maximum age of cepheids which are expected to outline well the spiral arms could be determined by Equation (1) and compared to the age of clusters with earliest main sequence type b2-3 ($U-B \lesssim -0\overset{\text{m}}{.}80$) or earlier, which are known to be spiral arm tracers by Becker's work. But the numerical age of clusters is critically dependent on the intrinsic colour of the brightest unevolved stars and hence on the colour excess assumed. It seems therefore safer to compare directly the periods with the spectral type of the earliest unevolved cluster members.

In Figure 1 the known cluster cepheids (Sandage and Tammann, 1969) are plotted with their periods against the earliest spectral types of their parent clusters. The four cepheids in the h + χ-association are plotted as an error box, because the spread in their periods as well as the work on the association by Wildey (1964) and Schild (1967) seem to indicate a finite formation time of the association. Also included in the diagram are WZ Sgr, SZ Tau, and Anon. Sct, which are believed to be members of the Sgr OB4-association (Tammann, 1969a), of NGC 1647 (Becker, 1969b), and of NGC 6649 (Tammann, 1969b), respectively. There is a clear relation between period and earliest spectral type. The scatter in the diagram is explainable by the non-unique relation between period and cepheid age, as already mentioned, and by observational errors in the determination of the earliest spectral types.

From Figure 1 one finds that all cepheids with $P > 20$ d and practically all cepheids with $P > 15$ d should be as young or younger than b 2-3 clusters and hence be as good spiral arm tracers as the latter. To go to cepheids with periods as low as 11.25 d (average age $= 3 \times 10^7$ yr according to Equation (1)) would apparently mean to

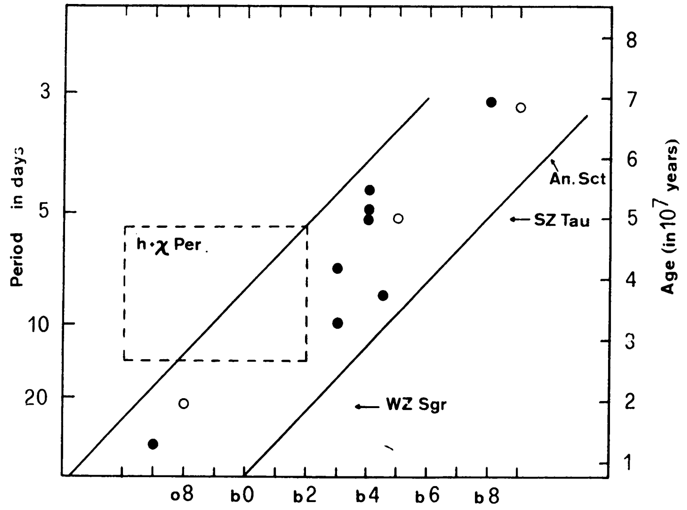

Fig. 1. The period of cluster cepheids vs. the earliest spectral type of their parent clusters. The scale at the right side gives the age of the cepheids according to Equation (1). Four cepheids in the $h+\chi$-association fall into the dotted square. Three cepheids, whose cluster membership is less reliable, are shown as open circles.

include some cepheids as old as b3-clusters which are known not to be confined to spiral arms.

3. The P-L-C Relation

The *P-L-C* relation used here is:

$$M_{\langle V\rangle} = -\,3.534 \log P + 2.647(\langle B^0\rangle - \langle V^0\rangle) = 2.469 \tag{2}$$

in the range $0.4 < \log P < 1.9$. This is essentially the same form as derived by Sandage and Tammann (1969) from 13 cepheids with known distances except for two slight modifications:

(a) The change of the pulsation constant Q along a constant period line in the $(M_V,\ B-V)$-plane was considered by Sandage and Tammann (1969) but not taken into account. The best straight line approximation for this change follows from Christy's theory of stellar pulsation (Christy, 1968), which predicts:

$$R^{1.69}/\mathfrak{M}^{0.66} = \text{const. (for } P < 10\text{ d)} \tag{3}$$

and

$$R^{1.83}/\mathfrak{M}^{0.78} = \text{const. (for } P > 10\text{ d)}. \tag{4}$$

Using a mass-luminosity relation of $L \propto \mathfrak{M}^{3.3}$ (Sandage and Gratton, 1963) and the same equations for the bolometric corrections and for the $(T_e,\ B-V)$-relation of supergiants as in Sandage and Tammann (1968) one finds for constant period a relation of:

$$M_V = 2.647(B - V) - \text{const}. \tag{5}$$

The coefficient of $(B-V)$ is the mean of 2.614 and 2.680, which are the correct values for $P<10$ d and $P>10$ d, respectively. (The value assumed before is 2.52).

(b) The mean magnitudes $\langle V\rangle$ and $\langle B\rangle$ of the cluster cepheids are taken from a list of photometric parameters, which were derived by Fourier analysis from all photoelectric observations of cepheids available (Schaltenbrand and Tammann, 1969)

The least square solution leading to Equation (2) is very little changed if EV Sct and VY Per are excluded ($0\overset{\mathrm{m}}{.}03$ in the constant term). It is still somewhat doubtful if the parent cluster of EV Sct, NGC 6664, is real (Tammann, 1969c), and VY Per shows the greatest deviation and may not belong to the h + χ-association. The average deviation from Equation (2) is for the 13 cepheids $\pm 0\overset{\mathrm{m}}{.}071$ (without VY Per $\pm 0\overset{\mathrm{m}}{.}055$), which is somewhat less than in the previous paper (Sandage and Tammann, 1969).

According to the theory of the instability strip the period-luminosity relation is depending on the effective temperature T_e, too. This dependence has usually been expressed by the observable quantity $(\langle B\rangle-\langle V\rangle)$. It is evident that instead of $(\langle B\rangle-\langle V\rangle)$ the colour $(\langle U\rangle-\langle B\rangle)$ could be used as well, the latter being almost as sensitive for temperature changes in supergiants. It is therefore attempted here to derive a *P-L-C* relation in M_V, $\log P$, and $(\langle U\rangle-\langle B\rangle)$.

For this purpose 41 cepheids with complete UBV-photometry are taken from the list by Sandage and Tammann (1968). Reliable colour excesses are known for these mainly from the work by Kraft (1961) and Bahner *et al.* (1962); (the cepheids BY Cas, S Nor, and SV Per, which are suspected to have companions, are exluded as well as the peculiar cepheid Y Oph (Evans, 1968)). Mean magnitudes of these cepheids are taken from Schaltenbrand and Tammann (1969). The absolute magnitudes $M_{\langle V\rangle}$ are determined from Equation (2). The intrinsic colours $\langle U\rangle^0-\langle B\rangle^0$ are derived under the assumption $E_{U-B}/E_{B-V}=0.80$. By least square solution one then finds:

$$M_{\langle V\rangle} = -\,3.382\,\log P + 1.834(\langle U^0\rangle - \langle B^0\rangle) - 1.700\,. \tag{6}$$

The fact that similar solutions are found if the cepheids are devided into two groups with $E_{B-V}<0\overset{\mathrm{m}}{.}55$ and $E_{B-V}>0\overset{\mathrm{m}}{.}55$, respectively, seems to prove in favour of the near correctness of the adopted ratio E_{U-B}/E_{B-V}. The average difference $\Delta M_{\langle V\rangle}$ between Equations (2) and (6) is for 41 cepheids $\pm 0\overset{\mathrm{m}}{.}094$.

4. The Colour Excess of Cepheids

The colour excesses of relatively few cepheids are well determined by means of spectroscopic or Γ-photometric observations. Since the colour excesses enter the distance determination of cepheids it is attempted here to derive the E_{B-V}-values purely from photometric data.

Equations (2) and (6) can be written in the form

$$M_{\langle V\rangle} = 3.534\,\log P + 2.647(\langle B\rangle - \langle V\rangle - E_{B-V}) - 2.469 \tag{7}$$

and

$$M_{\langle V\rangle} = 3.382\,\log P + 1.834(\langle U\rangle - \langle B\rangle - 0.80\,E_{B-V}) - 1.700\,. \tag{8}$$

Solving (7) and (8) for E_{B-V} leads to:

$$E_{B-V} = -0.129 \log P + 2.243(\langle B\rangle - \langle V\rangle) - 1.554(\langle U\rangle - \langle B\rangle) - 0.652. \qquad (9)$$

The colour excesses E_{B-V} were determined from Equation (9) for 41 cepheids with known spectroscopic E_{B-V}-values. A comparison of the results of the two methods is shown in Figure 2. There is no indication for a systematic difference. The mean deviation from the 45°-line amounts to $\pm 0\overset{m}{.}08$. Since the average mean error of a spectroscopically determined colour excess is about $\pm 0\overset{m}{.}03$, the colour excesses determined from Equation (9) should be good within $\pm 0\overset{m}{.}07$.

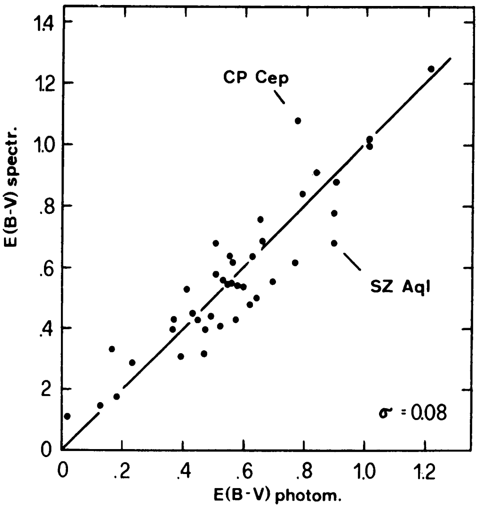

Fig. 2. Colour excesses E_{B-V} from spectroscopic or Γ-photometric observations vs. E_{B-V} from Equation (9). Two cepheids with exceptionally large deviations are indicated. The drawn line has the slope 1.

For cepheids where spectroscopic excesses are lacking as well as U-magnitudes E_{B-V} was taken from the list by Fernie (1967). These values are derived mainly under the assumption that cepheids have the same intrinsic colours at maximum light, which seems to be correct within about $\pm 0\overset{m}{.}10$ (Sandage and Tammann, 1968). The fact that Fernie's intrinsic colours are systematically redder by $\sim 0\overset{m}{.}06$ than those by Kraft can be neglected in the present context.

5. The Distances of Cepheids

From Equation (2) and an adopted absorption law $A_V = 3.0\ E_{B-V}$ the distance modulus becomes:

$$(m - M)^0 = \langle V\rangle + 3.534 \log P - 2.647(\langle B\rangle - \langle V\rangle) - 0.353\ E_{B-V} + 2.469. \qquad (10)$$

There are few astronomical formulae so kindly deviced by nature as this one: the coefficients of the observed quantities are the greater the higher the precision is with which they can be observed. The only quantity where an observational error could have any effect on the distance modulus is E_{B-V}; even here an error of $0^m.10$ affects the modulus by only $0^m.035$. The random scatter of cepheids around the adopted *P-L-C* relation seems also to be quite small as indicated by the calibrating cepheids.

It remains the question whether systematic errors have entered the *P-L-C* relation. The problem of the reliability of cluster distances based on the Hyades shall not be discussed here (see e.g. Sandage and Tammann, 1969), because any – quite unlikely – change of the Hyades distance would equally affect the clusters and cepheids, whose distances are to be compared here. In determining the slope of the *P-L-C* relation, RS Pup, the only calibrating cepheid with very long period, enters with great weight. However the slope found here seems to be quite reliable because in the range $0.4 < \log P < 1.9$ it nearly coincides with the best linear fit to the ridge line of the *P-L-C* relation derived from all well observed extragalactic cepheids (Sandage and Tammann, 1968) and agrees also very nearly with the slope Gascoigne (1969) found from the combined solution for cepheids in galactic clusters and in the Magellanic Clouds.

A list of distances from Equation (10) for cepheids with $P > 9$ d is given in Table I. It is attempted to include all galactic cepheids of Population I with sufficient observational data; however, cepheids of doubtful population and with suspected companions are excluded.

For a number of long period cepheids photoelectric photometry is missing. Distance estimates for these are taken from the list by Fernie and Hube (1968); they are not shown in Table I. The distances of cepheids in common in Table I and in the list by these authors agree reasonably well; this is somewhat surprising because they use a quite different period-luminosity relation.

6. Galactic Distribution of Cepheids

The distances of 32 cepheids with $P > 15$ d and of 20 cepheids with $15 > P > 11.25$ d are shown in Figure 3 projected into the galactic plane; also drawn are 14 cepheids of the long period group and 7 of the shorter period group with lacking photoelectric observations. The young clusters and the H II regions according to the latest results (Becker, 1969a) are drawn as open circles.

From Figure 3 the following conclusions can be drawn:

(a) The cepheids with $P > 15$ d either fall into the slightly extended boundaries, which are outlined as spiral arms by young cluster and H II regions, or lie at distances, where no young clusters and H II regions are known. The same holds for 25 out of 27 cepheids with $15 > P > 11.25$ d, only 2 of them fall between reliably determined spiral arms (TT Aql and Z Sct.). This result conforms with the view that long period cepheids, young clusters and the exciting stars of H II regions were formed essentially at the same places.

(b) The exception of TT Aql is not surprising. It lies mid-way between the spiral

TABLE I

Distances of Cepheids with $P > 9\text{d}$

(1) Cepheid	(2) l^{II}	(3) b^{II}	(4) $\log P$	(5) $\langle U \rangle$	(6) $\langle B \rangle$	(7) $\langle V \rangle$	(8) E_{sp}	(9) E_{ph}	(10) E_{Fernie}	(11) r (pc)
SZ Aql	35.6	− 2.3	1.234	11.06	10.09	8.66	0.68			1950
TT Aql	36.0	− 3.1	1.138	9.44	8.44	7.14	0.55			1000
FN Aql	38.5	− 3.1	0.977	10.53	9.62	8.38		0.59		1450
RX Aur	165.8	− 1.3	1.065	9.33	8.65	7.68		0.32		1760
SY Aur	164.7	+ 2.1	1.006	10.83	10.12	9.06	0.44			2660
YZ Aur	167.3	+ 0.9	1.260	12.74	11.79	10.38		0.87		4480
AN Aur	164.9	− 1.0	1.012	12.49	11.66	10.44		0.68		4010
RW Cam	144.9	+ 3.8	1.215	–	10.06	8.67			0.70	1990
SS CMa	239.2	− 4.2	1.092	11.97	11.11	9.87		0.62		3510
l Car	283.2	− 7.0	1.551	6.04	5.00	3.72		0.39		430
U Car	289.1	+ 0.1	1.588	8.35	7.46	6.27		0.43		1630
VY Car	286.6	+ 1.2	1.278	9.36	8.58	7.45		0.51		1790
WZ Car	289.3	− 1.2	1.362	–	10.46	9.29			0.33	4730
XX Car	291.3	− 4.9	1.196	–	10.39	9.35			0.30	4290
XY Car	291.4	− 3.9	1.095	–	10.50	9.30			0.49	2880
XZ Car	290.3	− 0.8	1.221	–	9.84	8.59			0.55*	1680
YZ Car	285.6	− 1.4	1.259	10.63	9.83	8.71		0.45		3160
AQ Car	285.8	− 3.3	0.990	10.44	9.78	8.84		0.29		2800
CR Car	285.7	− 0.4	0.990	13.82	12.90	11.58		0.75		5750
FI Car	287.8	+ 0.7	1.129	–	13.24	11.65			0.88	5170
FO Car	290.5	− 2.1	1.015	–	12.05	10.78			0.64	4440
FR Car	291.1	+ 0.6	1.030	11.65	10.82	9.68		0.51		3260
RW Cas	129.0	− 4.6	1.170	11.41	10.46	9.21	0.41			2980
RY Cas	115.3	− 3.3	1.084	12.34	11.31	9.94	0.76			2980
SZ Cas	134.8	− 1.2	1.134	12.39	11.32	9.83	0.88			2546
CH Cas	112.9	+ 1.6	1.179	–	12.61	10.96			0.94:	3830
CY Cas	113.9	+ 2.0	1.158	–	13.35	11.65	1.10			4640
DD Cas	116.8	+ 0.5	0.992	12.00	11.08	9.86	0.56			3020
TX Cen	315.2	− 0.6	1.233	13.50	12.23	10.53		1.04		3130
VW Cen	307.6	− 1.6	1.177	12.53	11.57	10.22		0.73		4010
XX Cen	309.5	+ 4.6	1.040	9.47	8.79	7.82		0.34		1790
KK Cen	294.2	+ 2.7	1.086	–	12.82	11.50			0.57	6620
KN Cen	307.8	− 2.1	1.532	12.50	11.40	9.84		0.96		4430
V339 Cen	313.5	− 0.5	0.976	10.73	9.90	8.70		0.64		1740
CP Cep	100.4	+ 1.1	1.252	13.53	12.18	10.54	1.08			3480
SU Cru	299.2	− 0.6	1.109	12.82	11.56	9.79		1.21		1640
X Cyg	76.9	− 4.3	1.215	8.43	7.55	6.40	0.45			970
SZ Cyg	84.4	+ 4.0	1.179	12.19	10.95	9.42		0.70		2250
TX Cyg	84.4	− 2.3	1.168	12.77	11.37	9.49	1.25			1380
VX Cyg	82.2	− 3.5	1.304	13.18	11.81	10.07		0.96		2730
BZ Cyg	84.8	+ 1.4	1.006	12.98	11.83	10.22	1.00			2140
CD Cyg	71.1	+ 1.4	1.232	11.33	10.29	8.97	0.64			2580
EZ Cyg	67.1	+ 0.6	1.067	13.70	12.51	11.06		0.63		4420

Table I (continued)

Cepheid	l^{II}	b^{II}	$\log P$	$\langle U \rangle$	$\langle B \rangle$	$\langle V \rangle$	E_{sp}	E_{ph}	E_{Fernie}	r (pc)
β Dor	271.7	−32.8	0.993	5.13	4.56	3.75		0.14		320
ζ Gem	195.7	+11.9	1.007	5.30	4.71	3.89	0.15			350
AA Gem	184.6	+ 2.7	1.053	11.56	10.81	9.71		0.53		3600
Z Lac	105.8	− 1.6	1.037	10.33	9.58	8.43	0.48			1860
T Mon	203.6	− 2.6	1.432	8.28	7.33	6.14	0.43			1180
SV Mon	203.7	− 3.7	1.183	10.11	9.30	8.25		0.28		2540
S Mus	299.6	− 7.5	0.985	7.52	6.96	6.14		0.22		920
UU Mus	296.8	− 3.2	1.066	11.84	10.91	9.78		0.29		3840
S Nor	327.8	− 5.4	0.989	8.01	7.36	6.41	0.21			910
U Nor	325.6	− 0.2	1.102	11.96	10.83	9.23		1.04		1570
SY Nor	327.5	− 0.7	1.102	11.72	10.85	9.50		0.89		2470
SV Per	162.6	− 1.5	1.047	10.55	9.99	8.95	0.44			2800
VX Per	132.8	− 3.0	1.037	11.38	10.52	9.30		0.61		2500
X Pup	236.1	− 0.8	1.414	10.70	9.76	8.54		0.45		3350
RS Pup	252.4	− 0.2	1.617	9.54	8.44	7.01		0.65		1710
VZ Pup	243.4	− 3.3	1.365	11.56	10.77	9.61		0.57		5290
AD Pup	241.9	− 0.0	1.133	-	10.97	9.88			0.42*	4620
AQ Pup	246.2	+ 0.1	1.475	11.09	10.15	8.79	0.62			3370
VY Sgr	10.1	− 1.1	1.132	-	13.50	11.53			1.30*	2920
WZ Sgr	12.1	− 1.3	1.339	10.56	9.41	8.02	0.68			1820
YZ Sgr	17.8	− 7.1	0.980	9.13	8.36	7.34		0.32		1230
RY Sco	356.5	− 3.4	1.308	10.49	9.44	7.99		0.79		1560
V500 Sco	359.0	− 1.4	0.969	11.03	10.03	8.74		0.55		1610
Y Sct	24.0	− 0.9	1.015	12.29	11.19	9.63	0.80			1810
Z Sct	26.8	− 0.8	1.111	11.88	10.94	9.60		0.74		2760
RU Sct	28.2	+ 0.2	1.294	12.61	11.21	9.50		0.84		2200
TY Sct	28.1	+ 0.1	1.044	13.80	12.52	10.79		1.11		2490
UZ Sct	19.2	− 1.5	1.169	14.78	13.17	11.28		0.94		3220
RY Vel	282.6	+ 1.5	1.449	10.71	9.71	8.36		0.64		2690
RZ Vel	262.9	− 1.9	1.310	-	8.23	7.11			0.30	1700
SV Vel	286.0	+ 2.4	1.149	-	9.65	8.57			0.35	2650
SW Vel	266.2	− 3.0	1.371	10.13	9.28	8.13		0.44		2790
SX Vel	265.5	− 2.2	0.980	-	9.14	8.26			0.33	2240
DD Vel	271.5	− 1.4	1.120	-	14.13	12.47			0.98*	6860
DR Vel	273.2	+ 1.3	1.049	-	11.10	9.54			0.85	1810
Ex Vel	274.1	− 2.2	1.122	-	13.31	11.72			0.88	5340
SV Vul	63.9	+ 0.3	1.654	9.85	8.69	7.22	0.64			1930

Column 1–4: name of cepheid with galactic coordinates and logarithm of period.
Column 5–6: mean magnitudes from Schaltenbrand and Tammann (1969).
Column 8: E_{B-V} from spectroscopic or Γ-photometric observations (Sandage and Tammann, 1968).
Column 9: E_{B-V} from Equation (9).
Column 10: E_{B-V} from Fernie (1967). Stars* indicate that E_{B-V} was determined from the period-colour relation for galactic cepheids (Sandage and Tammann, 1968, Equation (7)).
Column 11: the distance in pc from Equation (10).

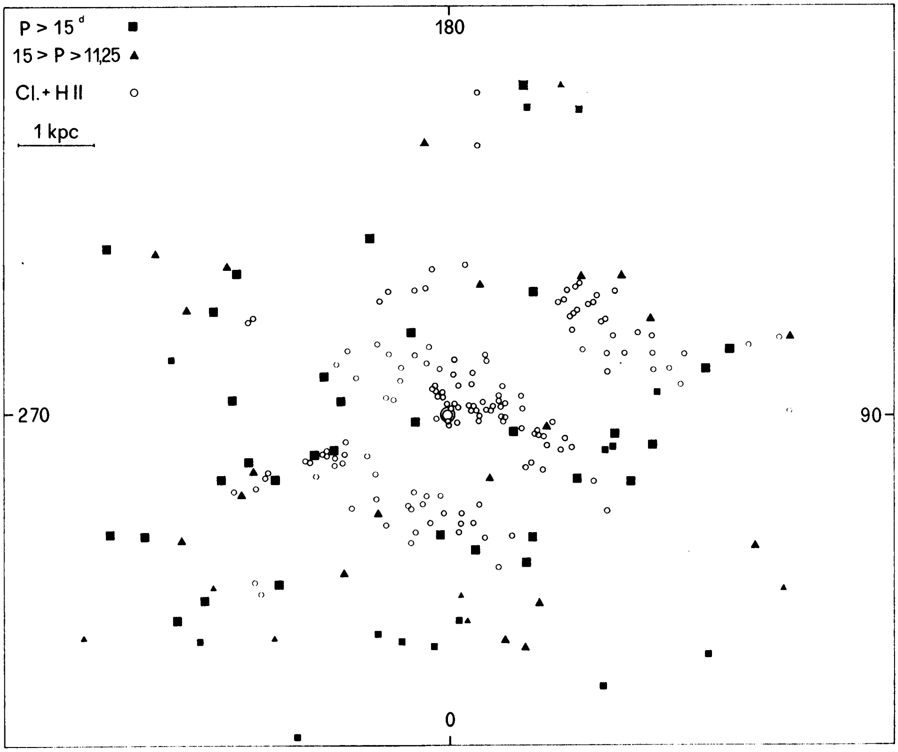

Fig. 3. The galactic distribution of young objects projected into the galactic plane. Big squares (■): cepheids with $P > 15$ days; big triangles (▲): cepheids with $15 > P > 11.25$ days. Small squares (■) and small triangles (▲): cepheids with uncertain distances in the corresponding period intervals; open circles (○): clusters with earliest type b2-3 and H II regions (compare Becker and Fenkart, this volume, p. 205, Figure 1).

arms 0 and −I (the designation of spiral arms according to Becker, (1963)). Its age is from Equation (1) 2.7×10^7 yr. If one assumes that it has moved in the galactic plane with 1.5 times the random speed of cepheids of 15 km s^{-1} (Kraft and Schmidt, 1963; Oort, 1964), and that its velocity is perpendicular to the axis of a spiral arm, it has travelled during its life-time very nearly the distance between the ridge line of one of the neighbouring spiral arms and its present location.

The case of Z Sct, lying between −I and −II, is less clear. There is a slight indication from Figure 3 that the distance between these two spiral arms decreases if one goes from $l^{\text{II}} = 310°$ to 0° to 30°. This possible merging of the spiral arms in the direction of Scutum might be supported by the distribution of early Be-stars (Schmidt-Kaler, 1964). If this was correct, Z Sct would fit well into the spiral pattern.

(c) The agreement between young clusters, H II regions and long period cepheids is especially tight in the spiral arm −I; it is still quite reasonable for the spiral arms 0 and +I. The existence of the spiral arms −II and +II, barely indicated by young clusters and H II regions, seems to be confirmed by the cepheids. There is hope that the spiral arm −II can be traced quite well from cepheids, when photoelectric UBV-observations of all long period cepheids in this direction become available.

(d) If one goes to shorter periods ($P<11.25$ d) more and more cepheids fall inbetween the spiral arms. Eventually the correlation between young clusters, H II regions and cepheids is smeared out and turns into the anti-correlation found by Fernie (1968).

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