work has indicated the possibility that the galactic potential field is of such a form that it may admit of a third integral of the equations of motion. Should this be so the ratio h/l need not be unity even in the steady state.

Evidence for differential galactic rotation is found. A weighted mean value of the Oort constant A is $+7 \cdot 8 \pm 3 \cdot 4$ (s.e.) km/sec.kpc. Whilst this is considerably smaller than the value appropriate to extreme Population I objects, it agrees well with the value that can be predicted from the velocity ellipsoids and systematic motions (5 km/sec.kpc).

Finally, differential galactic rotation for the Se variables on assuming them to be extreme Population I objects yields a visual absolute magnitude at maximum of $-3^{m}_{\cdot}4 \pm 0^{m}_{\cdot}8$ (s.e.). This is much brighter than the value of $-1^{m}_{\cdot}56$ recently found from statistical parallaxes.

References

Feast, M. W. (1963).—*M.N.* **125**: 367–415.
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Discussion

Landi Dessy: Do you measure emission or absorption lines?
Feast: Both, if possible. Eighty-six of the 114 have absorption as well as emission lines.
Landi Dessy: Do you always measure them at maximum?
Feast: Yes, but we have followed a few to lower brightness.

16. GALACTIC STRUCTURE AND ROTATION FROM CEPHEIDS

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Internally consistent distances to classical cepheids can be derived with considerable accuracy because they satisfy period-luminosity and period-colour relations. Studies of five cepheids that are members of galactic clusters have led to a revised period-colour relation and a new zero point for the period-luminosity relation. Distances have been computed for all cepheids given in recently published photoelectric surveys. The material can be regarded as complete to a distance of about 1500 pc.

The distribution of cepheids of all periods shows that within 1500 pc the vast majority of cepheids are on the side of the Sun toward the centre of the Galaxy. The only clear indication of structure in the distribution is seen toward $l^{II} = 290°$. This is probably the inner edge of a spiral arm in the Carina region, the central part of which may be lost owing to high obscuration at lower longitudes.

Long-period cepheids, with $M_V \leqslant -4 \cdot 3$, show a distribution quite similar to that exhibited by OB associations. Concentrations or spiral arms may be noted in Cyg and in the Per–Cas region. It is not clear how, or whether, these concentrations extend into the area $l^{II} = 180$ to $360°$. The Per–Cas arm seems to vanish in the direction of the anticentre. The OB associations are distributed roughly symmetrically about the Sun (within 1500 pc), in marked contrast with the asymmetry exhibited by cepheids of all periods. There are too few long-period cepheids within 1500 pc to say anything about their distribution locally.

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The distribution of z-coordinates shows that the Sun is located some 30 or 40 pc above the layer of cepheids. The average z-component relative to the layer of cepheids within 2 kpc is about 65 pc.

The solar motion of cepheids and the value of the galactic rotation constant A have been determined from available radial velocities. There is some evidence for a K term of either -2 km/sec.kpc, or a constant -3 km/sec. The components of solar motion found are 8 km/sec toward the galactic centre and 13 km/sec in the direction of rotation. An attempt to determine the curvature of the angular velocity curve failed. This must be due to localized systematic deviations from circular motion. Values of A in the range 13 to 16 km/sec per kpc were found for different ranges of galactocentric distance. The value of A finally adopted was 15 km/sec.kpc. It may be shown that earlier determinations of the value of A can be reconciled with the present one if the effect of the different distance scales used is taken into account.

The components of solar motion given above lead to a total solar motion of 16½ km/sec. The solar motion computed from tangential velocities of 18 nearby cepheids with accurate proper motions in conjunction with our distances amounts to 21 km/sec. The difference would suggest that our distances are too large by a factor of 1·27, corresponding to $0^m.5$ in the cepheid luminosities. The mean error is about $0^m.3$, however, and we do not feel that the small proper motions carry sufficient weight to justify a modification of the present distance scale of cepheids which depends on that of the galactic clusters.

For a full account of the above investigation see *Ap. J.* **137**: 249–67 (1963).

Discussion

Blaauw: With regard to your results, the mean absolute magnitudes of the cepheids which the late Dr. H. R. Morgan and I gave had a probable error of $\pm 0\cdot 3$ magnitude. In view of this the difference of $0\cdot 5$ magnitude is not embarrassing.

I was rather intrigued by the systematic deviation of the cepheids from the galactic plane. I take it that you do not blame this on selection effects. These differences of 30 to 40 pc are large in view of the spread in z. These cepheids have a range of ages and one wonders whether at their time of formation the neutral hydrogen layer in which they were formed was systematically displaced with respect to the present position. Have you looked into the question of whether the regions of large z dispersions of the cepheids are correlated with those where we now find deviations from the flat layer which is so well defined in the inner parts of the Galaxy up to about the distance of the Sun?

Perek: Did you plot the rotation curve from the angular velocity data?

Schmidt: This requires an assumption about the value of $\omega(R_0)$. The angular velocity is $\omega(R) = \omega(R_0) - 3\cdot 0(R - R_0) + 0\cdot 16(R - R_0)^2$, where R_0 was taken as 10 kpc.

Westerlund: RS Puppis with $\log P = 1\cdot 617$ is a member of an association of about 24 OB stars. Its distance modulus derived from the association is $m - M = 11\cdot 2$. Its absolute magnitude from the distance modulus is $M_V = -6\cdot 1$ and determined from Kraft's period-luminosity relation is $-5\cdot 8$. The agreement appears sufficiently good to prove the correctness of Kraft's curve.

Heard: What value of R_0 did you use in the analysis?

Schmidt: $R_0 = 10$ kpc; however, the value of A found depends little on whether this value or a value of $8\cdot 2$ kpc is used.

Weaver: Agreement is noted between Berkeley results on the kinematical analysis of the cepheid variables (by B. Takase) and the Kraft–Schmidt results.

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Some 130 cepheid variables which have accurate photometric data and also radial velocity or proper motion data or both were used by Takase to determine a consistent set of values concerning the galactic distance scale, the galactic rotation, and the local stellar motion.

He solved the equations which express the relations between the observed motion, the solar motion, the differential galactic rotation, the peculiar motion, and several systematic correction terms, under the condition that the expectation for the peculiar motion is zero. Distances of the cepheids were calculated by using the period-luminosity and the period-colour relations recently established by Kraft (*Ap.J.* **134**: 616–32 (1961)).

He tried two kinds of solutions, one of which includes a K-term and the other does not, and calculations were made for several values of R_0, the distance of the Sun from the galactic centre. The table shows the results for cases where the AR_0 values (A is the Oort constant) are closest to 156 km/sec, as determined by Schmidt (*B.A.N.* **13**: 15–41 (1956)) from 21-cm radio observations.

The zero-point correction to Kraft's period-luminosity relation, derived by the statistical parallax method employing the proper motion data, was found to be practically zero. Further, he tried calculations in which the "Basic Solar Motion" and "Standard Solar Motion" are assumed.

COMPILATION OF KINEMATIC PARAMETERS DETERMINED AT BERKELEY FROM CEPHEID VARIABLE STARS

	Symbol	Unit	Values with no K Term ($\pm$m.e.)	Values with a K Term ($\pm$m.e.)
Sun's distance	R_0	(kpc)	11·0	11·1
K term	K	(km/sec)	0	$-4·0\pm1·0$
Angular rotational velocity and	$\omega(R_0)$	(km/sec.kpc)	$31·1\pm5·4$	$30·8\pm5·3$
its first and second	$\omega'(R_0)$	(km/sec.kpc^2)	$-2·6\pm0·2$	$-2·5\pm0·2$
derivatives	$\omega''(R_0)$	(km/sec.kpc^3)	$0·2\pm0·2$	$0·2\pm0·2$
Oort constant	A	(km/sec.kpc)	$14·2\pm1·0$	$14·1\pm0·9$
Solar motion	$S_\odot$	(km/sec)	$19·1\pm1·6$	$18·8\pm1·5$
Apex in galactic longitude and	$L_\odot^{\rm II}$	(deg)	$54·9\pm6·3$	$57·4\pm6·1$
latitude	$B_\odot^{\rm II}$	(deg)	$22·4\pm2·0$	$22·8\pm1·9$

Gascoigne: Did you make separate solutions for cepheids of short and long period? This of course should be a check on the coefficient of the $\log P$ term.

Schmidt: Yes, we did. We found that the slope of the SMC leads to better agreement than the slope of the LMC. The number of long period variables is small, however, so that this check does not carry large weight.

Gascoigne: It seems worth commenting on the closeness of the agreement between this value of A and that derived recently from clusters by Johnson *et al.*

Kerr: The mean plane of the local hydrogen could well be 10 to 20 pc below the overall mean galactic plane, but, as far as I know, no good solution has yet been made for this. Has any separate study been made of the mean z of the cepheids in different directions?

Schmidt: Since incompleteness may have an effect beyond 1500 pc, the number of cepheids for a study of this kind would probably be too small.