BAADE-WESSELINK RADII OF LONG PERIOD CEPHEIDS NEW
OBSERVATIONAL RESULTS

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Abstract The radii of Galactic Cepheids as determined from
a version of the Baade-Wesselink technique are shown to de-
pend upon the colour index used to define the temperature
scale. The (V-I) radii are systematically larger than the
commonly used (B-V) radii and are probably better estimators
of the true radii. There still remains a problem, however,
in reconciling the period-radius relation with the period-
luminosity-colour relation.

1. Observations
        A programme of observations of galactic Cepheids with P>10
days has recently been completed at SAAO and results will appear in the
literature in due course (Coulson & Caldwell. in preparation). Prelim-
inary results for 9 of these stars are discussed here together with
those for 6 other stars, with 9<P<17 days (Coulson, Caldwell & Gieren
1984, in press). These are best compared with similar data for shorter
period Cepheids obtained by Gieren (1982, et op cit) and reanalysed here.

Broadband UBVRI photometric measures have been obtained at Sutherland
(SAAO) and La Silla (ESO). The measures are on the Cousins' standard
system (Menzies, Banfield & Laing 1980). They have been combined with
older photometry from the literature to enable redeterminations of the
periods and with the best of this older data to allow full specification
of the photometric properties around the pulsation cycle.

The radial velocities were all obtained with the radial velocity spectro-
meter at the coudé focus of the SAAO 1.9m telescope at Sutherland. They
are essentially measures of the FeI lines (Coulson 1983) and are on the
Wilson (1953) standard system. Older radial velocites in the literature
proved to be of considerably poorer quality and have not been combined
with the new data.

Phase coverage for the stars discussed here is practically complete and
since the photometry and radial velocities have been obtained contemp-
oraneously they allow radius determinations free from the uncertainties
of phase mismatching.

2. Radii
        Radii were obtained using Balona's (1977) maximum-likelihood
version of the Baade-Wesselink method. We have modified his original

formulation to account for large radial amplitudes ($\delta R/R > 0.1$) and have used not only V and B-V as magnitude and colour, but also B,R,I and V-R, V-I and R-I. The derived radii are found to be essentially independent of the choice of magnitude, but show systematic differences with colour. Fig. 1 shows the radius difference

$$\Delta = \log R_{V-I} - \log R_{B-V}$$

plotted against log P. Clearly Δ is significantly larger than zero and is probably period dependent.

$$\Delta = (0.023 \pm 0.016) + (0.029 \pm 0.016) \log P \qquad (1)$$

(se/pt = 0.023).

If the (V-I) results are less affected by gravity than the (B-V) results then they may be considered better estimates of the sizes of the stars and we may correct (B-V) radii by equation (1). This we have done for the 29 radii derived above plus those for the 32 stars studied by Balona (1977) for which there are reddening estimates (Dean, Warren & Cousins 1978). These radii yield a mean relation:

$$\log R = (0.637 \pm 0.021) \log P + (1.215 \pm 0.028) \qquad (2)$$

(s.e./pt = 0.049).

3. The PLC Zero Point

With these corrected mean radii we may also determine the mean absolute magnitude

$$<M_V> = A<B-V>_o - 5 \log R + C \qquad (3)$$

(see Balona 1977, equation 1.3).

In this equation C is a term usually given as

$$C = M_{bol\ \odot} + 10 \log T_{eff\ \odot} - 10a_o - b_o \qquad (4)$$

were a_o, b_o are assumed constants of the relations

$$\log T_{eff} = a_o + a_1 <B-V>_o \qquad (5)$$

$$M_{bol} - M_V = b_o + b_1 <B-V>_o \qquad (6)$$

From M_V we may then derive estimates of the zero-point of the P-L-C relation, γ :

$$<M_V> = \alpha \log P + \beta <B-V>_o + \gamma \qquad (7)$$

Equations (3) & (7) yield $C-\gamma$ in the terms of several observables:

$$C-\gamma = \alpha \log P + (\beta-A) <B-V>_o + 5 \log R \qquad (8)$$

From the 61 corrected (B-V) - radii derived above we have calculated $C-\gamma$ using nominal values of $\alpha = -3.80$, $\beta = 2.70$, $A = 2.15$ and plot the results against $\log P$ in Figure 2. Cleary $C-\gamma$ is not a constant for all Cepheids. This implies that at least one of the above assumptions is incorrect. It seems most likely that the temperature and/or bolometric correction calibrations may depend upon surface gravity and hence give rise to a period dependence of the type seen here.

Until this dependence is fully quantified the determination of γ from Cepheid radii will remain impracticable.

References

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Dean, J.F., Warren, P.R. & Cousins, A.W.J., 1978. M.N.R.A.S., 183, 569.
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Menzies, J.W., Banfield, R.M. & Laing, J.D., 1980. SAAO Circ. No. 5,
        p 149.
Wilson, R.E., 1953. General Catalogue of Stellar Radial Velocities,
        Carnegie Inst. of Washington, D.C.

Figure 1.
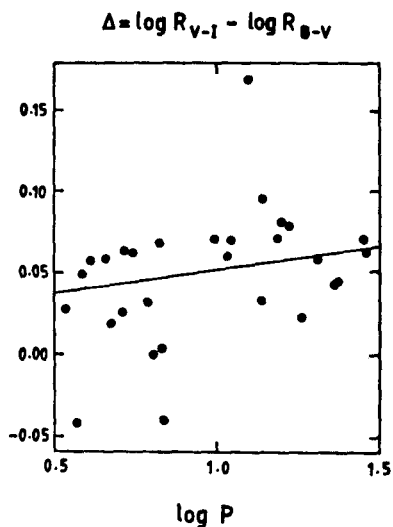Radius Differences
For 29 Galactic Cepheids

Figure 2.
C-γ for 61 Galactic Cepheids
using corrected (B-V)-Radii
$C-\gamma = -3.8 \log P + 0.55 \langle B-V \rangle_o +$
$5 \log R$.

$\Delta = \log R_{V-I} - \log R_{B-V}$

$(C-\gamma)'$