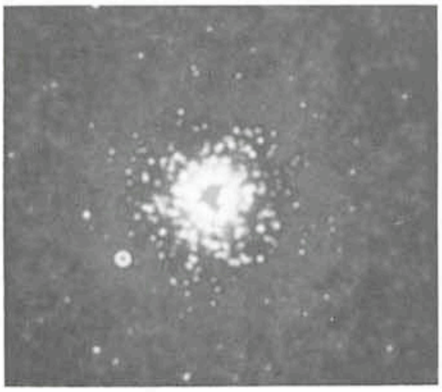

Central field of NGC 1851 (1.'7 × 2.'3) in U with a coated GEC CCD at the 2.2-m telescope. North is up, east to the left.

phys. **138,** 415; 1985, ESO preprint No. 400; IAU circular No. 4101 and No. 4146: AC211) we could expect to succeed again with one the most favourable targets of the southern hemisphere.

The choice of the coated GEC CCD was driven by 3 of its properties (when compared with a classical RCA chip):

(1) A higher and flatter response in the U band which would make it possible to obtain shorter exposures and a better fit of the U bandwidth.

(2) Very good cosmetic properties.

(3) A smaller pixel dimension giving a better sampling of the point spread function, which is important when doing stellar photometry in a crowded field.

On the other hand saturation by bright stars should be avoided because remanence effects could affect the photometry of the fainter stars in the following frames.

We actually obtained valuable observations in the 3 nights from December 30, 1985, to January 2, 1986, with seeing of about 1 arcsecond. The figure shows one 10-minute exposure frame in the U passband, of a 1.7 × 2.3 arcminute field on the central part of NGC 1851. Due to crowding the limiting magnitude is about U = 17.

RR Lyrae, Delta Scuti, SX Phoenicis Stars and the Baade-Wesselink Method[1]

G. MEYLAN[2] and G. BURKI, Geneva Observatory

1. RR Lyrae Stars as Primary Distance Indicators

Our general representation of the universe which surrounds us rests on the determination of the distances of the nearest galaxies by using primary distance indicators, all of them stellar and calibrated in our own Galaxy through parallaxes or photometric methods. The construction of the distance scale up to the most remote galaxies is built up via secondary and tertiary distance indicators (e.g., respectively supergiants and integrated luminosity of the brightest galaxy of the considered cluster).

As primary distance indicators, the RR Lyrae variable stars play, as do also the cepheids, an essential role in the determination of the extragalactic distance scale. Appearing numerous in the field as in globular clusters, they are easily observable, being about 55 times as luminous as the sun, and readily identifiable through their photometric and spectroscopic properties. They serve to calibrate the distance of the globular clusters in our Galaxy and in its nearest neighbours, globular clusters used themselves as secondary distance indicators. But the distance determination of these star clusters appears always indirect, not being based on estimations of mean absolute visual magnitude $\overline{M}_v$ of individual RR Lyrae cluster members, but assuming them to have the same mean absolute visual magnitude as the RR Lyrae field stars. Unfortunately, the influence of metallicity on the absolute magnitude of RR Lyrae stars is still controversial, different studies using various methods (statistical parallaxes, moving groups, cluster main sequence fitting, and Baade-Wesselink) giving very different results. Thus, the determination of numerous individual radii of RR Lyrae stars, in the field as in globular clusters, by use of the most direct approach, i.e. the Baade-Wesselink method, appears the best way to solve the problem of the absolute luminosity of RR Lyrae stars.

In other respects, RR Lyrae stars appear as fundamental chemical, kinematical and dynamical probes for the knowledge of the halo of the Galaxy. For example, the observation of a very distant and fast RR Lyrae star (d = 59 kpc and V_r = −465 ± 27 km/s) allows Hawkins (1984) to attribute to our Galaxy a total mass $M_G = 1.4 \times 10^{12}\ M_\odot$. Finally, they offer observational constraints on stellar evolution models and pulsation theories.

2. RR Lyrae Star Classification

Radially pulsating A-F giants, RR Lyrae stars are grouped in different families, following the characteristics of their luminosity curves. The present classification is an updated version of the former one established by Bailey as early as in 1895.

RRab Lyrae stars are variables with *asymmetric* light curves (steep ascending branch), periods from 0.3 to 1.2 days and amplitudes from 0.5 to 2 magnitudes, pulsating in the fundamental mode (see Figure 1 for an example of such an asymmetric light curve, with the case of RR Cet).

RRc Lyrae stars are variables with nearly *symmetric,* sometimes sinusoidal light curves with periods from 0.2 to 0.5 day and amplitudes not greater than 0.8 magnitude, pulsating in the first harmonic.

The classification of RRs variable stars, also called dwarf cepheids, has been revised during the past few years, owing to the conclusions of Breger (1979, 1980):

(i) The majority of dwarf cepheids resemble the population I Delta Scuti stars in nearly all respects. Those stars are now classified as variables of Delta Scuti type by Kholopov et al. (1985). Delta Scuti stars are pulsating variable A0-F5 III-V stars with light amplitude from 0.003 to 0.9 magnitude and period from 0.01 to 0.2 day (see Figure 5 for an example of such a more symmetric light curve, with the case of BS Aqr).

(ii) A small group of short period variables (a few field stars and 3 blue stragglers in ω Cen) shows low metallicities, high space motions and low luminosities. They are population II short-period variables, of the spherical component or of the old disk galactic population, classified as variables of SX Phoenicis type by Kholopov et al. (1985). SX Phoenicis stars, with spectral types A2-F5, resemble phenomenologically Delta Scuti.

3. The Baade-Wesselink Method

Baade (1926) noticed that the theory of pulsating stars could be tested by use of measurements in magnitude, colour

[1] Based on simultaneous observations from La Silla Observatory (Chile) in photometry and from the Haute-Provence Observatory (France) in radial velocity.

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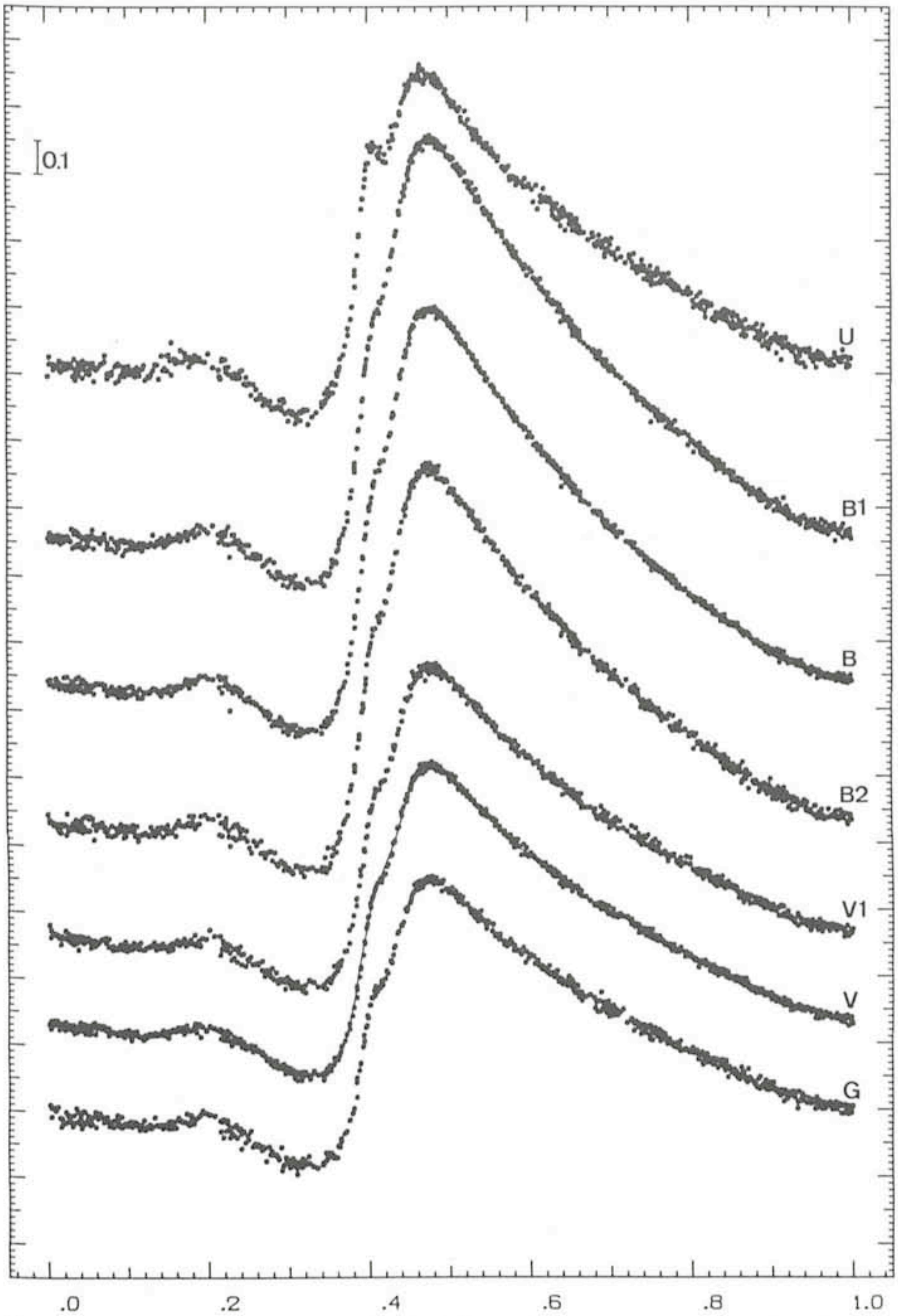

Figure 1: *Luminosity curves measured in the 7 filters of Geneva photometry for the RR Lyrae star RR Cet.*

index and radial velocity, one of the results being the determination of the mean radius R_0 of the observed star. The argument is described in the 3 following items:

(i) The star being considered as a black body, the surface brightness can be deduced from the observed colour index, the visible surface being obtained by division of the observed light by the surface brightness. The radius, in an arbitrary unit, can be obtained as a function of the phase φ.

(ii) The displacement of the stellar surface can be obtained in kilometres by integration of the radial velocity curve.

(iii) The radius and the surface displacement being calculated in phase, the mean radius R_0 can be deduced, because one of its fractions is known.

Baade never tried to apply his idea and other astronomers did not succeed in their attempts. Wesselink (1946), giving up the assumption of black body, has established what is nowadays known as the Baade-Wesselink method (hereafter B-W). The improvement is based on the two following considerations:

(i) For each considered variable star, a unique relation between an observed colour index and the effective temperature T_e is assumed. Then, two phases with the same colour index value have also the same T_e, i.e. the same surface brightness.

(ii) The mass and the depth of the reversing layer do not vary during the pulsation cycle, so that the observed radial velocity curve is related to the same particles all over the cycle. The radii of the reversing layer and of the photosphere vary in the same ratio during the pulsation cycle (these assumptions were not explicitely given in the original Wesselink paper).

The B-W method takes advantage of the relation which relies upon the spectroscopic and the photometric radii at two given phases. The first one results from the integration between the two phases of the pulsation velocity curve (from the radial velocity). The second one comes from the ratio L/T_e^4, the luminosity and the effective temperature being obtained via the observation of a magnitude and of a colour index respectively. Notice that instead of a couple of observations at 2 different phases, a few tens, or even hundreds of couples of such observations are used, leading to systems of equations solved by least-squares.

The use of the B-W method may actually vary in the details of the different assumptions taken into account. Hereafter, 3 different variations have been applied to the observations. Each of them takes into account a different manner to solve the problem of the T_e determination. First, a method (Balona and Stobie 1979) which uses a linear relation between T_e and [B-V]. It is based on the amplitudes and phases of the first component of the Fourier series on the light, colour and radial velocity curves. Second, a method in which R_0 results from the best fit of the ΔR_C on ΔR_O, where ΔR_C is the radius variation inferred from both photometric and radial velocity data and ΔR_O from integration of the radial velocity curve (Burki and Benz 1982). In this method, the relation between T_e and [B-V] is approximated by a polynomial curve and the bolometric correction is obtained by Kurucz models. Third, a method in which the variation of T_e, results from photometric calibration (Burki and Meylan 1986a).

4. Observational Data

Two RR Lyrae, one Delta Scuti and one SX Phoenicis stars have been selected for a B-W analysis. Such radius determinations need high quality measurements in both photometry and radial velocity. Geneva photometry and CORAVEL velocimetry both fulfil the above requirement. The 4 stars have been chosen, not too far from the celestial equator in order to be observed simultaneously from La Silla Observatory (Swiss telescope) in photometry and from the Haute-Provence Observatory (France) in radial velocity. These simultaneous measurements allow to determine the physical parameters as

		Photometry			Radial velocity		
Name	Period [d]	N	$\overline{V}$ [mag]	σ_{res} [mag]	N	$\overline{V}_r$ [km/s]	σ_{res} [km/s]
RR Cet	0.5530253	609	9.745	0.009	60	−75.1	1.8
DX Del	0.47261673	423	9.949	0.010	49	−55.1	1.4
BS Aqr	0.197822776	421	9.388	0.008	63	+41.1	1.0
DY Peg	0.072926373	110	10.380	0.018	60	−25.3	5.4

TABLE 1: *General information concerning the 4 considered stars.*

temperature, gravity, metal content, radius, mass, luminosity and to deduce the distance of the stars.

The Geneva multicolour photometric system is constituted of a set of seven filters, three wide passband filters called U, B, and V (slightly different from the UBV filters of Johnson) and four intermediate passband filters called B1, B2, V1, and G, the B1 and B2 filters being contained in the B filter, and the V1 and G filters in V filter (Golay 1980). In the present study, the average precision of a measurement is typically of 0.007 magnitude.

CORAVEL is a spectrophotometer for determining stellar radial velocities by cross-correlation between the spectrum of the observed stars and a suitable mask located in the focal plane (Baranne et al. 1979). In the present study the average precision is typically of 0.5 km/s.

Table 1 gives the name and period of the 4 considered stars, and for photometry and radial velocity, the number of measurements, the mean visual magnitude $\overline{V}$ or mean radial velocity $\overline{V}_r$, and the residual standard deviation σ_{res} obtained around the function fitted through observations (Meylan et al. 1986).

5. RR Lyrae Stars and the B-W Method

Figure 1 displays the photometric observations, concerning RR Cet, obtained with the 7 filters of Geneva photometry. From top to bottom are drawn the U, B1, B, B2, V1, V, and G magnitude observations in function of the phase φ. The adopted origin of time is HJD 2440000. The scale in magnitude is given in the upper left corner. Because of the non-sinusoidal character of these curves, the number of useful harmonics required to obtain a satisfying fit is large. The fitted curve of the V magnitude is drawn.

Figures 2a, 2b, and 2c display, from top to bottom, the observations and the fitted curves of the V magnitude, of the Geneva [B-V] colour index, and of the radial velocity V_r.

Similar results have been obtained for DX Del. RR Cet and DX Del, with an RRab type, exhibit a sharply asymmetrical light curve, with a steep ascending branch in rising light. The maximum of the brightness is followed by a slow decrease of the luminosity. This is typical of RR Lyrae stars of this kind, having a period around 0.5 day. Besides these general features on light curves, a small hump is clearly visible in the ascending branches of these two stars, especially in the U filter (top of Figure 1). The radial velocity curves look very similar to the

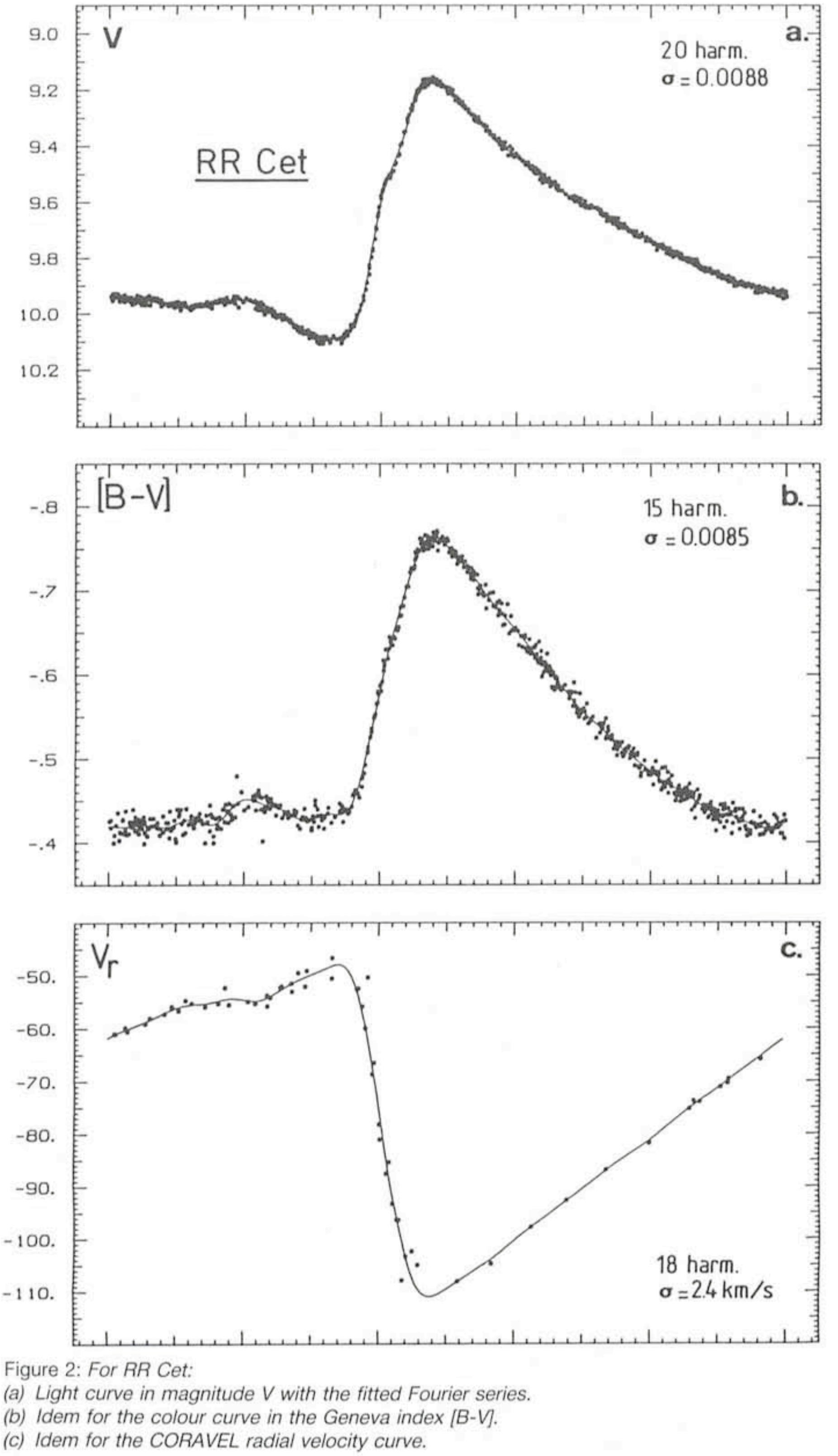

Figure 2: *For RR Cet:*
(a) Light curve in magnitude V with the fitted Fourier series.
(b) Idem for the colour curve in the Geneva index [B-V].
(c) Idem for the CORAVEL radial velocity curve.

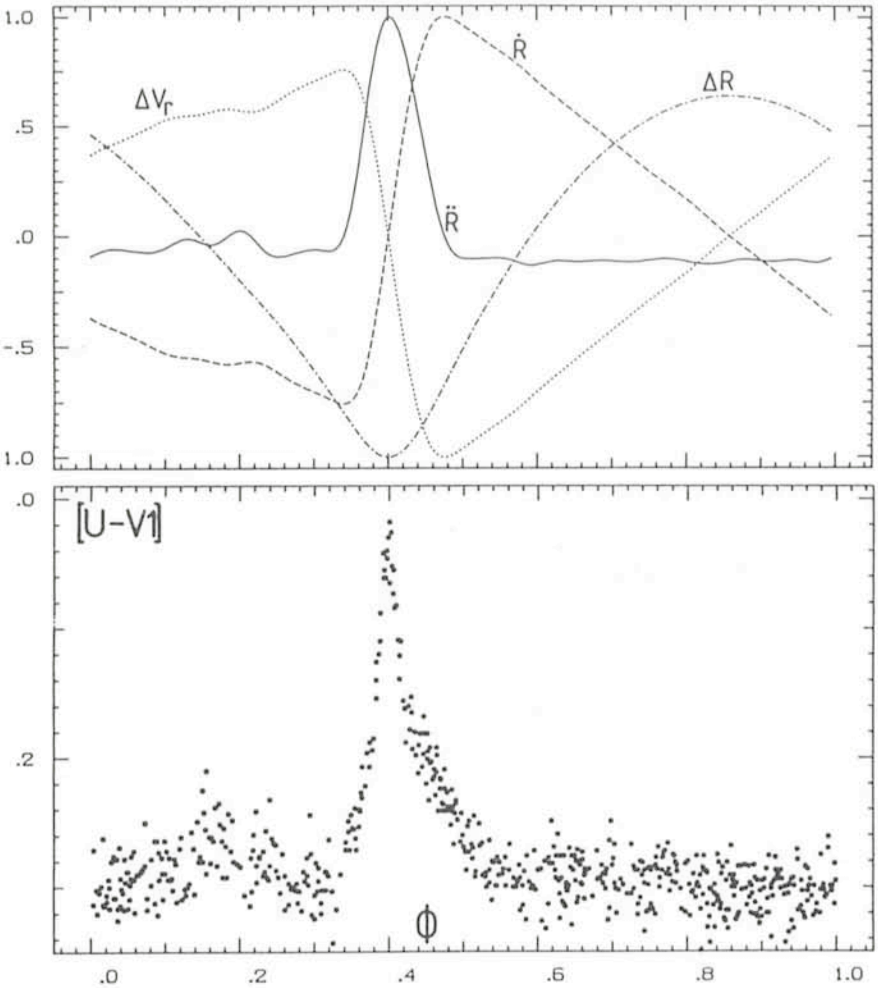

Figure 3: *For RR Cet:*
(a) Curves of radial velocity $\Delta V_r = V_r - \overline{V}_r$, of radius variation ΔR, of velocity with respect to the stellar centre $\dot{R}$, and of acceleration $\ddot{R}$. The value +1.0 of the ordinate axis corresponds to +36 km/s for ΔV_r, +0.51 $R_\odot$ for ΔR, +49 km/s for $\dot{R}$, and +24 m/s² for $\ddot{R}$.
(b) Variation of the Geneva colour index [U-V1].

light curves, the largest radial velocity corresponding to the minimum of light, the smallest radial velocity to the maximum. Comparing light curve and radial velocity curve, it appears that the hump in luminosity occurs roughly when the radial velocity, corrected from the mean $\overline{V}_r$, from positive becomes negative. *This phase corresponds to the minimum radius, i.e. the maximum contraction.*

From the radial velocity curve V_r, we can derive several curves which characterize the pulsation cycle: first the curve of the surface velocity with respect to the stellar centre

$$\dot{R}(t) = -\beta(V_r(t) - \overline{V}_r), \quad (1)$$

second the curve of the radius variation

$$\Delta R(t) = R(t) - R_o = \int \dot{R}(t)dt \quad (2)$$

and third the curve of the acceleration of the stellar surface $\ddot{R}(t)$, where $\beta = 1.36$ is the conversion factor from radial to pulsational velocity (Burki and Benz 1982), $\overline{V}_r$ is the mean radial velocity given in Table 1 and R_o is the mean stellar radius. These 4 curves are displayed in Figure 3a in the case of RR Cet.

The shape of the acceleration curve is especially noteworthy. A strong outward acceleration $\ddot{R}_{max}$ = 24 m/s² occurs at minimum radius; outside the phase interval 0.33 – 0.48, the pulsation cycle is characterized by a slightly decelerated motion of the surface layer. The above hump occurs in the various magnitude curves of RR Cet, during rising light, at minimum radius, i.e. at phase 0.40. This hump is especially well marked in the magnitudes U curves. In this context, the variation of the colour index [U-V1] in Figure 3b is interesting: it looks perfectly like the acceleration curve displayed in Figure 3a. The [U-V1] curve has a strong peak of amplitude 0.30 at phase 0.40, whereas this index is approximately constant during the major part of the pulsation cycle. Then an important excess of ultraviolet radiation is produced during a brief interval of phase, near minimum radius. To explain this phenomenon, different models consider the presence of shock wave, due for example to the collision between rising and falling atmosphere layers; an alternative could be the increase of the turbulence deeper in the atmosphere.

Already in 1959, Abt showed the difficulties in applying the B-W method to RR Lyrae stars, partly because one of the assumptions, colour uniquely related to temperature, is probably not satisfied through the whole pulsation cycle. The hump at mid-rising light, observed in all light curves and in [U-V1] is the photometric evidence of this fact.

For our purpose, i.e. the determination of the mean radius, it is important to know that the B-W method gives incorrect results around minimum radius. To avoid these disagreements, previous studies have corrected the photometric observations for the estimated effect of the shock wave. In the present work, another way has been chosen: the small interval in phase around the minimum radius is excluded. Thus, the mean radius calculated is minimally dependent on the phenomenon biasing the results of the B-W method. The results concerning RR Cet and DX Del are given in Table 2; they are the mean of the determinations through the 3 considered variants of the B-W method (Burki and Meylan 1986a, b).

6. The Absolute Magnitude of RR Lyrae Stars

This problem has been discussed recently by many authors, including de Vaucouleurs (1978), Manduca et al. (1981), Sandage (1982), Stothers (1983) and Hawley et al. (1986). The results of these various determinations of $\overline{M}_v$ are compared in Figures 4a and 4b, where $\overline{M}_v$ is plotted versus [Fe/H]. They are grouped in 3 different methods:

(i) *Determination based on the B-W analysis.* Apart from the 2 RR Lyrae stars studied here, B-W values are published for 5 other individual RR Lyrae stars (Figure 4a). The mean value for these 7 stars equals $\langle \overline{M}_v \rangle = 0.57 \pm 0.09$ in agreement with the mean value 0.61 ± 0.15 adopted by Stothers (1983). However, Figure 4a suggests that $\overline{M}_v$ could vary with [Fe/H] or with the period, since P and [Fe/H] are correlated

Name	R_o [$R_\odot$]	$\overline{M}_v$ [mag]	d [pc]
RR Cet	6.7 ± 0.2	0.28 ± 0.14	760 ± 40
DX Del	5.5 ± 0.2	0.49 ± 0.16	750 ± 45
BS Aqr	3.2 ± 0.4	1.4 ± 0.3	410 ± 60
DY Peg	1.4 ± 0.4	3.2 ± 0.5	250 ± 80

TABLE 2: *Results about mean radius R_o, mean absolute visual magnitude $\overline{M}_v$, and distance for the 4 considered stars.*

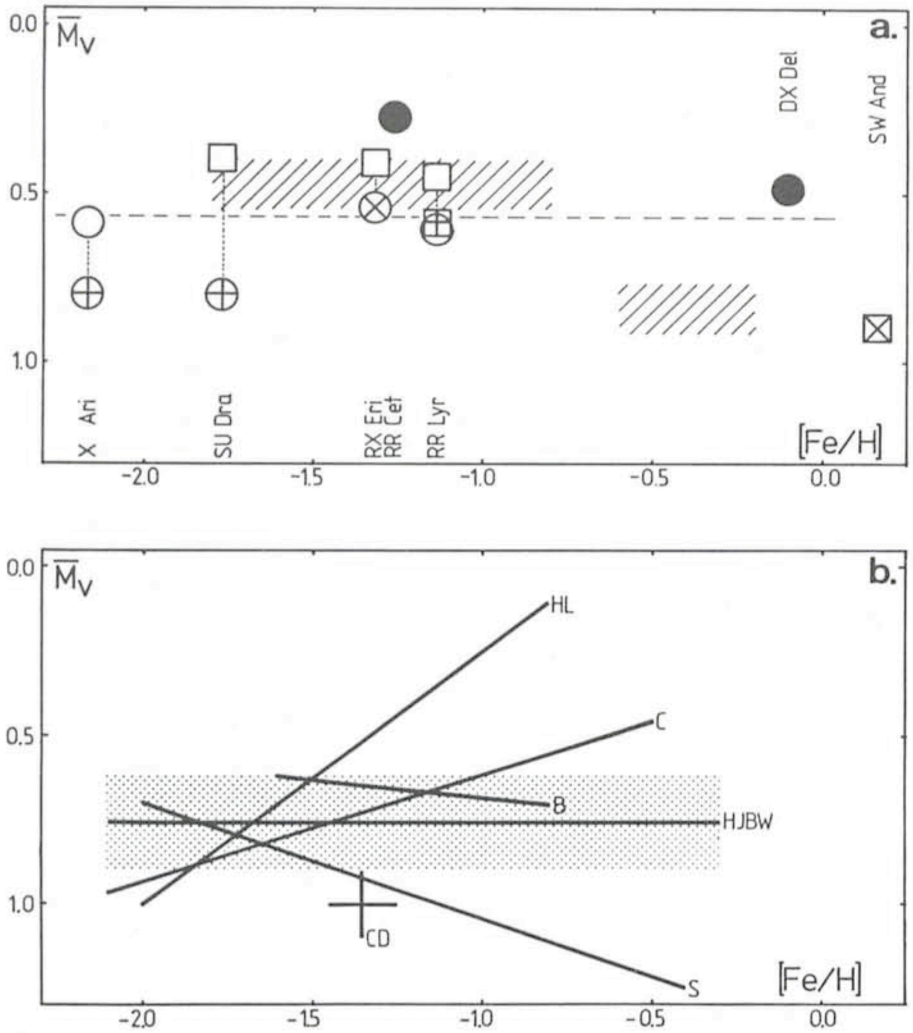

Figure 4: *The various determinations of $\overline{M}_v$ for RR Lyrae stars plotted versus [Fe/H]. The type of symbol refers to the authors of the $\overline{M}_v$ determination.*
(a) B-W method: ● Burki and Meylan (1986), ○ Manduca et al. (1981), ⊕ Oke (1966) and Oke et al. (1962), ⊗ Woolley and Dean (1976), □ Siegel (1982), ⊞ Wallerstein and Brugel (1979), ⊠ McNamara and Feltz (1977); hatched areas: average of the determinations of McDonald (1981), Woolley and Savage (1971) and Woolley and Davies (1977). The horizontal line represents the mean value of $\overline{M}_v$ based on the 7 RR Lyrae stars.
(b) Globular clusters and statistical parallaxes: relations given by S for Sandage (1982), C for Carney (1980), B for Butler et al. (1978), HL for Heck and Lakaye (1978), CD for Clube and Dawe (1980), and HJBW for Hawley et al. (1986).

according to Sandage (1982). Although the sample at our disposal is still small, this effect can be evaluated as follows: the RR Lyrae stars of intermediate metallicity [Fe/H] ≃ −1.2 could be slightly brighter by about 0.2 magnitude than either those being very deficient or those having a solar composition.

(ii) *Determination based on globular clusters analysis.* Tremendous discrepancies exist between the determinations based on the B-W method (field stars) and on globular clusters (Figure 4b): the relation of Carney (1980), based on globular cluster main sequence fitting, is fainter by about 0.2 magnitude for stars with [Fe/H] ≤ −1.0 (C relation in Figure 4b), and the relation for globular clusters by Sandage (1982) is fainter by about 0.5 magnitude for stars with [Fe/H] ≥ −1.2 (S relation in Figure 4b). The case of ω Cen is interesting because there is a wide range of [Fe/H] values among its numerous RR Lyrae member stars. According to Butler et al. (1978), there is virtually no dependence of $\overline{M}_v$ on [Fe/H] for these stars. Their mean relation is drawn in Figure 4b (B relation), using 5.2 kpc for the distance to this cluster. The difference in magnitude between the mean B-W and mean ω Cen relations can be reduced to zero by adopting 5.5 kpc for the distance to this globular cluster.

(iii) *Determination based on statistical parallaxes.* The most recent analysis gives $\langle \overline{M}_v \rangle = 0.76 \pm 0.14$ (Hawley et al. 1986), without any significant dependence on metallicity (HJBW relation in Figure 4b). This mean value, fainter by about 0.2 magnitude than the mean B-W value $\langle \overline{M}_v \rangle = 0.57 \pm 0.09$, is nevertheless in agreement at the 1 σ level. The results of the studies of Heck and Lakaye (1978) and Clube and Dawe

List of ESO Preprints (December 1985 – February 1986)

407. H. Quintana, R.E. de Souza and L. Arakaki: Morphological Subclustering and Mass Segregation in Galaxy Clusters. *Astronomy and Astrophysics.* December 1985.
408. A. Iovino and P.A. Shaver: Gravitational Lensing in the QSO Pair Q1548 + 114A, B. *Astronomy and Astrophysics.* December 1985.
409. A. Tornambè and A. Chieffi: Extremely Metal-Deficient Stars II. Evolution of Intermediate Mass Stars up to C-Ignition or Core Degeneracy. *Monthly Notices of the Royal Astronomical Society.* December 1985.
410. I. Manousoyannaki and G. Chincarini: The Infrared (H) Surface Brightness of Galaxies as a Function of the Morphological Type. *Astronomy and Astrophysics.* December 1985.
411. L. Woltjer: Recent Developments on the Crab Nebula. Proceedings of the Advanced Study Institute on "High Energy Phenomena Around Collapsed Stars", Cargèse, 2-13 September 1985. January 1986.
412. F. Matteucci: Some Considerations on the Origin of Nitrogen. *Monthly Notices of the Royal Astronomical Society.* January 1986.
413. M. Heydari-Malayeri and G. Testor: Detection and Study of Two H II Blobs in the LMC Giant H II Region N 160 and Investigation of Their Nebular and Stellar Environment. *Astronomy and Astrophysics.* January 1986.
414. O. Stahl and B. Wolf: Circumstellar Shells Around Luminous Emission-Line Stars in the Large Magellanic Cloud.

(1980), are also displayed in Figure 4b (HL and CD relations).

7. Delta Scuti, SX Phoenicis Stars and the B-W Method

Figure 5 displays the photometric observations obtained through the 7 filters of Geneva photometry, concerning the Delta Scuti star BS Aqr. From top to bottom are drawn the U, B1, B, B2, V1, V, and G magnitude observations in function of the phase φ. The adopted origin of time is HJD 2440000. The scale in magnitude is given in the upper left corner. The fitted curve of the V magnitude is drawn.

For the same star, Figures 6a, 6b, 6c, and 6d display, from top to bottom, the observations and the fitted curves of the V magnitude, of the Geneva [B-V] colour index, of the radial velocity V_r, and of the 3 curves ΔR, $\dot{R}$, and $\ddot{R}$ describing the pulsation cycle. Very similar figures are obtained for the SX Phoenicis star DY Peg.

The comparison of the curves in Figures 5 and 6 concerning BS Aqr with those in Figures 1 and 2 concerning RR Cet, i.e. an RRab Lyrae star, induces the following remarks:

(i) The light, colours and velocity curves are more symmetric: 3 to 5 harmonics of the Fourier series are sufficient to describe the observed variations in luminosity and in radial velocity, instead of 15 to 20 for the two RR Lyrae stars.

(ii) The amplitudes are smaller.

(iii) The width of the peak in the $\ddot{R}$ curve is much larger, instead of 15% of the period in the case of RR Cet and DX Del.

(iv) No hump is observed on the light curve at the phase of minimum radius, which means that the perturbations of the stellar atmosphere by shock wave and/or by increase of the turbulence is less important in these Delta Scuti and SX Phoenicis stars than in RR Lyrae stars.

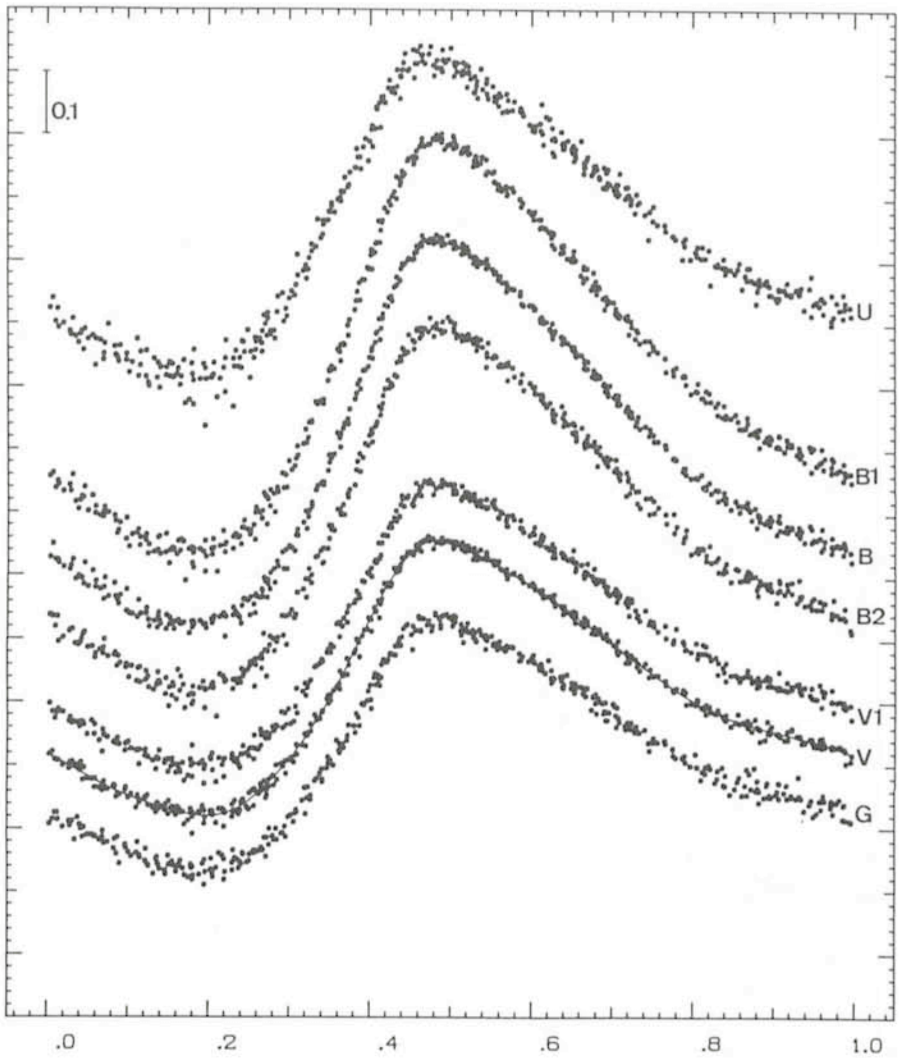

Figure 5: *Luminosity curves measured in the 7 filters of Geneva photometry for the Delta Scuti star BS Aqr.*

Various intervals of phase have been investigated: whole cycle, rising and diminishing light, increasing and decreasing radius. For both stars the R_0 value of the mean radius for the whole cycle

Astronomy and Astrophysics. January 1986.

415. J. Breysacher: Absolute Magnitudes and Evolutionary Status of Wolf-Rayet Stars. *Astronomy and Astrophysics.* January 1986.
416. U. Heber et al.: A Spectroscopic Study of HB Stars in the Galactic Globular Cluster NGC 6752. *Astronomy and Astrophysics.* January 1986.
417. J. Surdej et al.: Further Investigation of the Pair of Quasars Q0107–025 A and B. *Astronomy and Astrophysics.* February 1986.
418. D. Baade: Nonradial and Radial Oscillations Observed in Non-Emission Line OB Dwarfs and Giants. Invited talk presented at Joint Discussion III "Solar and Stellar Nonradial Oscillations" during the IAU XIX General Assembley in New Delhi (November 1985). To appear in "Highlights of Astronomy", Vol. 7. February 1986.
419. L.B. Lucy: Radiatively-Driven Stellar Winds. Paper presented at IAU Colloquium No. 89: Radiation Hydrodynamics in Stars and Compact Objects. February 1986.
420. P. Focardi, B. Marano and G. Vettolani: The Large Scale Distribution of Galaxies in the Linx-Gemini Region. *Astronomy and Astrophysics.* February 1986.
421. E.J. Wampler: The Iron Spectra of PG 1700+518 and PG 2302+029. *Astronomy and Astrophysics.* February 1986.
422. P.A. Shaver: Statistics of Quasar Pairs. *Nature.* February 1986.
423. D. Alloin et al. Recurrent Outbursts in the Broad Line Region of NGC 1566. *Astrophysical Journal.* February 1986.
424. S. di Serego Alighieri and M.A.C. Perryman: The Time-Resolved Imaging Mode (TRIM) of the ESA Photon Counting Detector. Paper presented at SPIE Conference on "Instrumentation in Astronomy VI", Tucson, 3-8 March 1986. February 1986.

STAFF MOVEMENTS

Arrivals

Europe:

AVILA, Gerardo (Mex.), Engineer/Physicist
AZIAKOU, Patricia (F), Adm. Clerk Purchasing
BEELEN, Guido (B), Electronics Engineer
BUYTENDIJK, Felice (NL), Receptionist
GIRAUD, Edmond (F), Fellow
STANGA, Ruggero (I), Associate

Departures

Chile:

MÜLLER, Guido (CH), Electro-Mech. Engineer
FOING, B. (F), Fellow

case is approximately an average of the values obtained with the partial intervals of phase. The average of the results obtained through the 3 variants of the B-W method are given in Table 2 (Burki and Meylan 1986c).

8. The log R – log P Relation for Pulsating Stars

The existence of a well-defined relation between the values of log R and log P in the case of the classical cepheids has been known for many years (see Fernie 1984 for a recent study). Such a relation exists also for population II cepheids (BL Herculis and W Virginis stars). It is roughly parallel to the classical cepheid relation but is displaced by about 0.4 in log R. In Figure 7 are plotted for these 3 kinds of variables all the determinations by the B-W method found in the literature, binaries having been eliminated. In the same figure are also plotted the variables of RR Lyrae, Delta Scuti and SX Phoenicis classes, for which a radius determination exists by B-W analysis. The only SX Phoenicis star having a B-W determination is DY Peg, from the present work.

It is remarkable to see that the linear log R – log P relation for population II cepheids can be extrapolated to the small log P values and satisfies globally well the RR Lyrae, Delta Scuti and SX Phoenicis stars.

Conclusion

The present application of the Baade-Wesselink method to the determination of the mean radius, and then the absolute magnitude, of short-period variables as RR Lyrae stars, appears successful if we take the precaution to exclude a short interval in phase, about the maximum contraction, where shock wave and/or turbulence increase bias the hypotheses on which the method is built up.

The determination of a large number of such stellar radii will make it possible to increase our understanding of the absolute magnitude of RR Lyrae stars, so that they may be used as distance indicators in a more reliable manner.

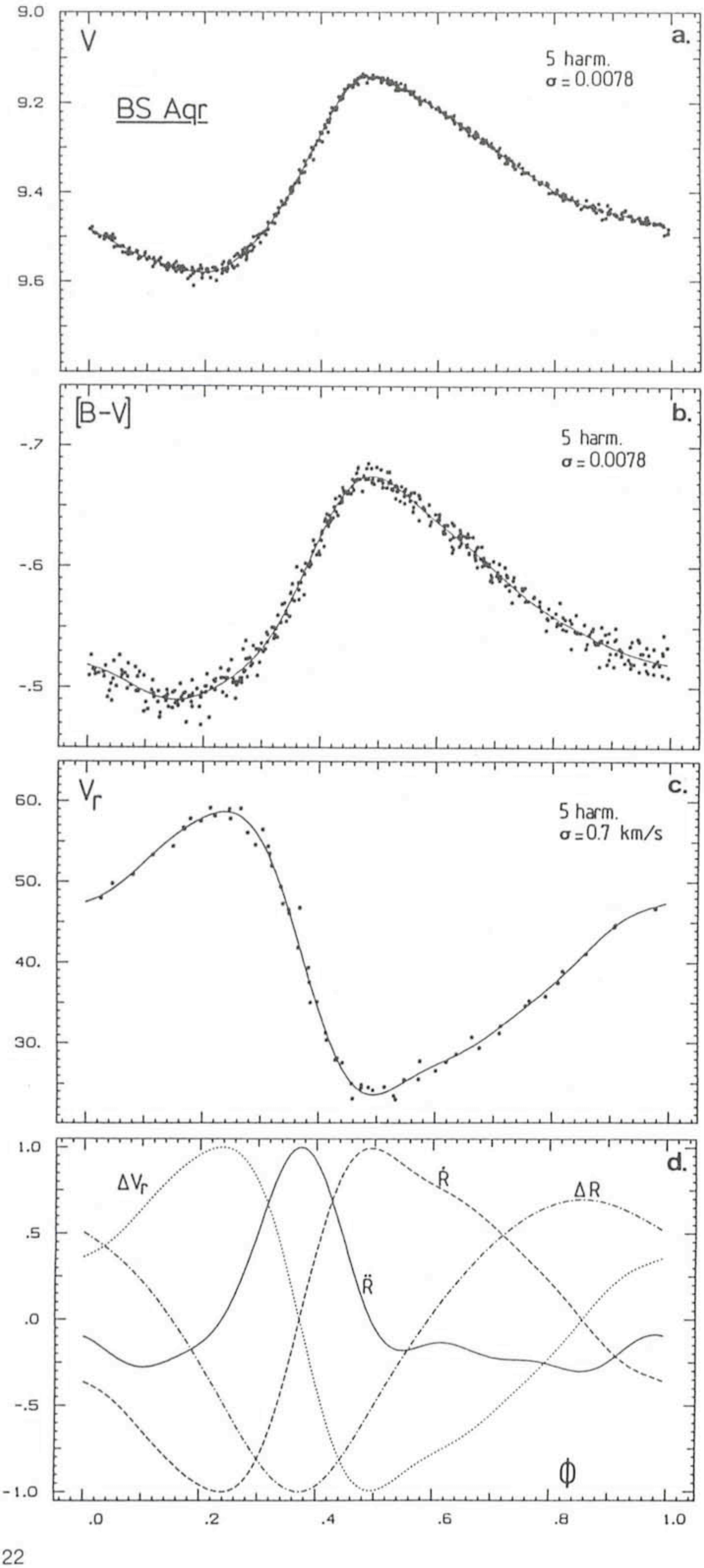

Figure 6: *For BS Aqr:*
(a) Light curve in magnitude V with the fitted Fourier series.
(b) Idem for the colour curve in the Geneva index [B-V].
(c) Idem for the CORAVEL radial velocity curve.
(d) Curves of radial velocity $\Delta V_r = V_r - \overline{V}_r$, of radius variation ΔR, of velocity with respect to the stellar centre $\dot{R}$, and of acceleration $\ddot{R}$. The value +1.0 of the ordinate axis corresponds to +17.6 km/s for ΔV_r, +0.10 $R_\odot$ for ΔR, +24.0 km/s for $\dot{R}$, and +19.5 m/s^2 for $\ddot{R}$.

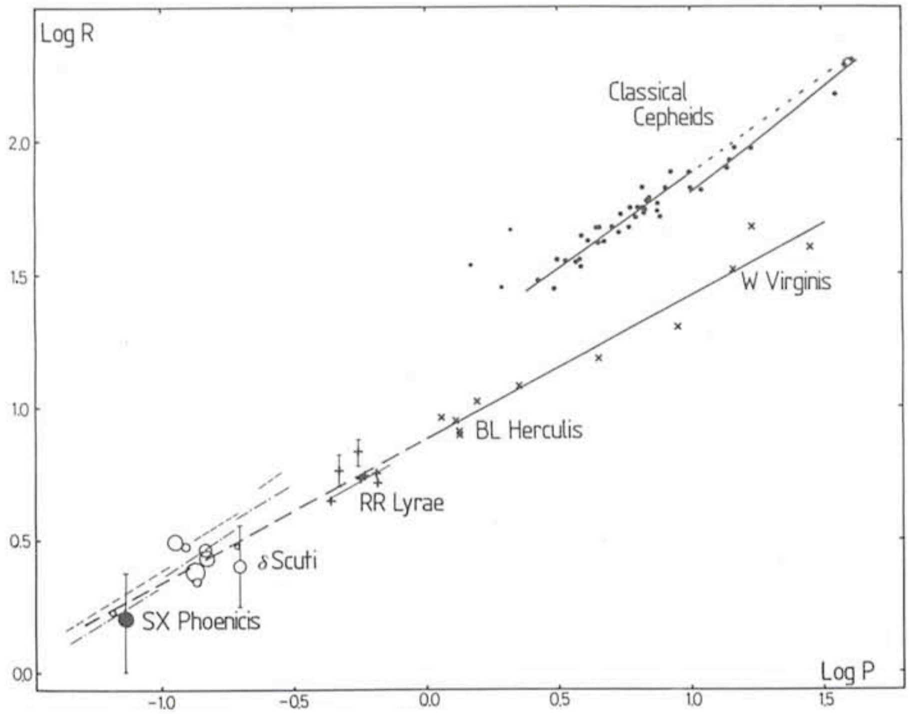

Figure 7: *The log R vs. log P diagram for six classes of pulsating stars. The 4 stars with error bars are RR Cet, DX Del, BS Aqr, and DY Peg (present work).*

and is directly attached to the Office of the Director General. The sale of conference proceedings, etc. will also be taken care of by this service.

The ESO Information and Photographic Service will inform the media and interested persons about events at ESO of general interest. These will include results of scientific research (in particular new discoveries) made at ESO's La Silla observatory, as well as technical matters in connection with ongoing telescope projects and auxiliary astronomical instrumentation. Major scientific meetings at ESO will also be covered.

The information will become available in the form of press releases and through the *Messenger*. It is the intention to organize Press Conferences whenever major events occur; members of the press will receive invitations in advance. Archival and current pictures, related to astronomical and other activities at ESO will be made available upon request. A catalogue is in preparation and will be announced in the June issue of the *Messenger*.

Members of the press, who would like to visit the ESO Headquarters in Garching must contact Mrs. E. Voelk (tel: (089) 320-06-276) at least one week in advance.

The Head of the ESO Information and Photographic Service is Dr. Richard M. West, a Danish astronomer who has been with ESO since 1970.

ESO Information and Photographic Service

ESO has established a new service, which from now on handles the organization's public relations matters. It is located at the ESO Headquarters at Garching. It incorporates the functions of the former ESO Sky Atlas Laboratory

Performance Tests of DAOPHOT/INVENTORY Photometry Programmes in Dense Stellar Fields

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A comparative test of DAOPHOT and INVENTORY reduction programmes was performed at ESO Garching computer centre, in November 1985, on six frames of globular cluster fields obtained at the Danish 1.5-m telescope with the RCA CCD # 1. The scale is 0."47 per pixel and the seing was almost constant around 1."1–1."3.

The comparison of the two programmes is based on three different tests:

(1) analysis of very dense stellar fields (centre of the globular cluster Pal 6); (2) analysis of very faint stars in a relatively clean field of NGC 7006; (3) comparison of the photometry in two V frames of NGC 7006.

For the first two cases the comparison is based on the quality of the resulting instrumental colour-magnitude diagrams, for the last one the frame-to-frame difference for each star is computed, and the standard deviation per magnitude interval is derived.

1. The Field of Pal 6

A couple of average B, V frames obtained from 2 V, 4-minute and 2 B, 20-minute exposures have been analyzed with INVENTORY and DAOPHOT. Figure 1 shows the approximately 110" × 110" region used for the comparison. 360 stars with a limiting magnitude of V~21 have been detected with INVENTORY and 300 with DAOPHOT. The average star density at V~21 is about 70 pixels per star rising at about 25 pixels per star in the 60" × 60" central region where most of the stars have been detected.

Figures 2 and 3 present the c-m diagram of Pal 6 obtained with INVENTORY and DAOPHOT respectively. In both plots a very red, diffuse giant branch is visible, with a possible horizontal branch at about 3 magnitudes below the giant tip. The diagrams are contaminated by the galactic background population, mostly in the blue part where a group of blue, bright stars is well defined. As demonstrated by the c-m diagrams of the field (Ortolani, unpublished data) they belong to the galactic field population. The upper part of the diagrams is comparable, but the scatter at the level of V~19.5 seems higher in INVENTORY than in DAOPHOT. The superiority of DAOPHOT in searching and centring the stars in the most crowded part of the cluster is also indicated by a visual inspection of the pictures.