THE GLOBULAR CLUSTER AND HORIZONTAL BRANCH CONTENT OF THE BULGE AND HALO

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1. The Transition From Halo to Bulge

The radial variations ("gradients") of three properties of the horizontal branch (hereafter HB) across the transition region ("edge") between Halo and Bulge place modest constraints on the early history of these regions and possible interactions between them. The extant data are fragmentary, and the conclusions correspondingly uncertain. The observables are HB morphology, heavy element abundance, and space density. The data base is constrained by sampling techniques. According to current dogma HB stars are descendents of low-mass stars that grow degenerate He cores during post-main sequence evolution, so they are old. Unfortunately, we cannot sample the whole HB. In most parts of the Galaxy our knowledge of the field HB is limited to those species that are amenable to discovery by simple survey techniques, namely, the BHB and RR Lyr components. This is an annoyance, because it is the *total* HB that traces the density of its parent population (Preston, Shectman, and Beers 1991a) and the RHB component must be inferred by indirect methods. Furthermore, well above the Galactic plane, where nearly all searches have been conducted (see Preston *et al* 1991a for references), these two species occur only in that subset of the population for which $[Fe/H] < -0.8$ [a generalization, incidentally, that does not apply to RR Lyr stars in the solar neighborhood (Preston 1959) or in the Bulge (Walker & Terndrup 1991)]. So, bear in mind that our deductions flow from an incomplete sampling of the metal-poor component of the HB. Finally, by "edge" of the Bulge I refer to the intuitive boundary seen in maps of IRAS 12-25 micron point sources (Habing *et al* 1985, Harmon and Gilmore 1988) or, equivalently, to the FWHM of the areal distribution of M-giants (Blanco & Terndrup 1989), which define an elliptical region of enhanced density with axis ratio $c/a \sim 0.7$ and characteristic dimension ~ 1 kpc. I leave the assessment of Weinberg's (1992) recent counter view to others at this symposium.

1.1. THE HB MORPHOLOGY GRADIENT

Three independent lines of evidence indicate that the color distribution of the HB in the Galactic Halo reddens with increasing Galactocentric distance (R):

(1) The HB color distributions, described by the parameters $B/(B+R)$ (Mironov 1972) or $(B-R)/(B+V+R)$ (Lee 1989), of families of globular clusters defined by Galactic location, shift redward at fixed composition as R increases (Searle & Zinn

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1978, hereafter SZ; Zinn 1980, 1986; Lee 1992a). Recall that B, V, and R denote the blue, RR Lyr, and red components of the HB. The redward shift is accompanied by an increase in dispersion. This seminal discovery by SZ introduced HB morphology, however defined, as a parameter of Galactic structure.

(2) The mean B-V color of field BHB stars, appropriately defined, increases with R on $4 < R < 12$ kpc in spite of a small negative abundance gradient that, by itself, would produce an effect of opposite sign, were mean HB mass constant throughout the halo (Preston, Shectman, & Beers 1991a).

(3) The space density of field BHB stars appears to decline outward more rapidly than that of the RR Lyr stars in the vicinity of the solar radius, which implies a reddening of the field HB with increasing R (Preston *et al* 1991a).

SZ cautiously suggested the simplest explanation proffered by HB theory in the context of Galactic structure, namely, that mean HB mass increases (age decreases) outward in the Halo. The observational basis for this conclusion was subsequently refined by Zinn (1980, 1986), and strengthened more recently by the construction of semi-empirical correlations between age and HB morphology among the globular clusters (Sarajedini and King 1989, VandenBerg, Bolte & Stetson 1990, Sarajedini and Demarque 1990, Preston *et al* 1991a). Particular attention (King, Demarque & Green 1988, Bolte 1989, Demarque *et al* 1989, Green & Norris 1990) has been paid to the globular clusters NGC 288 and NGC 362, which possess similar abundances and Galactocentric distances, but different HB morphologies ("blue" and "red", respectively) and ages (older and younger, respectively).

Although the FHB is very "blue" at the solar radius, n(BHB)/n(RR Lyr)~6 [n = number density], and appears to become even bluer as R decreases, the HB in Baade's Window (hereafter BW) is certainly "red" (Terndrup 1988). I have used the scant data at my disposal to quantify how the morphology gradient changes sign abruptly at the "edge" of the Bulge.

We have identified some 700 BHB candidates in the Curtis Schmidt objective prism field CS30321, which overlaps the Oort-Plaut field at $l = 0$, $b = -10$ reinvestigated by Wesselink (1987). *UBV* photometry of 150 of these indicate that virtually all of the fainter candidates are BHB stars (Preston, Shectman, & Beers 1991a, 1991b), so I used apparent magnitudes derived from a photoelectric calibration of candidate brightness classes (Beers, Preston & Shectman 1988) to derive an observed ratio n(BHB)/n(RR(Lyr) ~ 4 near $R = 2$ kpc from a plot of RR star and BHB candidate counts *versus* distance modulus in the region of overlap. Wesselink's RR Lyr counts are virtually complete in the apparent magnitude interval of interest, but the objective prism data are incomplete by a factor of 2 or more at $B = 15$, so the true ratio is probably 8 or more: the field HB continues to become "bluer" to $R \sim 2$ kpc.

To quantify morphology of the metal-poor HB in BW, I counted BHB, RR Lyr, and RHB stars in a strip 0.2 mag. high [~FWHM for an R^{-3} density law at $l=0$, $b=-4$] superposed on Terndrup's CMD at V(RR Lyr) = 16.8 [calculated from B(RR Lyr) = 17.55 (Blanco 1984), $(B\text{-}V)_0 = 0.30$, and $E(B\text{-}V) = 0.45$ (Terndrup 1988)]. I took the shape of the HB blueward of the RR Lyr gap from the globular clusters (Preston *et al* 1991a) and terminated the RHB at $(B\text{-}V)_0 = 0.85$, the approximate red end of the HB in 47 Tuc (Lee 1976, Hesser *et al* 1987). To count RR Lyr stars observed at random phases, I supposed that RR Lyr stars lie in an inclined strip appropriate for a V light amplitude of 1 mag. and a linearly correlated $B\text{-}V$ variation of amplitude 0.35 mag. Such stars will be found with greatest probability near minimum light, i.e., in the lower right corner of the strip. Finally, I counted stars in boxes with dimensions 0.05 in $B\text{-}V$ and 0.5 in V to derive areal densities of contaminators above and below the HB and interpolated to derive corrections along the HB. The corrected numbers of BHB, RR Lyr, and RHB stars are 3.5, 2.1, and 18, respectively -- much work for small numbers. The RR Lyrae value, 2.1, is to be compared with 1.5 estimated from Blanco's (1984) areal density of 0.10/square arc minute and Terndrups's field of 15 square arc minutes. These meager results verify that the metal-poor HB in BW is "red" and that n(BHB)/n(RR Lyr) ~ 1 at R = 0.5 kpc, i.e., lower by a factor of 8 than it is at $R=2$ kpc. These estimates can be improved by additional photometry in BW, but it will be difficult to make accurate counts of the HB stars of higher abundance. The HB of the relatively metal-rich globular cluster NGC 6553 studied by Ortolani, Barbuy, & Bica (1991) appears to overlap the giant branch, and one can see vague evidence of this phenomenon in Terndrup's CMD of BW. Subtraction of a giant branch contribution from total counts in the region of the HB by interpolation of giant branch counts into the HB region from above and below would produce a first approximation. As of now we have neither theoretical nor empirical locations for HB's of solar metallicity or greater.

1.2. THE ABUNDANCE GRADIENT

Exterior to the solar radius the Halo abundance gradient is undetectably small by all techniques that have been employed to measure it (Zinn 1985; Suntzeff, Kinman & Kraft 1990, hereafter SKK; Carney *et al* 1990). However, on $2 < R < 8$ the gradient derived from field RR Lyr stars, -0.10 dex/kpc, is twice that of the Halo globular clusters (SKK). The gradient derived from RR Lyr stars in clusters binned in intervals of R differs from the cluster gradient in the same manner, as shown in Fig. 1, a phenomenon that appears to be produced entirely by the gradient in HB morphology (Zinn 1986, SKK): clusters of lower-than-average abundance near R_0 produce copious numbers of RR Lyr stars, while those of comparable abundance in

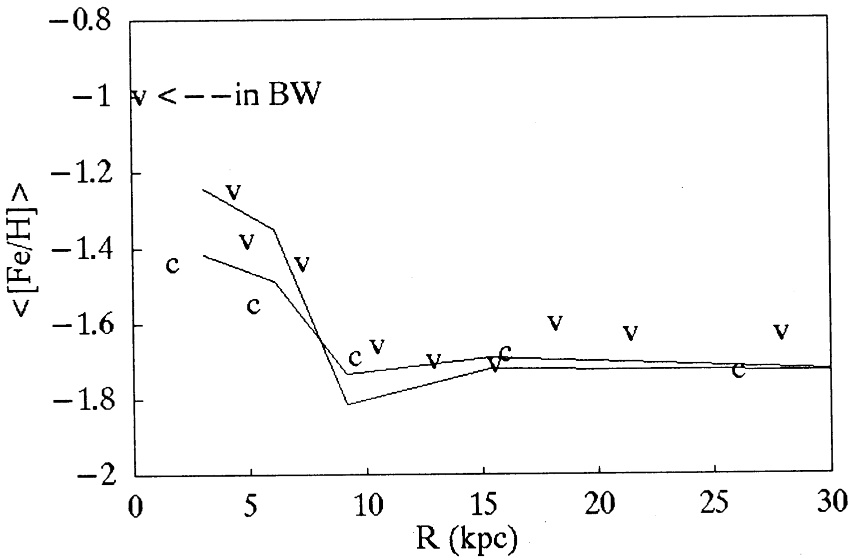

Fig. 1.-The variations of <[Fe/H]> for the globular cluster data ("c") of Zinn (1985) and the RR Lyr data ("v") of SKK, binned in intervals of Galactocentric *R*. The segmented curves represent the mean abundances of the SKK cluster sample and of the RR Lyr stars contained in that sample, also binned in intervals of *R*. The gradient of HB morphology biases the RR Lyr sample against low [Fe/H] at small *R*.

the inner Halo produce few or none at all because of their "blue" morphologies. Thus, the cluster gradient is more nearly representative of the Halo field gradient exterior to *R* = 2 kpc. Direct measurement of the Halo gradient by measurements of *bona fide* tracers of the field, e.g., red giants or turnoff stars, would provide welcome, though laborious, confirmation of this surmise. As noted below, the distinction between properties of clusters and co-spatial field populations may be important in the central region of the Galaxy.

The mean abundance of RR Lyr stars in BW (Walker & Terndrup 1991) lies along a linear extension of the SKK data for the inner Halo (see Fig. 1). If the foregoing interpretation of observed Halo gradients is correct, this behavior must be a purely accidental consequence of the interplay between partially correlated changes in HB morphology and abundance distributions that accompany the transition from Halo to Bulge. I refer to "partial correlations", because HB morphology depends on three composition parameters, core mass, and mean HB mass, in addition to assumptions about the sensitvity of progenitor mass-loss to abundance. Critics of variable age as the cause of the morphology gradient can try to invent defensible alternatives with other combinations of these parameters.

The particular assumptions made recently by Lee (1992a, 1992b) lead him to the conclusion that the decrease of mean HB mass (increase of age) with decreasing *R* in the Halo continues into the Bulge, which, accordingly, contains the oldest stellar population in the Galaxy. Such an old population could only be reconciled with Harmon and Gilmore's (1988) relatively young (age<10 Gy) Miras by an extended period of star formation in the Bulge, but such reconciliation may not be necessary in view of the greater ages for Miras reported by Blommaert *et al* (1992) at this symposium. Spectroscopic determination of the extent of the [O/Fe] plateau in the Bulge may constrain the allowable age spread (Matteucci & Brocato 1990).

Globular clusters cannot be used to extend the Halo gradient into the Bulge, because so few clusters have been found there. The abundance distribution of those few clusters that can be located within a kiloparsec of the Galactic Center does not resemble that of Rich's (1990) field giants. These remarks follow from the presentations in Figs. 2 and 3. To construct the Figures I used the Galactocentric distances of Webbink (1985) and abundances from, in order of preference, Armandroff (1989), Zinn & West (1984), and Webbink (1985).

Aguilar, Hut, & Ostriker (1988) calculate that globular clusters formed at $R < 2$ kpc are destroyed efficiently in a Hubble time, and those that survive may sink inward and out of sight due to dynamical friction. Their calculations warn us that some globular clusters that we now see in the inner Halo and Bulge may have spiraled into these regions from the outside, so the abundance gradient across the edge of the Bulge is better estimated by use of Rich's K giants at $R = 0.5$ kpc and the Halo globular clusters just exterior to $R = 2$ kpc, in which case the gradient out of the plane, near the edge of the Bulge, is ~ -0.8 dex/kpc, some 20 times steeper than that of the inner Halo.

1.3. THE DENSITY GRADIENT OF THE METAL-POOR HORIZONTAL BRANCH

Survey techniques define the "metal-poor HB" as one that contains RR Lyr and/or BHB stars. Exterior to $R = 2$ kpc the upper abundance bound from globular cluster data (SKK 1991) is ~ -0.8. In BW the upper bound appears to be larger by about 0.3 dex (Walker & Terndrup 1991). From BHB and RR Lyr counts near the solar radius and a small RHB correction inferred from local globular clusters we estimated the total HB density at R_0 to be 42 kpc^{-3} (Preston *et al* 1991a). At $R = 2$ kpc the HB is so blue, n(BHB)/n(RR Lyr)~8, that the RHB correction is probably miniscule, i.e., the sum of Wesselink's (1987) RR Lyraes and our BHB estimate is very nearly the total HB. In BW we estimate the total density from Blanco's (1984) RR Lyr data and the n(BHB)/n(RR Lyr) and n(RHB)/n(RR Lyr) number ratios given in Section 1.1 above. From these data we can sketch the run of density of the

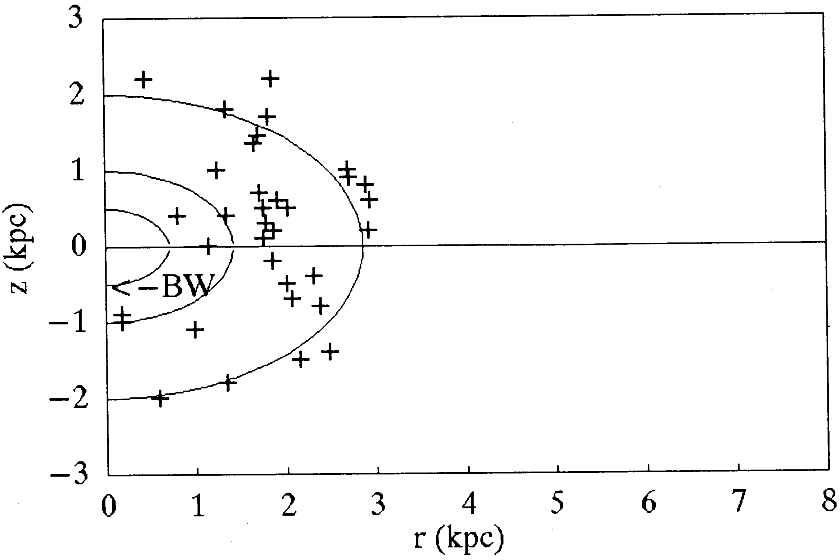

Fig. 2. - The locations of globular clusters within R = 3 kpc, according to Webbink (1985), are plotted in cylindrical coordinates. Isodensity contours inferred from cool giants (c/a = 0.7) are shown for c = 0.5, 1.0, and 2.0 kpc. All of the clusters are exterior to the tangent point in BW.

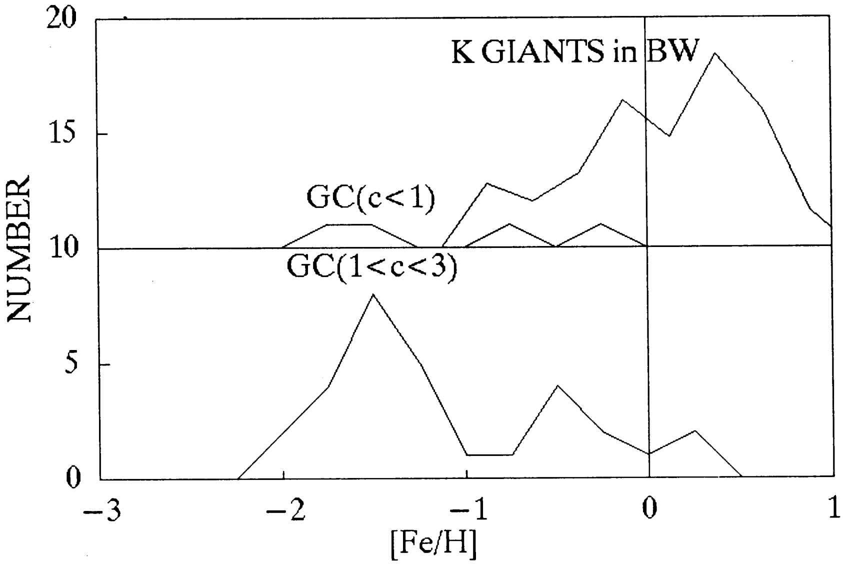

Fig. 3. - The abundance distribution of the four globular clusters interior to the ellipsoid c = 1.0 kpc does not match that of Rich's (1990) K giants in BW. It resembles a subset of the cluster abundance distribution in the adjacent ellipsoidal shell.

total HB in Fig. 4. After the RR Lyr counts are corrected for the gross changes in HB morphology that occur near the edge of the bulge, the total HB density in BW appears to lie, approximately, on an inward extension of the Halo density distribution.

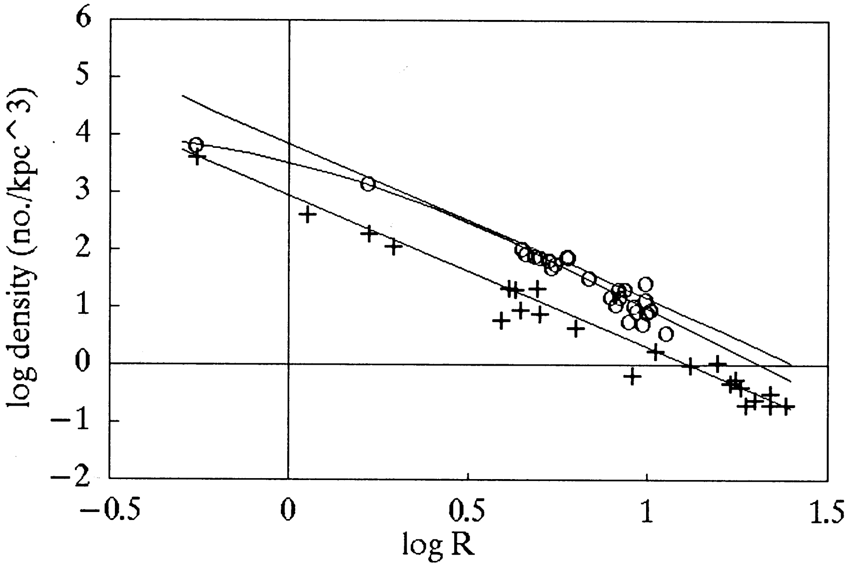

Fig. 4. - The Galactic density variations of RR Lyr stars (+) and BHB stars (o). The uppermost of the three curves is a schematic representation of the density of the total metal-poor HB derived from fragments of information, as described in the text.

I used the density law of the Blanco & Terndrup (1989) spheroid component, scaled to the HB densities at R = 0.5 kpc and at R = 2.0 kpc, to estimate the mass of the stellar population associated with the metal-poor HB within R = 1 kpc. Converting HB numbers to mass by use of L_V/N_{HB} = 500 (Preston *et al* 1991a) and M/L_V = 2.5, I obtain metal-poor masses in the range 2.6E+8 to 3.4E+8. In these calculations ~75% of the contribution to the integral is located inside of 0.5 kpc, where there are no HB data, so the result is largely an artifact of the adopted density law. These masses, ~ 2 to 3 percent of the total mass derived by Blanco & Terndrup, are comparable (to within a factor of ~ 2) to those expected for the metal poor component in a simple model of yield twice solar. The HB data, poor as it admittedly is, corroborates Rich's (1990) conclusion that there is no gross G-dwarf problem in the Bulge. I offer this crude calculation not as a polished result but rather as an illustration of how improvements in the HB data can be used to explore the chemical evolution of the Bulge.

In summary, the behavior of the HB seems to be in reasonable accord with a suggestion made by Searle (1979) in Liege thirteen years ago. The basic features of abundance distributions throughout the Halo-Bulge system can be attributed to variations of Hartwick's (1976) gas-depletion rate during star formation, large and somewhat variable among Searle's primordial fragments of the outer Halo, and declining steeply, perhaps to zero, in the densest portions of the central attracting mass, where star formation first took place, if Lee's (1992a, 1992b) arguments should prove to be correct.

2. Variable Stars in the Galactic Bulge

The RR Lyr and Mira variable stars have been used extensively to explore properties of the Bulge. These are but two of the several classes of variable stars long known to inhabit globular clusters (Hogg 1973). More recently a whole new literature has arisen about the occurrence of binary stars and blue stragglers, their putative progeny, and theoretical treatment of the capture/ejection processes that alter binary populations and accelerate the dynamical evolution of clusters (see Leonard 1989 and Mateo *et al* 1990). The Bulge offers a rather different environment in which to study physical properties of the variable stars for their own sake, and from these there will be feedback in the form of information about the structure, kinematics, age, and chemical properties of the Bulge. These remarks are preamble to a description of work in progress at the Las Campanas Observatory.

A major photometric search for variable objects in the Galactic Bulge began in April of this year as a Carnegie-Princeton-Warsaw collaboration, led by Bohdan Paczynski, at the LCO 1-m telescope equipped with a Ford 2048^2 chip. The ultimate goal is detection of gravitational microlensing of Bulge stars by all compact objects (stars, brown dwarfs, planets) that contribute to the Galactic Disk. Success in this endeavor is precursor to the search for dark matter in the Galactic Halo.

Eleven fields are measured on each suitable night in the V and I passbands. Sixty nights have been assigned to the project in the current calendar year and we anticipate this level of support for an additional three years. Because the quality of the photometry for faint stars in crowded fields is very sensitive to "seeing", observations are restricted to nights when the FWHM of the PSF is less than 1.5". Under these conditions each of the nine CCD images in BW produces photometry of 100,000 to 150,000 stars, of which ~ 40% have formal errors < 0.10 magnitudes. The errors increase with apparent magnitude as indicated below:

V	sigma	N
20.0	0.07	33000
20.5	0.10	55000
21.0	0.15	80000

Further details of the project (observations, reductions, preliminary results) are presented in a poster paper at this symposium prepared by Mario Mateo on behalf of the project participants.

In a lensing project intrinsic variable stars are undesirable distractions that spawn false hope. Therefore, all of the variables must be found and their properties established, if only to ignore them on a regular basis. These will be collected in a catalogue of nuisances and stored in a NASA-sponsored data base for use by the community for sundry purposes. For example:

Bar structure: Whitelock & Catchpole (1992) have presented evidence for longitudinal asymmetry in the density distribution of Bulge Miras that can be understood in terms of bar structure. RR Lyr stars in fields that straddle the Galactic Center offer an opportunity to search for such structure in a population of different abundance and, presumably, age.

RR Lyrae Stars: Blanco (1992) finds that the <P> of RRa type variables in WI (l =0.6, b = -5.5) is larger (0.537 days) than that in BW (0.497 days), a difference she suggests may be due to the abundance gradient. Mean periods elsewhere in the Bulge will test the generality of this apparent variation of period with location.

Cataclysmic variables: Some 85% of all M31 novae occur in its bulge. Cappacioli *et al* (1989) estimate 29 ± 4 novae outbursts per year (see also Ciardullo *et al* 1987). According to the scenario developed by Shara and his collaborators (1986), a population rich in novae also should contain a rich population of dwarf novae which should appear on $19 < V < 20$ during outbursts in the Bulge fields observed by Terndrup (1988). Detection of a population of mass-accreting white dwarfs in the Bulge would be important, as they are promising candidates for precursors of SNI.

Dwarf cepheids & anomolous cepheids: Dwarf cepheids have been discovered in 2 globular clusters: Omega Cen (Jorgensen & Hansen 1984) and NGC 5466 (Mateo *et al* 1990). Their masses, estimated from pulsation theory, are ~ 1.3 solar masses. It has been proposed that dwarf cepheids in globular clusters are consequences of stellar mergers, produced either by star-star collisions or by coalescence of close binaries. The former process should be ineffective in the Bulge. Comparison of the number ratio of dwarf cepheids to close binaries in the Bulge and in globular clusters should permit evaluation of the relative importance of these mechanisms for the production of dwarf cepheids and of a related kind of variable, the anomolous cepheids found in dwarf galaxies and globular clusters (Nemec *et al* 1988, Wallerstein & Cox 1984).

Eclipsing binaries: With the advent of very large telescopes it will be possible to contemplate mass determinations at the main sequence turnoff by spectroscopic observations of detached eclipsing binaries. These will be found in the photometric survey. Meanwhile, more luminous semi-detached Algol systems (hereafter EASD) can provide immediate gratification, because they can be observed with existing telescopes to set a lower limit to the mass of stars at the main sequence turnoff in the Bulge, as outlined below.

A long-neglected paper by S. Gaposchkin (1954) assures us that such stars exist in BW. Of 45 eclipsers in BW identified by Baade (1946, 1951) and investigated by Gaposchkin, 30 exhibit the shallow secondary minima and lie in the period range 1 to 4 days characteristic of EASDs in the 4th edition of the *General Catalogue of Variable Stars* (Kholopov 1985). The apparent magnitude distribution of these stars is reasonably represented by an error-broadened power-law density fitted to the RR Lyr stars in the same field and shifted by 0.6 mag. in *B* (Fig. 5). If accepted at face value, this means that the dispersions in luminosity of the two species are similar.

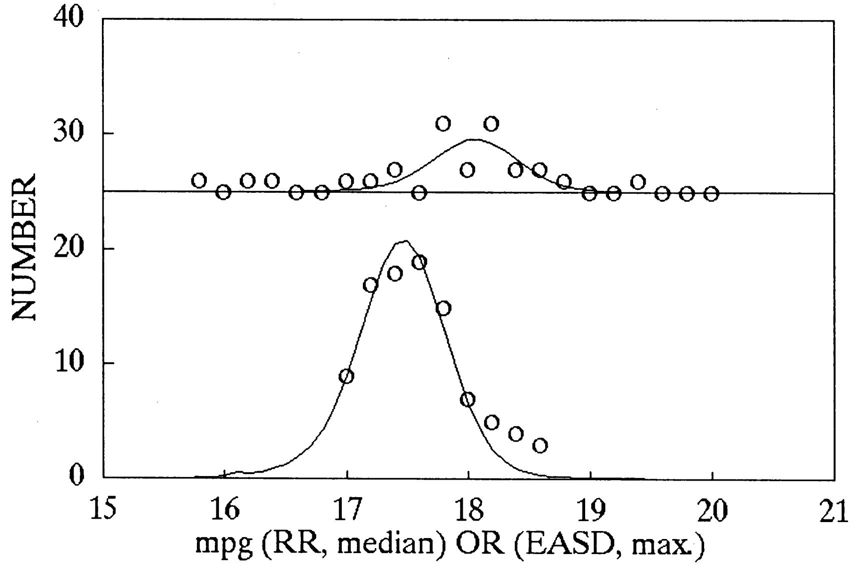

Fig. 5. The apparent magnitude distributions of EASDs (top panel) and RR Lyr stars (bottom panel) in BW. A power law density distribution, broadened by a Gaussian error function, was fitted to the RR Lyr data. The same curve, scaled and shifted by 0.6 mag., is used to represent the EASD apparent magnitude distribution.

The notion of essentially mono-luminous EASDs is a surprise in itself, for it implies, at the least, a preferred mass-ratio among the initial primaries. In time we shall learn whether this feature of Gaposchkin's data is real or is merely an indication of magnitude-dependent incompleteness. Meanwhile, consider the consequences of mono-luminous EASDs at $B = 18.1$.

(1) Absolute magnitudes of EASD primaries in BW. Estimate with $M_B(\mathrm{h}) = M_B(\mathrm{RR}) + 0.6 + \mathrm{D}B$, in which h refers to the hot component and $\mathrm{D}B \sim 0.2$ is a typical increment to B(EASD) that results from subtraction of secondary light outside of eclipse (Cester et al 1978, Amman & Walter 1973). Using $M_V = 0.85$ for the relatively metal-rich RR Lyr stars in BW (Walker & Terndrup 1991) with $(B\text{-}V)_0 = 0.3$ for the intrinsic colors of the RR Lyr stars, obtain $M_B(\mathrm{h}) = 1.95$, which is 0.17 mag. smaller than the mean for the three least luminous(least massive) EASDs tabulated by Popper (1980a) and similar to the bright limit ($M_V \sim 1.9$) of the composite luminosity function of blue stragglers in the globular clusters Omega Cen, M3, NGC 5466, NGC 5053, and NGC 6101 (Sarajedini & Da Costa 1991).

(2) Lower limit to stellar mass at MS Turnoff in BW. Using no more than conservation of mass we may write

$$\begin{array}{ccccc} \text{observed EASD} & = & \text{initial binary} & + & \text{hypothetical mass loss} \\ m_\mathrm{h} + m_\mathrm{c} & = & m_\mathrm{p} + m_\mathrm{s} & + & m_\mathrm{l} \end{array}$$

in which h and c denote the hot(primary) and cool(secondary) components of the EASD, p and s denote the primary and secondary components of the initial, unevolved binary, and m_l is mass lost from the system during or prior to mass transfer. From the theory of mass-transfer binaries (Kippenhahn & Weigert 1967, Paczynski 1971) we expect that EASDs arise as a consequence of the binary-perturbed evolution of initial primaries from the main sequence, so $m_\mathrm{p} = m_\mathrm{TO}$, and

$$m_\mathrm{TO} = m_\mathrm{h}(1 + q)/(1 + Q - L)$$

in which Q, q, and L are the secondary masses and mass loss expressed as fractions of their respective primaries. The quantities Q and L are unknown, so we set $Q = 1$ and $L = 0$ to summarize what can be learned in the form of a lower limit to m_TO (upper limit to age) of the parent population,

$$m_\mathrm{TO} > m_\mathrm{h}(1 + q)/2,$$

i.e., the turnoff mass must be greater than half of the total mass of the initial binary. The true limit must be a bit larger, because $Q = 1$ cannot produce an EASD. Measurement of m_h and q for EASDs in BW is barely within the grasp of 4-m class telescopes. To entice observers I applied this formalism to three of the least massive EASDs in the solar neighborhood (Popper 1980a, 1980b). Interpolation of masses in the lifetime *versus* [Fe/H] relations for [Fe/H] = 0.0 and Y = 0.30 in Fig. 5 of VandenBerg & Laskerides (1987) leads to upper limits on age of <7, <10, and <25: Gy for AS Eri, TW And, and RY Aqr, respectively. Limits smaller than 10 Gy in the Bulge would be interesting. In view of the considerable uncertainties that attend other methods of age estimation in the Bulge, I reckon that this one is worthy of pursuit.

Finally, the co-spatial counts of RR Lyr stars and Algols in the Bulge may provide a norm for judging the effects of stellar encounters on binary populations in the dense environments of globular clusters. The number ratios of these two species in the general field at $|b| > 30^o$ (Kholopov 1985), in BW (Gaposchkin 1954), and in all globular clusters (Hogg 1973) are tabulated below:

Sample	n(RR)	n(EASD)	n(RR/n(EASD)
GCVS4$\|b\|>30^o$	526	51	4.5*
BW	113	35	3.2
Glob. Clusters	1900	2**	950

* The number of EASDs in GCVS4 was arbitrarily increased by the factor $10^{0.6DB}$.

** One in Omega Cen (Jensen & Jorgensen 1985) and one in NGC 5466 (Mateo *et al* 1990)

I removed the RR Lyr stars of Kinman, Wirtanen & Janes (1966) in Coma from the statistics because the search technique (Kinman 1965) used to find them was biased against discovery of variable stars with $P > 1$ day. The ratio is uninterpretable at low latitudes because of the large numbers of massive Algols of the Young Disk that are found there. After application of a modest volume correction factor to the EASDs in the *General Catalogue of Variable Stars* based on the absolute magnitude difference $DM_B = M_B(\mathrm{EASD}) - M_B(\mathrm{RR}) \sim 0.6$ in BW, the ratios at high latitudes and in the Bulge are comparable. Both are smaller than the ratio in globular clusters by more than two orders of magnitude, which means that the cluster antecedents of EASDs (1) never existed in significant numbers, (2) have been destroyed efficiently, or (3) have sunk to the inadequately explored cluster centers.

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DISCUSSION

King: You use the word spheroid exactly as I recommended, you used it geometrically and you did not talk about a spheroid population, which was the thing that I abominated.

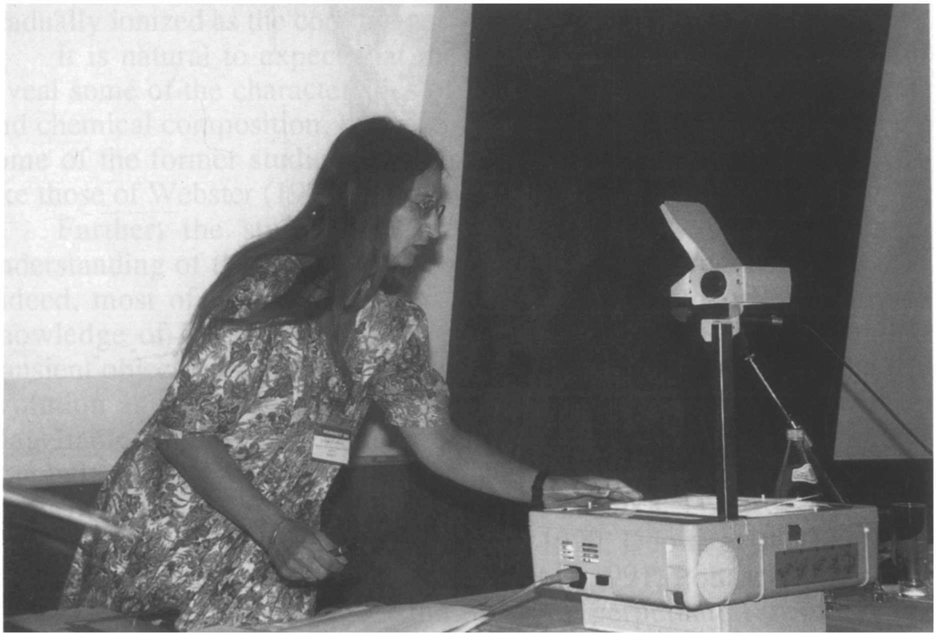
Preston: Thank you Ivan.

Tyson: Rich and I have a poster, where there is an abundance distribution given for a field interior to Baade's window, one of the clear windows in Sagittarius at -2.5 degrees (Baade's window is at -4 degrees) and in that field we do not find the mean abundance to go up to infinity as your graph had shown. So abundances scaling up to infinity may be premature at this point, interior to Baade's window!

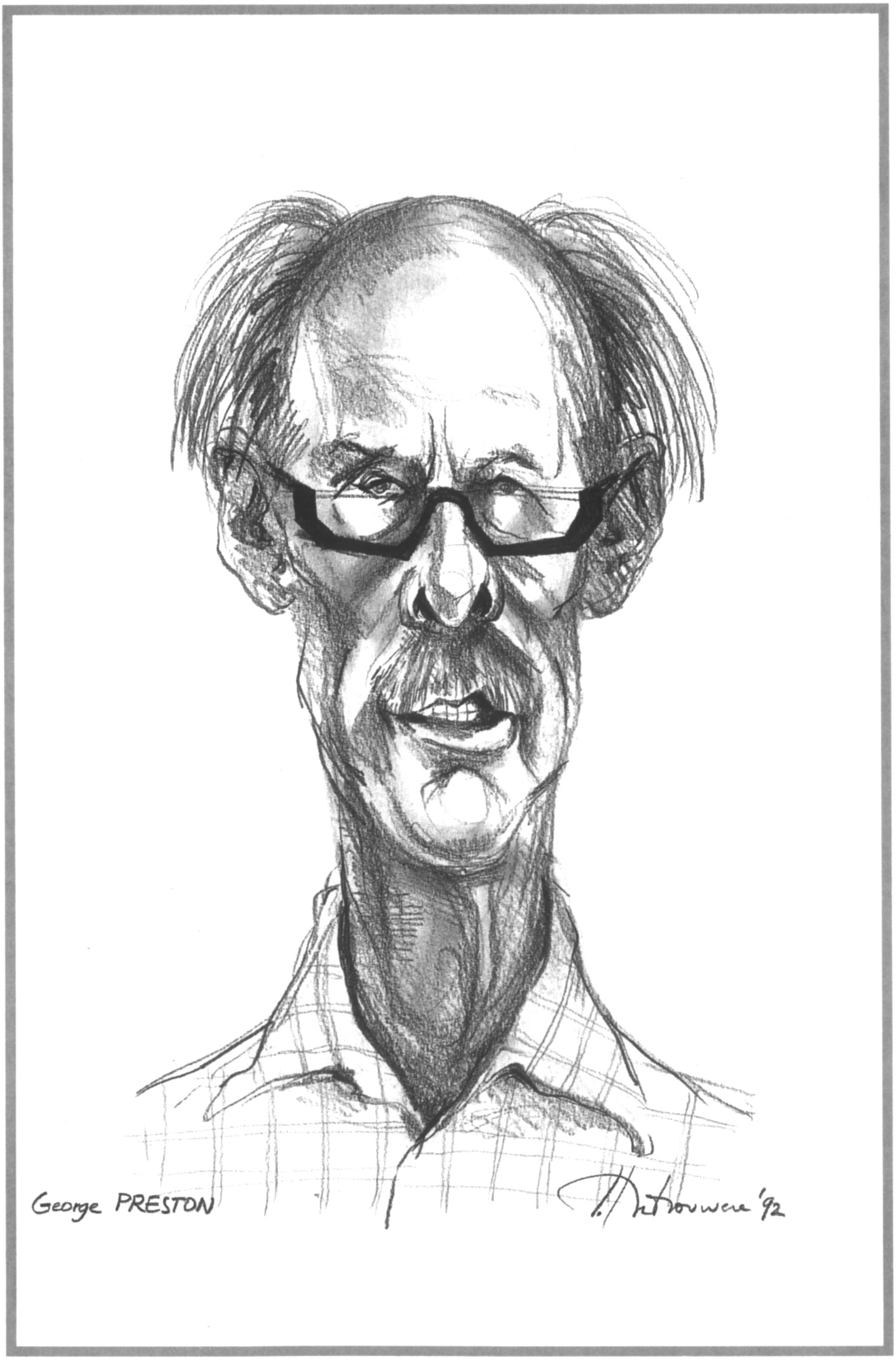
Preston: I stand corrected, the abundances do not go up to infinity!

Ng: In my poster I show the C-M diagram for a quarter of a million stars in the same field, and I don't think that the blue horizontal branch stars are as blue as you proposed in that field.

Preston: I don't know what to say, I measured 150 of them myself and I believe my own colors. I measured them with an aperture photometer one by one and I'm proud of those colors, and they're just as blue as I said they were...



G. Stasinska


George PRESTON