STAR AND STAR CLUSTER SPECTRAL LIBRARIES

E. Bica
Instituto de Física-UFRGS, Porto Alegre, RS, Brazil

ABSTRACT. This paper reviews spectral libraries of stars and star clusters, together with their applications to population synthesis. The problem of abundance calibrations for metal rich populations is also addressed, in particular index definitions and non-solar CNO/Fe ratios. A stellar population data bank would be important to accelerate progress in the field and would optimize the use of future telescope time.

1. INTRODUCTION

Stellar libraries have been collected since quite long for the analysis of composite stellar populations. An early example is de Vaucouleurs and de Vaucouleurs' (1959) synthesis of an LMC bar integrated spectrum. In the 60's and early 70's the libraries consisted of photographic spectra (e.g. Spinrad 1962) and photoelectric photometry like Faber's (1973) 10 colour system. The natural evolution of these techniques with the development of linear detector arrays was spectrophotometry. In the early studies and in the subsequent ones with low resolution scanners it was clear the intention by the authors to visualise the models they were computing (e.g. O'Connell, 1976). Detailed spectral visualisations became possible by means of observations carried out with high resolution scanners and/or CCD detectors (e.g. Pickles 1985; Bica 1988, hereafter B88).

2. STELLAR LIBRARIES

So far the stellar libraries which have been used more often are Gunn and Stryker's (1983, hereafter GS83) and Jacoby *et al.*'s (1984, hereafter JHC84). The main advantage in GS83 is the wide spectral coverage ($3130 < \lambda < 10800$ Å), but the resolution is low (20 Å in the blue and 40 Å in the near-infrared). JHC84 spans $3510 < \lambda < 7427$ Å at a resolution of $\approx$4.5 Å. The libraries contain respectively 175 and 161 entries, which consist mostly of solar neighbourhood stars of spectral types O to M and luminosity classes from V to I. Pickles (1985) presented a library of 200 stars at $\approx$15 Åresolution, in the range $3600 < \lambda < 10000$ Å ; this library was later complemented with Baade window giants (Pickles and van den Kruit 1990). Faber *et al.* (1985) studied 110 stars at 9 Å resolution in the range $4000 < \lambda < 6200$ Å. They are K giants and subgiants, as well as some giants in metal poor globular clusters. Alloin and Bica (1989 and references therein) studied the near-infrared NaI and CaII lines at 3 Å resolution in F to M stars of luminosity classes V to I. These spectra are corrected for earth atmosphere absorptions, and are complementary to JHC84 in wavelength range. Rose (1985) collected a high resolution blue- violet library, in a stellar population study based on central depth of lines.

Many other stellar libraries and data sets exist in the literature, but it would be impossible to mention all of them here. As an illustration of spectra dedicated to particular types of stars, I mention Mould and Aaronson's (1980) library of carbon and other late

B. Barbuy and A. Renzini (eds.), The Stellar Populations of Galaxies, 215–224.

type stars and Melnick's (1985) one of early type stars in 30 Doradus.

2.1 INFRARED AND ULTRAVIOLET

Detector developments in the infrared have made possible the acquisition of high quality spectra. Frogel *et al.* (1991) studied 18 solar neighbourhood and 14 Baade window M giants in the range $1< \lambda <2.5$ μm, which were complemented with visible spectra. The IUE data bank contains most types of stars, in the range $1000< \lambda <3000$ Åat an average resolution of ≈7 Å.

2.2 A DATA BANK FOR STELLAR POPULATIONS

Now it has been ≈20 years of linear detector spectra of stars and star clusters (sect. 3). In addition, an enormous amount of galaxy spectra have been accumulated in the literature in the form of individual objects or sets. Examples of large sets are the blue to red spectra of 455 Ellipticals by Faber *et al.* (1989), 320 galaxies of various types (Véron-Cetty and Véron 1986) and 161 spirals (Keel *et al.* 1985). Bica and Alloin (1987a, 1987b; hereafter BA87a and so on) have collected spectra for 170 galaxies in the interval $3700< \lambda <10000$ Å , which were recently complemented with the near-ultraviolet, in view of connecting template populations to IUE spectra. It would be important to store all these spectra in a stellar population data bank, which could be operated by existing facilities like the CDS and the NASA-IPAC. This would certainly accelerate progress in the field and would optimize future telescope time allocation, by improving S/N ratio and complementing wavelength ranges for the same objects, and by observing new ones. The stored data should be as much calibrated as possible by the authors: absolute flux calibrations are not essential, relative ones are ideal, but only wavelength calibrated spectra are useful too.

2.3 MODEL LIBRARIES

Spectral models based on stellar atmospheres may turn out to be the only way to have some stars with special characteristics in libraries, like low luminosity metal poor stars. Kurucz (1979) presented a model library which included ≈1 million atomic lines, but the absence of molecular lines precluded the generation of realistic models for late spectral types. Only recently molecular lines have been included in detail, together with atomic lines (e.g. Erdelyi Mendes and Barbuy 1991). Kurucz (this meeting) has presented a new series of models with a comprehensive set of molecular and atomic data. Much work is still necessary in spectral models in order to fit in detail observed spectra, in particular for late type and/or metal rich stars, and as well as for objects with non-solar CNO/Fe ratio.

2.4 POPULATION SYNTHESIS WITH STELLAR LIBRARIES

Population synthesis using stellar libraries has been often applied to nuclei (e.g. Pickles 1985) and other subsystems in galaxies (Gregg 1989), allowing one to obtain information such as fractions of different stellar types and age components. Applications of stellar libraries to star cluster integrated spectra have not been exploited as much. Clusters present an additional synthesis constraint with respect to galaxies, which is the statiscally complete parts of the observed HR diagram. Santos Jr. *et al.* (1990) have studied the rich Galactic open cluster M11 and now we have applied the same method to the moderately metal rich globular cluster 47 Tuc in the range 3100< λ <9800Å. It is possible to infer on the low main sequence IMF: the near-infrared is essential for this purpose and the infrared range should be even more discriminating. The 47 Tuc minus model residuals in the MgI 5175Å region point to a higher heavy element abundance in the model, as expected because it uses solar neighbourhood stars from GS83's library. However 47 Tuc presents a *stronger* blue-violet blanketing which, according to a synthesis with laboratory molecular patterns, it is very possibly caused by molecules involving C,N and O (Santos Jr. et al., this meeting). This would suggest that non-solar CNO/Fe ratios occur in the Halo/Bulge transition, similarly to those detected for O/Fe in halo giants (Barbuy 1988).

Stellar libraries have also been used for spectral visualisation of evolutionary synthesis models (Bruzual 1983; Guiderdoni and Rocca-Volmerange 1987).

3. STAR CLUSTER LIBRARIES

Early studies of cluster integrated spectra were based on photographic material (e.g. van den Bergh 1969). During the 80's many observations based on modern detectors were published: Burstein *et al.* (1984) studied M31 and Galactic globular clusters (GGC) in the range 3900< λ <6200 Å; Rabin (1982) analysed intermediate and old age Magellanic Cloud clusters (MCC), GGCs and the Galactic open cluster (GOC) NGC2243 in the range 3800< λ <6200 Å ; Rose (1985) collected high dispersion spectra of GGCs and the GOC M67 spanning 3800< λ <5200 Å, whereas Tripicco (1989) performed a similar analysis for M31 clusters. Huchra *et al.* (1991 and references therein) have derived velocities and metallicities for M31 and GGCs. All such studies concentrated efforts on the visible part of the spectrum, in particular the blue region. BA86a and BA87b have studied GGCs, GOCs and MCCs: in addition to the visible range, the near-infrared one has been observed and recently the data set has been extended to the near-ultraviolet.

3.1 POPULATION SYNTHESIS BASED ON A CLUSTER LIBRARY

B88 presented a population synthesis method of galaxy nuclei using the base of star cluster spectra in BA86a and BA87b. The synthesis derives ages and metallicities of population components. Other parameters controlling the star formation are inlaid in the cluster spectra, which considerably simplifies the analysis. A *grid* of cluster equivalent widths and underlying continua as a function of age and metallicity (BA86b, BA87b) is used in the computations, whereas the cluster spectra are employed for visualisation purposes. Two algorithms were developed for the solution of the inverse problem: a) combinations of grid elements (B88); (b) multi-minimization which basically merges the advantages of the combination method with those of classical minimization algorithms (Schmidt *et al.* 1989). In addition to Shapley-Ames galaxy nuclei (B88), the synthesis has been applied to the M31, M32 and NGC205 nuclei (Bica *et al.* 1990a), M33 and other blue nuclei (Schmidt *et al.*

1990), and galaxies in the distant cluster Abell 370 (Jablonka *et al.* 1990). The subtraction of an appropiate population model has allowed one to study in detail emission components, in some cases to an unprecedent luminosity level (Bonatto *et al.* 1989; Storchi-Bergmann *et al.* 1991).

Metallicity and age scales are not yet settled, but the synthesis results are essentially independent of these uncertainties because they connect directly observables in the galaxy spectra to those in the cluster grid.

3.2 ULTRAVIOLET STUDIES

The cluster library, combined to IUE data, was used to probe the three possible explanations for the UV turnup in giant E galaxies (BA88 and references therein). No new synthesis was performed, we simply checked in the UV the behaviour of the synthesis components previously obtained from the visible/near-infrared ranges in B88. a) A young burst of star formation reproduces the turnup and is compatible with the synthesis; b) horizontal branch stars associated to the old metal poor components have a negligible UV contribution, and even if one exagerates such amount, it does not fit the shape of the UV turnup unless a very anomalous HB is present; c) post AGB stars associated to the old metal rich components (the dominant ones in the giant E synthesis) explain the turnup, if ≈5 of such UV bright stars were detected in very metal rich globular clusters like NGC6528 and NGC6553.

The near-ultraviolet range is very important not only for the possibility of connections to UV satellite observations, but also for its spectral features. A new library of star clusters and galaxies has been collected in this range (Bica et al. 1991a). The 3360 Å NH band shares the effect of metallic feature wavelength dilution (BA86a, BA87b), as one approaches younger ages. Index definitions for the balmer jump and the 4000 Å break throughout the literature are basically the same. We illustrate in Fig. 1 their behaviour in globular clusters of various metallicities. For the metal rich group G1 the feature is purely 4000 Å break, whereas for the metal poor group G5 it is mostly balmer jump from blue horizontal branch stars.

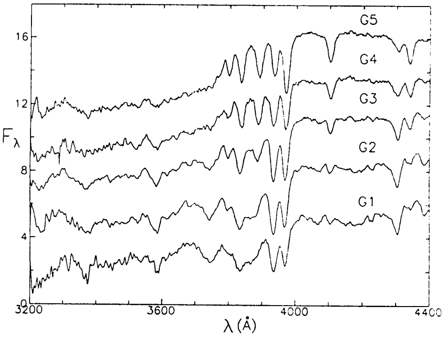

Fig. 1

3.3 CLUSTER SPECTRA AND UBV PHOTOMETRY IN THE LMC

The spectral evolution of LMC star clusters younger than 500 Myr presents two phases where the flux from red stars is enhanced in the red/near-infrared ranges (Bica et al. 1990b, BA87b, BA86a): a) the red supergiant phase (RSG) at t≈10 Myr and b) there is evidence of an effect involving M type AGB stars at t≈100 Myr. Recently we have enlarged the sample of LMC clusters with UBV photometry to 624 entries. We have detected the Helium-flash gap (Fig. 2) at t≈600 Myr (Bica it et al. 1991b), which denotes the first appearance of red giant branch stars (Sweigart *et al.* 1991, and references therein). Fig. 2 presents many other features which are worth commenting. The youngest HII regions are not in the upper left corner of the (U-B) vs (B-V) diagram, mainly because of the way emission lines evolve in the different filters. The massive clusters containing RSGs are concentrated in a clump, whereas many small ones jump to red (B-V) colours because of stochastic effects. The RSG phase has been confirmed in models of integrated colour evolution using two different sources for massive star tracks (Arimoto and Bica 1989; Girardi and Bica in this meeting). There is a marginal evidence for a gap near t≈20 Myr in Fig. 2 which could be associated to the AGB phase transition. It should be recalled that the age ticks are from a scale without overshooting.

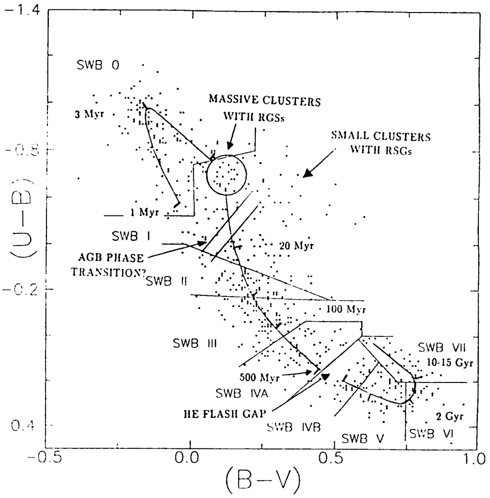

Fig. 2

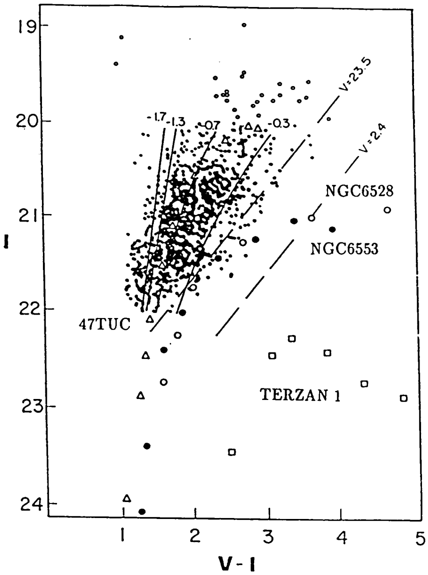

Fig. 3

3.4 CLUSTER LIBRARY AND CMDs OF LOCAL GROUP GALAXIES

The bulge globular clusters NGC6528 and NGC6553 present very strong-lined spectra, comparable to those in many giant galaxy nuclei (BA86a, BA87b). They are clearly more metallic than clusters like 47 Tuc, which is usually taken as prototype of metal rich ones in the literature. Ortolani *et al.* (1990) have started a systematic colour magnitude diagram (CMD) survey of bulge clusters, under excellent seeing conditions, because of crowded fields. Bica *et al.* (1991c) have gathered such clusters in the absolute I vs (V-I) diagram and compared them to CMDs of local group galaxies in the literature. It is clear from this study that metallicity histograms based on the red giant branch (RGB) width should not be performed at constant luminosity level because metal rich RGBs change their morphology and become fainter, owing to blanketing effects. We illustrate in Fig. 3 the cluster sequences on the M32 CMD by Freedman (1989). There is an inclined observational cutoff through the diagram because the plate limits are different. Metal rich populations such as that in NGC6553 have not been attained in M32's CMD. According to the M32 synthesis in Bica *et al.* (1990), this component is necessary because those corresponding to the observed part of the CMD are not strong-lined enough to account for the M32 spectrum. Freedman pointed out that the average metallicity she was deriving was possibly a lower limit. Our synthesis intermediate age component is compatible with Freedman's detection of AGB stars, whose luminosity points to an age of ≈5 Gyr. It should be pointed out that the intermediate age giant branch certainly overlaps with part of the old age RGB. The synthesis metallicity dispersion corresponding to the observed part of the CMD is also compatible with Freedman's study: small contributions are observed for [Z/Z⊙]<-1, in particular if one considers that the stars close to the plate limit have larger photometric errors. The synthesis shows a metallicity dispersion, not only for a similarly small amount of metal poor components, but also because the solar and the [Z/Z⊙]=-0.5 components are spectroscopically very different. Population synthesis in a wider spectral range and a deeper CMD are necessary to shed more light on the M32 question.

3.5 M31 CLUSTERS

We have recently observed 2 open and 7 globular clusters in M31 (Jablonka *et al.* 1991). The wide spectral range allows one to infer confidently on age, metallicity and reddening, based on our previous grid and spectral cluster data. In particular we find evidence that the cluster Mayall IV (G219) is not a classical metal poor globular cluster as previously classified. Its properties resemble those of an intermediate age cluster of [Z/Z⊙]≈-1. Previous studies were performed in the blue-visual region, where metallic features appear to be considerably diluted by the age effect, which is not the case in the near- infrared. An inspection of the spectra in Burstein *et al.* (1984), which reach the red range, shows that indeed M IV is considerably bluer than globular clusters of [Z/Z⊙]≈-2.

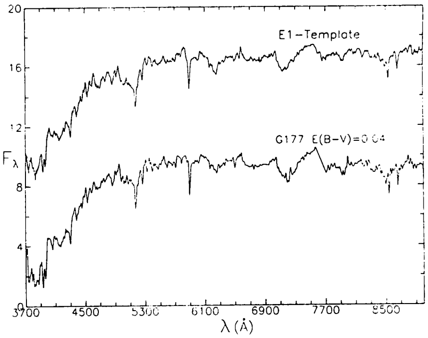

Fig. 4

In the inner bulge of M31, G170 is a cluster as strong-lined as NGC6553 in our Galaxy; G177 and G158 are even more metallic. G177 is compared in Fig. 4 to an average of the strongest-lined E galaxies in B88. The absorption features are comparable. This definetely throws down a dogma in the stellar population literature, which used to state that star clusters do not overlap with giant galaxies in spectral properties. This wrong notion dissiminated because in previous comparisons of clusters and galaxies the "metal rich" clusters were similar to 47 Tuc.

3.6 CNO ENHANCEMENT IN BULGES?

In addition to the super metal rich cluster G177 in the central bulge of M31, we have studied G158, which is as strong-lined as G177 (Fig. 5a). However they differ in the sense that G177 has a stronger blue-violet blanketing, as illustrated by the difference spectrum in Fig. 5b, where the residuals between 47 Tuc and its model built with solar neighbourhood disc stars (section 2.4) are also shown. The blue-violet residuals are very similar, although in one case we are dealing with super metal rich clusters while in the other with sub-solar and solar heavy element abundances. The fact that G158 behaves like disc stars led us to suspect that it is an inner disc cluster, whereas G177 is a genuine inner bulge cluster (Bica *et al.* 1991d). According to the molecular synthesis in sect. 2.4 the blue-violet blanketing arises from molecules involving CNO elements. These evidences point to a non-solar CNO/Fe ratio in bulges.

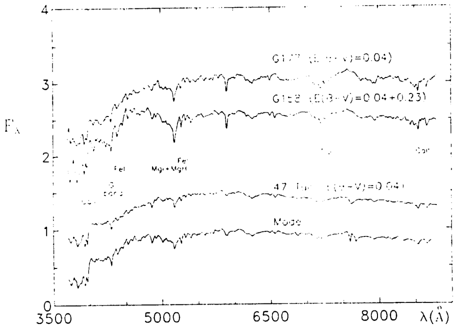

Fig. 5a

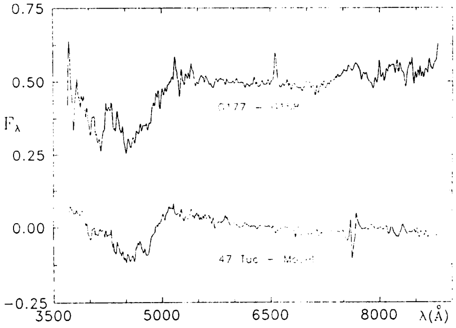

Fig. 5b

3.7 THE CALIBRATION PROBLEM OF METAL RICH POPULATIONS

Recently new results on the metallicity calibration of metal rich populations have been presented. According to Zinn and West's (1984) scale, NGC6553 has [Fe/H]=-0.29, slightly lower than that derived by Barbuy *et al.* (1991) from high dispersion analysis of the giant III-17. The star shows a Nitrogen enhancement.

Brodie and Huchra (1990) have derived a spectral metallicity calibration for extragalactic globular clusters, which was tied to Zinn and West's scale. The application of this scale to G158 and G177 led to [Fe/H]=-0.26 and -0.15 respectively (Huchra *et al.* 1991). This would imply that the average [Fe/H] for the strongest-lined E galaxies is essentially solar (Fig. 4). In this scenario, the blue-violet blanketing excesses should be due to higher than solar CNO/Fe ratios. However in detail there are still discrepancies; a comparison of G158 to a solar abundance old cluster model (Fig. 5a) shows that G158 cannot have [Fe/H]=-0.26, because line strengths are at least a factor two stronger in G158.

The problem of scales appears to be not just one of ranking and selecting cluster calibrators. The way that indices are defined might play an important role too. The continuum tracings for equivalent widths in BA86a are sensitive to a global blanketing in the region $4050 < \lambda < 4500$ Å, which is almost comparable to the C_2 and MgH absorptions around 5100 Å. In the Lick system the best metallicity indices are MgH and Mg2 which have flux side bands in high continuum zones. Mgb is not as good, certainly because its sidebands are located within the MgH absorption. Brodie and Huchra have used six indices as primary calibrators. Four of them, i.e. the CNB, G, Fe52 and Δ , have sidebands in absorbed regions. Some of these indices might saturate, whereas the tracings would still show differences among metal rich populations. It would be important to compare in detail index behaviour among different systems.

The metallicity scale used in B88 relies on an average of cluster values from Zinn's third calibration (Zinn and West, 1984) and from Bica and Pastoriza (1983). The latter calibration is similar to Zinn's first one (high values). It might turn out that Zinn's first calibration is closer to a Z_{CNO} scale, while the third one to a Z_{Fe} scale.

4. CONCLUSIONS

A data bank for spectra of stars, star clusters and galaxies would accelerate progress in stellar population studies, and would optimize the use of telescope time. Much of the blanketing excess in bulge populations with respect to the solar spectrum appears to be caused by molecules involving CNO elements. The problem of line index definitions is of major importance for the abundance calibration of metal rich populations.

ACKNOWLEDGMENT: I thank the State of Rio Grande do Sul Science Foundation FAPERGS for a grant which made possible UFRGS group members to attend this meeting.

REFERENCES

Alloin, D., Bica, E. 1989, A&A, 217, 57
Arimoto, N., Bica, E. 1989, A&A, 222, 89
Barbuy, B. 1988, A&A, 191, 121
Barbuy, B., Castro, S., Ortolani, S., and Bica, E. 1991, A&A, submitted
Bica, E. 1988, A&A, 195, 76
Bica, E., Alloin, D. 1986a, A&A, 162, 21
Bica, E., Alloin, D. 1986b, A&AS, 66, 171
Bica, E., Alloin, D. 1987a, A&AS, 70, 281
Bica, E., Alloin, D. 1987b, A&A, 186, 49
Bica, E., Alloin, D. 1988, A&A, 192, 98
Bica, E., Alloin, D., and Schmidt, A. 1990a, A&A, 228, 23
Bica, E., Alloin, D., and Santos Jr., J. F. C. 1990b, A&A, 235, 103
Bica, E., Alloin, D., and Schmitt, H., 1991a, in preparation
Bica, E., Clariá, J. J., Dottori, H., Santos Jr., J. F. C., and Piatti, A. 1991b, ApJ Letters, in press
Bica, E., Barbuy, B., Ortolani, S. 1991c, ApJ Letters, in press
Bica, E., Jablonka, P., Santos Jr., J. F. C., Alloin, D., Dottori, H. 1991d, A&A, in press
Bica, E., Pastoriza, M. 1983, ApSS, 91, 99

Bonatto, Ch., Bica, E., and Alloin, D. 1989, A&A, 226, 23
Brodie, J. P., Huchra, J. P. 1990, ApJ, 362, 503
Bruzual, G. 1983, ApJ, 273, 105
Burstein, D., Faber, S. M., Gaskell, C. M., and Krumm, N. 1984, ApJ, 287, 586
Erdelyi-Mendes, M., Barbuy, B. 1991, A&A, 241, 176
Faber, S. M. 1973, ApJ, 179, 731
Faber, S. M., Friel, E. D., Burstein, D., and Gaskell, C. M. 1984, ApJS, 57, 711
Faber, S. M., Wegner, G., Burstein, D., Davies, R. L., Dressler, A., Lynden- Bell, D., and Terlevich, R. J. 1989, ApJS, 69, 763
Freedman, W. L., 1989, AJ, 98, 1285
Frogel, J. A., Tendrup, D. M., and Whitford, A. E. 1991, ApJ, in press
Gregg, M. D. 1989, ApJ, 337, 45
Guiderdoni, B., Rocca-Volmerange, B. 1987, A&A, 186, 1
Gunn, J. E., and Stryker, L. L. 1983, ApJS, 52, 121
Huchra, J. P., Brodie, J. P., and Stephen, M. K. 1991, ApJ, 370, 495
Jablonka, P., Alloin, D., and Bica, E. 1990, A&A, 235, 22
Jablonka, P., Alloin, D., and Bica, E. 1991, A&A, submitted
Jacoby, G. H., Hunter, D. A., and Christian, C. A. 1984, ApJS, 56, 257
Keel, W. C., Kennicutt, R. C., Hummel, E., and van der Hulst, J. M. 1985, AJ, 90, 708
Kurucz, R. L. 1979, ApJS, 40, 1
Melnick, J. 1985, A&A, 153, 235
Mould, J., Aaronson, M. 1980, ApJ, 240, 464
O'Connell, R. W. 1976, ApJ, 206, 370
Ortolani, S., Barbuy, B., and Bica, E. 1990, A&A, 236, 362
Pickles, A. J. 1985, ApJ, 296, 340
Pickles, A. J., van der Kruit, P. C. 1990, A&AS, 84, 421
Rabin, D. 1982, ApJ, 261, 85
Rose, J. A. 1985, AJ, 90, 1927
Santos Jr., J. F. C., Bica, E., and Dottori, H. 1990, PASP, 102, 454
Schmidt, A., Bica, E., and Dottori, H. 1989, MNRAS, 238, 925
Schmidt, A., Bica, E., and Alloin, D. 1990, MNRAS, 243, 620
Spinrad, H. 1962, ApJ, 135, 715
Storchi-Bergmann, T., Bica, E., and Pastoriza, M. 1990, MNRAS, 245, 749
Sweigart, A. V., Greggio, L., and Renzini, A. 1990, ApJ, 364, 527
Tripicco, M. J. 1989, AJ, 97, 735
de Vaucouleurs, G., de Vaucouleurs, A. 1959, PASP, 71
van den Bergh, S. 1969, ApJS, 19, 145
Véron-Cetty, M. P., Véron, P. 1986, A&AS, 66, 335
Zinn, R., West, M. 1984, ApJS, 55, 45

DISCUSSION

VAN DEN BERGH: The metal-poor cluster Mayall IV is located in the *outer* halo of M31. How would you account for the existence of a young population component in such an object?

BICA: M IV might have been formed in an interaction of M31 with a companion, or else it suggests an usual scenario for galaxy formation with late gas clouds. In our Galaxy the cluster Ruprecht 106 poses a similar problem (Buonanno *et al.* 1991, AJ, 100, 1811). M IV might as well have originated from a gas cloud accreted by M31. The occurence of an intermediate age cluster in the outer halo is not more defying to canonical models than that of the metal rich globular M II (G1), which is more distant in the M31 halo. In Christian *et al.*'s CMD (1991, AJ, 101, 848), M IV shows two RGB sequences (their Fig. 3). They interpreted one as a metal poor classical globular and the other as a metal rich field contamination. An intermediate age RGB might occupy the same locus as the former. Another possibility is a merger, as might be the case of ω Cen.

Rocca-Volmerange: We compared the template globular cluster G2 from B88 with our synthetic stellar population model using Yale tracks. The comparison gives an excellent fit at the same age 17 Gyrs for both. But if the evolutionary tracks change I assume that your time evolution scale has also to change.

BICA: Ages attributed to clusters through different tracks may change, but the synthesis results with the cluster grid will remain essentially unchanged because it is an inverse problem of feature equivalent widths in a galaxy against those in the cluster grid. The fractions will not change, only the ages attributed to them. The same holds true for eventual changes in metallicity calibrations.

MOULD: You mentioned that you see evidence for the AGB phase transition in Magellanic Cloud clusters. What turn-off mass would you associate with this phase transition, and is this consistent with the massive AGB star evolution discussed by Renzini yesterday?

BICA: There is a clear gap denoting the RGB phase transition in SWB IV clusters; for the AGB phase transition there is only marginal evidence of a gap in the (U-B) vs (B-V) diagram in SWB I, close to the borderline with SWB II clusters (Fig. 2). We find spectroscopically an enhancement of M star features in clusters of age $\approx$100 Myr (SWB III) like NGC1866 (Bica *et al.* 1990b). In the CMD of Galactic open clusters of this age there is evidence for an extended AGB of M stars (Bica et al. 1990, Rev. Mexicana Å, 21, 202), which might be the peak flux contribution of massive AGB stars. According to Renzini the turn-off mass of clusters in the AGB phase transition should be at $\approx$5 $M_\odot$ and for the RGB one at $\approx$2 $M_\odot$. The observational evidences are basically consistent the massive AGB star evolution discussed by Renzini.