Mem. S.A.It. Vol. 75, 32

Memorie della

Building up the Galactic Halo: The Sagittarius dSph and the globular cluster M22 ⋆ ⋆⋆

L. Monaco[1,2], F. R. Ferraro[2], M. Bellazzini[1] and E. Pancino[1]

[1] INAF - Osservatorio Astronomico di Bologna, via Ranzani,1 40127 Bologna, Italy - e-mail: monaco,bellazzini,pancino@bo.astro.it
[2] Dipartimento di Astronomia, Università di Bologna, via Ranzani,1 40127 Bologna, Italy - e-mail: ferraro@bo.astro.it

Abstract. The Sagittarius dwarf spheroidal (Sgr) and a few paculiar Galactic Globular Clusters (GGC) can be considered as building blocks of the Galactic Halo. We present a series of results based on a wide field photometry of the Sgr system and the GGC M22. In particular for Sgr we present: (1) the detection of the RGB-bump, a feature that together with the shape of the RGB can be used to constrain the allowed range of age and metallicity and (2) the detection of a clear blue horizontal branch which probes the existance of a metal poor population. In the case of M22 we present clear evidence that differential reddening is the primary cause for the observed spread of the evolutionary sequences.

Key words. galaxies: individual (Sagittarius dwarf spheroidal) – globular clusters: individual (M 22) – stars: evolution

1. Introduction

There is now a growing wealth of evidence that the Galactic Halo has been, at least partially, assembled by the slow accretion of sub-units. This process could be a promising local counterpart of the hierarchical merging acting on cosmological scale (Freeman & Bland-Hawthorn 2002).

In the context the study of both accreting events (i.e. Sgr) and peculiar globular clusters (i.e. ω Cen, M22) can be important. Our group is currently involved in the study of both these types of objects. In this contribution we will discuss the cases of Sgr and M22.

The Sgr dSph (Ibata et al. 1994) offers the unique opportunity of studing an ongoing process of accretion. However due to the intrinsic low surface brightness of this distrupting sys-

Send offprint requests to: L. Monaco

⋆ Based on observations made with the European Southern Observatory telescopes, using the Wide Field Imager, as part of the observing program 65.L-0463. Also based on data obtained from the ESO/ST-ECF Science Archive Facility.

⋆⋆ This publication makes use of data products from the Two Micron All Sky Survey, which is a joint project of the University of Massachusetts and the Infrared Processing and Analysis Center/California Institute of Technology, funded by the National Aeronautics and Space Administration and the National Science Foundation

Correspondence to: via Ranzani,1 40127 Bologna, ITALY

tem, an adequate characterization of the evolutionary features of the stellar populations in the main body of Sgr is still lacking. In the following section we will show how a large area survey (one square degree) centered on the globular cluster M54, which is thought to be the nucleus of Sgr, reveals several features never seen before in this galaxy.

The globular cluster M22, besides ω Cen, is the only other globular cluster suspected to have a significant metallicity spread (Hesser, Hartwick, & McClure 1977) and eventually it could be another remnant of a past merging event. In the last section however, we will show that in M22 an important role is played by differential reddening, thus leaving not much room for a large metallicity spread.

2. A detailed view of the evolutionary features of the Sgr dSph

In the following subsection we will illustrate some results based on the wide field photometry presented by Monaco et al. (2002), where we have first detected the RGB-bump.

2.1. The Red Giant Brach Bump

We analysed a sample of images obtained at the 2.2m ESO/MPI telescope at la Silla, Chile, using the *Wide Field Imager* (WFI) covering a wide region of $\sim 1^\circ \times 1^\circ$ around M 54. In Fig. 1 the $(V, V-I)$ CMD for a subsample of the ~490,000 stars measured in the global field of view is shown. The RGB of the Sgr's metal-rich population (Pop-A, which is the dominant population) is easily recognizeable at the red side of the diagram, extending to a very red color, $(V-I) \sim 2.7$, with the corresponding, well populated red HB clump at $V \sim 18.22$. The RGB bump of the Sgr can also easily be seen as a clump of stars along the RGB at $V \sim 18.5$ and $(V-I) \sim 1.2$.

In Fig. 1 (right-hand panels), we show the differential (lower panel) and cumulative (upper panel) luminosity functions for the RGB of the Pop-A Sgr (selected from the global sample). The RGB-bump is clearly identified in both panels of Fig. 1: it is located at V^{bump}=18.55±0.05.This is the first detection of such a feature in the Sgr dSph.

In the simplest scenario, the presence of a single-peaked bump in the differential LF suggest the existence of a dominant stellar population, relatively homogeneous in metallicity and age, in the inner regions of the Sgr galaxy.

The Pop-A RGB is well fitted by the RGB ridge-line of the globular cluster 47 Tuc, that has $[M/H] \simeq -0.6$. However, a significant difference in the RGB-bump luminosity between Sgr and 47 Tuc has been measured (of about 0.12 mag). This fact suggest that Pop A is several Gyr younger than 47 Tuc, in good agreement with previous results based on the comparison of the Main Sequence Turn Off's (Bellazzini et al. 1999; Layden & Sarajedini 2000). On the other hand, since at a fixed metallicity a younger age implies bluer RGB colors, we have to conclude that the mean metallicity of Pop A should be higher than that of 47 Tuc (see, e.g. Cole 2001).

A full self-consistency among the spectroscopic and photometric constraints (including the RGB-bump) is achieved if a mean metallicity of $-0.6 < [M/H] \leq -0.4$ and a mean age of $7 \geq age \geq 4$ Gyr are assumed for Pop-A.

2.2. A Blue Horizontal Branch

All the stars with r>15' from the M54 center are plotted in Fig. 1 (left-hand panel). A clear blue horizontal sequence can be recognized at V≃18.2 and 0.15≤(V-I)≤0.4. Note that these stars cannot be associated to M 54 ($R_t \simeq 7.5$ arcmin Trager, King, & Djorgovski 1995). Hence the mere detection of this BHB is a strong and unanbiguous demonstration of the presence of a metal poor population in Sgr (see also Layden & Sarajedini 2000; Bellazzini et al. 1999).

A BHB was never seen in the main body of Sgr before. Newberg et al. (2002) detected a blue HB in a halo structure which they claim to be associated with Sgr. The detection of an extended BHB in the main body of the Sgr provides a further confimation that the structure detected by Newberg et al. (2002) can be associated with the Sgr.

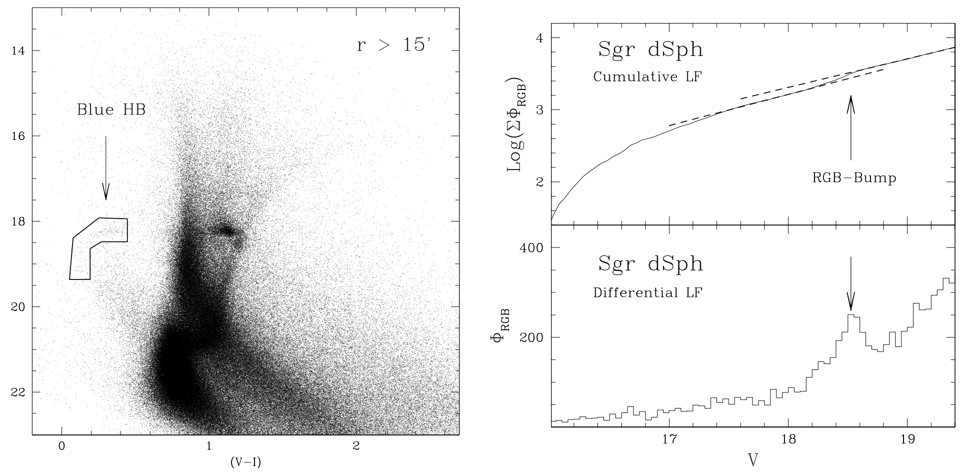

Fig. 1. Left-hand panel: color-magnitude diagram for the stars of our samples which are more than 15' far from M 54. Right-hand panels: Differential (lower panel) and cumulative (upper panel) luminosity functions for the stars selected in the region of the RGB of the Sgr. The arrows indicate the location of the RGB-bump at V=18.55±0.05.

3. M22: really a peculiar cluster?

We again analysed images taken using the WFI, the total area covered is 30'×30'. The most striking feature which can be seen in the color magnitude diagram of M22 is the large color spread of the RGB (see Fig. 2. This color spread could be due either to an internal metallicity spread or to the presence of differential reddening, or both.

The presence of differential reddening was already put into evidence in the past (see also Richter, Hilker, & Richtler (1999)). However the presence of differential reddening does not exclude the presence of some (small) degree of metallicity spread. In order to estimate the amount of differential reddening present in the region of M22 in Fig. 2 (right hand panels) we compared the RGB color dispersions in the (B-V), (V-I) and (J-K) colors.

On each panel a gaussian curve representing the instrumental error is also plotted. While in the (B-V) and (V-I) color the gaussian is quite different from the real distribution, in the (J-K) color, which is the less sensitive to reddening, the gaussian curve approches quite closely the observed color distribution.

From these diagrams we evaluate the amount of differential reddening, ΔE(B-V)=0.06±0.01, and that the width of the RGB scales from the optical planes to the infrared plane exactly as expected from the reddening law. This leads us to conclude that an eventual residual metallicity spread must be small.

Until now, no firm conclusion from the spectroscopic studies to the problem of the metallicity spread has been drawn for M22. However Lehnert, Bell, & Cohen (1991) found a $\Delta[Fe/H]$ ≃0.4 dex for a sample of 10 stars (the larger sample studied so far).

In order to solve the debate about the metallicity spread of M 22 we are performing high resolution spectroscopy: 10 spectra of RGB stars have been already acquired using UVES@VLT. Moreover M 22 is one of the target to be observed by the new ESO-VLT multi-fiber spectrograph FLAMES using the observing time granted to the Ital-FLAMES consortium.

Acknowledgements. Lorenzo Monaco is supported by the Italian Ministero dell'Università e della ricerca scientifica through the grant COFIN-2001028897 assigned to the project *The origin and*

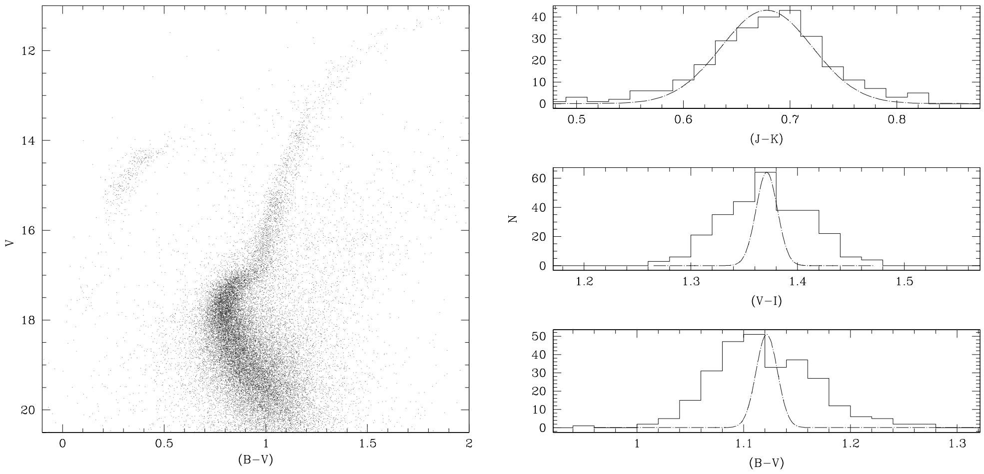

Fig. 2. Left panels: color magnitude diagram of M22. Right panels: the width of the RGB is shown in the (B-V), (V-I) and (J-K) colors.

the evolution of Stellar Population in the Galactic Spheroid.

References

Bellazzini M., Ferraro F. R., Buonanno R. 1999, MNRAS, 307, 619 (B99)

Cole A. A. 2001, ApJ, 559, L17

Freeman K. & Bland-Hawthorn J. 2002, ARA&A, 40, 487

Hesser J. E., Hartwick F. D. A., & McClure R. D. 1977, ApJS, 33, 471

Ibata R. A., Gilmore G., & Irwin M. J. 1994, Nature, 370, 194

Layden A.C. & Sarajedini A. 2000, AJ, 119, 1760

Lehnert M. D., Bell R. A., & Cohen J. G. 1991, ApJ, 367, 514

Majewski S. R., Skrutskie M. F., Weinberg M. D., Ostheimer J. C., submitted to ApJ

Monaco L., Ferraro F. R., Bellazzini M. & Pancino E. 2002, ApJ, 578, 47L

Moore B., Ghigna S., Governato F., Lake G., Quinn T., Stadel J., & Tozzi P. 1999, ApJ, 524, L19

Newberg H. J. et al. 2002, ApJ, 569, 245

Norris J. E., Freeman K. C., & Mighell K. J. 1996, ApJ, 462, 241

Richter P., Hilker M., & Richtler T. 1999, AAP, 350, 476

Trager S. C., King I. R., & Djorgovski S. 1995, AJ, 109, 218