Mem. S.A.It. Vol. 75, 142

Memorie della

Young stellar clusters in LMC: Can we still learn something from NGC 1866?

E. Brocato[1], G. Raimondo[1], E. Di Carlo[1], V. Castellani[2], F. Caputo[2] and I. Musella[3]

[1] INAF-O. A. di Teramo, via M. Maggini s.n.c., I-64100 Teramo, Italy e-mail: brocato@te.astro.it, raimondo@te.astro.it, dicarlo@te.astro.it
[2] INAF–O. A. di Roma, Via di Frascati, 33, I-00040 Monte Porzio Catone, Italy e-mail: vittorio@mporzio.astro.it, caputo@mporzio.astro.it
[3] INAF–O. A. di Capodimonte, via Moiariello 16, I-80131 Napoli, Italy e-mail: ilaria@na.astro.it

Abstract.
We briefly go through recent results on the LMC young stellar cluster NGC 1866. The luminosity function, as derived by HST data, is compared to theoretical predictions obtained by stellar models of intermediate mass stars to constrain the assumptions on the treatment of convective cores. Preliminary clues on the distance of NGC 1866 and its Cepheids are presented and shortly discussed.

Key words. distance scale — star clusters: general — galaxies: LMC

1. Introduction

The star clusters of the Large Magellanic Cloud (LMC) represent a unique opportunity of studying young stellar populations. There are at least three main features which make of particular interest to investigate these stellar aggregates in the LMC: *i*) a wide spread of age (from few Myr to several Gyr); *ii*) a remarkable richness in the number of stars i.e. LMC clusters may have a mass comparable to a typical galactic globular cluster; *iii*) they are close enough to allow detailed observation of single stars.

This combination of characteristics makes LMC clusters very appealing for nearly all the aspects of the star cluster astrophysics. For example, the stars populating these clusters have been used over the years to probe stellar evolution theory, to study variables (Cepheids and RRLyrae), to evaluate the mass function and luminosity function of main sequence (MS) stars, to quantify the occurrence of binaries, to analyze the integrated properties of young stellar populations, to investigate the cluster formation, evolution and dynamics, to constrain the history of LMC, and much more.

The LMC cluster NGC 1866 is the archetype of such a plenty of research work available just 'round the corner'. Here we present the results recently obtained by our group and an handful of indications from a work in progress.

Send offprint requests to: E. Brocato
Correspondence to: via M. Maggini s.n.c., I-64100 Teramo

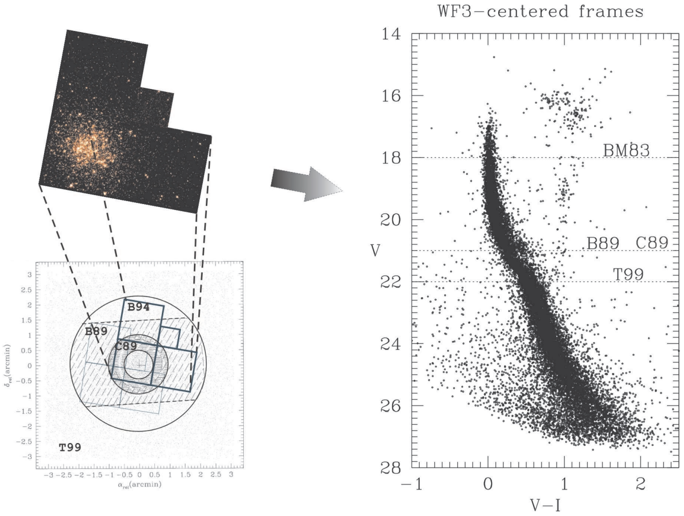

Fig. 1. The WF3 pointing of NGC 1866 is compared to fields of view of previous works (C89, B89, B94, T99). The correspondent CMD is also presented, the horizontal dotted lines show the magnitude limit of the ground based observations.

2. The CMD and the luminosity function of NGC1866

The observations obtained with ground-based telescopes provided precise color magnitude diagrams (CMD) [Becker & Mathews (1983), Chiosi et al. (1989), Brocato et al. (1989), Brocato et al. (1994), Testa et al. (1999)]. Unfortunately, the severe crowding in NGC 1866 prevented the measurement of a complete sample of stars located in the central region of the cluster. A dedicated project allowed HST observations and, thus, a CMD showing stars of nearly all the apparent extension of NGC 1866 is now available (Brocato et al. 2003). Fig. 1 shows the CMD as obtained with one pointing of the HST.

The analysis of the internal region discloses a number of interesting features. For example, we realized that the observed luminosity function (LF) of the MS stars is very well reproduced by simulations which imply a Salpeter mass distribution down to $V \sim$ 25mag. Another interesting information on the behavior of the LF as a function of the distance from the cluster center was found. The red giant massive stars are more concentrated in the very internal regions than low mass MS stars.

Since Becker & Mathews (1983), NGC 1866 has been widely studied to evaluate the efficiency of the overshooting process in stars with convective core [Brocato et al. (2003), Barmina et al. (2002) and references therein].

When stellar evolutionary models are compared to the observations, one finds that classical models - as computed with a recent version of the FRANEC code (Cassisi et al. 1999) - disclose a very good agreement. As a fine tuning of the models, the comparison suggests that the size of the convective core of intermediate mass stars as predicted by these FRANEC models is only **slightly** underestimated (see Fig. 2). From the comparison one may estimate that an overshooting efficiency of the order of $0.1 \times H_p$ may improve the fit. However, we recall that the overshooting mechanism is only one possible way of extending the size of convective cores and other uncertainties or modifications on the physical assumptions may be able of producing a similar effect.

3. Clues on the distance of NGC 1866 and its Cepheid population

NGC 1866 has been recently used to constrain the distance of the Large Magellanic Cloud

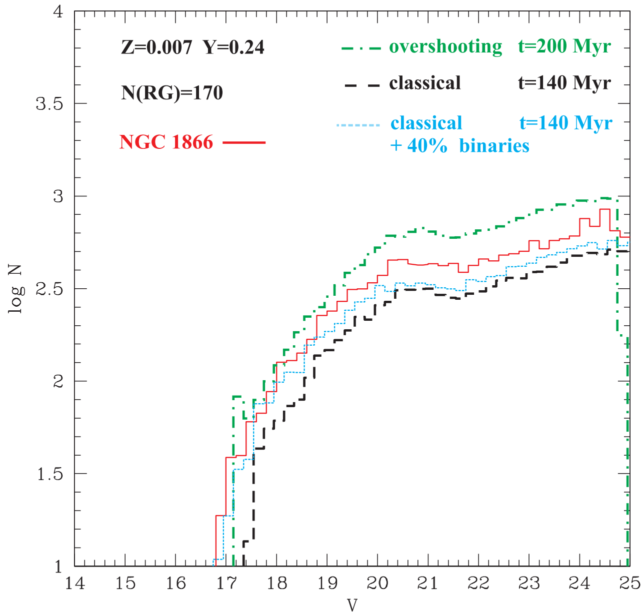

Fig. 2. The luminosity function of NGC 1866 is compared to the theoretical ones. Classical and overshooting models are computed with the same code but the last ones assume $0.25 \times H_P$.

(Walker et al. 2001), which is still a relevant and debated question because it has a remarkable impact on the determination of the extragalactic distance scale (Benedict et al. 2002).

The distance evaluation by Walker and collaborators has been obtained by using the MS-fitting method and provided a distance modulus of 18.35 ± 0.05 (1σ). The distance question has been further investigated by Salaris et al. (2003) who confirm the above result by using the local subdwarf sequence as reference MS. The same paper shows that the red clump method applied to the surrounding field stars gives a longer distance (18.53 ±0.07).

At this point one may recall that NGC 1866 is likely the star cluster with the largest Cepheid population known up to now (more than 20, e.g. Welch & Stetson 1993). Being Cepheids one of the most reliable distance indicators, several efforts have been performed to catch the distance of NGC 1866 by using its Cepheids (Gieren et al. 2000 and reference therein). Unfortunately, the crowding problems already experienced in studying the CMD also affected the precise definition of the light curves and properties of these stars.

By selecting Cepheids for which an high quality light curve is available from the literature, we find that their average magnitudes and colors are exactly located at the extreme blue side of the He burning loop as defined by the HST CMD and by our synthetic CMD (see Fig. 3).

This preliminary result is quite promising in view of: *i*) a new and possibly conclusive evaluation of the distance of this cluster (and of LMC); *ii*) an accurate evaluation of the red edge of the instability strip; *iii*) a statistically reliable comparison between the evolutionary mass and the pulsational one of the Cepheids in NGC 1866 (see also Bono & Marconi 1997).

What we would like to emphasize here is that NGC 1866 discloses the possibility of deriving its distance by using the two most reliable method (MS-fitting + Cepheids) on the same sample of stars. To this aim we used archive data to derive the location of 5 new Cepheid candidates. Furthermore, observing time to derive the light curves for the Cepheids

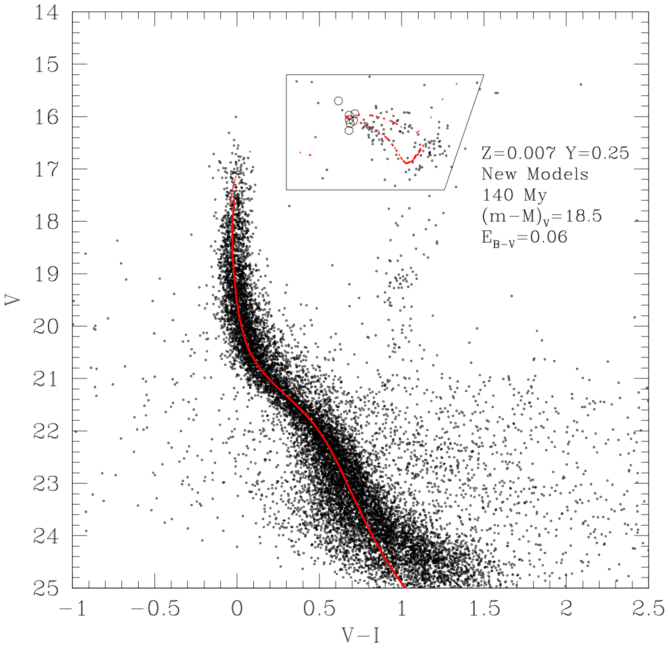

Fig. 3. The CMD of NGC 1866 is fitted by the synthetic one as computed with classical models for the labelled age and metallicity. Open circles represent the location of Cepheids as derived by Gieren et al (2000) data.

located in the crowded regions has been requested (VLT).

4. Conclusions

In spite of the 208 retrieved results that one may obtain from NASA Astrophysics Data System (ADS) in submitting a query on NGC 1866 as "object for selection", we conclude that this cluster still holds a number of relevant scientific information which deserve detailed observations and research work. Here, we emphasize the relevance of a complete and homogeneous work on the Cepheid population of this massive and unique LMC star cluster.

Acknowledgements. Part of this work was supported by INAF - P.R.I.N. 2002: "Stars and clusters as tracers of the LMC structure and evolution".

References

Barmina, R., Girardi, L., Chiosi, C. 2002, A&A, 385, 847
Benedict, G.F. et al. 2002 AJ 123, 473.
Bono, G. & Marconi M. 1997, MNRAS, 290, 353
Becker, S.A. & Mathews, G.J. 1983, ApJ, 270, 155 (BM83)
Brocato, E., Buonanno, R., Castellani, V., Walker, A. R. 1989, ApJS, 71, 25 (B89)
Brocato, E., Castellani, V., Piersimoni, A. M. 1994, A&A, 290, 59 (B94)
Brocato, E., Castellani, V., Di Carlo, E., Raimondo, G., Walker, A. R. 2003, AJ, 125, 3111
Cassisi, S. et al. 1999, A&AS, 134, 103
Chiosi, C., Bertelli, G., Meylan, G., Ortolani, S. 1989, A&AS, 78, 89 (C89)
Gieren, W. P., et al. 2000, ApJS, 129, 111
Testa V., Ferraro F.R., Chieffi A., et al. 1999, AJ, 118, 2839 (T99)
Salaris, M., Percival, S. M., Brocato, E., Raimondo, G., Walker 2003, ApJ, 588, 801
Walker A.R. et al. 2001, ApJ, 560, L139
Welch, D.L., & Stetson, P.B. 1993, AJ, 105, 1813