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Memorie della

Old Open Clusters

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Abstract. Open clusters are among the best tracers of the Galactic disk properties (ages, distances, metallicities, etc. and their evolution in space and time). In this framework, we are working on a long term programme dedicated to the study of old Open Clusters. We are analyzing photometric and spectroscopic data for a fair sample of Open Clusters, with the intent of determining in a precise and homogeneous way their distances, ages, reddenings, and detailed chemical abundances.

Key words. Galactic disk – Open Clusters – CM diagram – Chemical abundances

1. Introduction

Open clusters (OC's) are important for several reasons: i) they are very good tracers of the Galactic disk properties (e.g., they are among the very few disk objects for which precise distances and ages can be determined); ii) they provide information on how the Milky Way formed (e.g., old OC's define the first epoch of formation of the present thin disk); iii) they contribute to the understanding of Galactic chemical evolution (e.g., they define the radial abundance gradient now and in the past); iv) they are laboratories for stellar theory (e.g., they can be used to test evolutionary models for low and intermediate mass stars). For a recent, thorough review, see Friel (1995).

Despite all that, OC's have been relatively poorly studied up to now: there are more than 1200 objects in catalogues (Lynga 1987, Mermilliod 1995, Dias et al. 2002), but only a fraction have recent CCD studies. Among OC's we are particularly interested in the old ones (about 80 are presently known), since they provide information on the whole lifetime of the Galactic disk.

2. Our sample: photometry

Using parameters simply taken from literature may introduce spurious effects, since different techniques give very inhomogeneous results, spoiling even the relative ranking (see e.g., Twarog et al. 1997, Carraro et al. 1998).

Accuracy and homogeneity of treatment are pre-requisites to fully exploit the OC's to reconstruct the Galactic disk history, and we are working on that. We have begun several years ago to build a large sample of clusters covering the entire relevant position - age - metallicity range. We have collected CCD multiband photometric data for about 30 objects, using ESO and Italian telescopes. We have already published results for 9 of them

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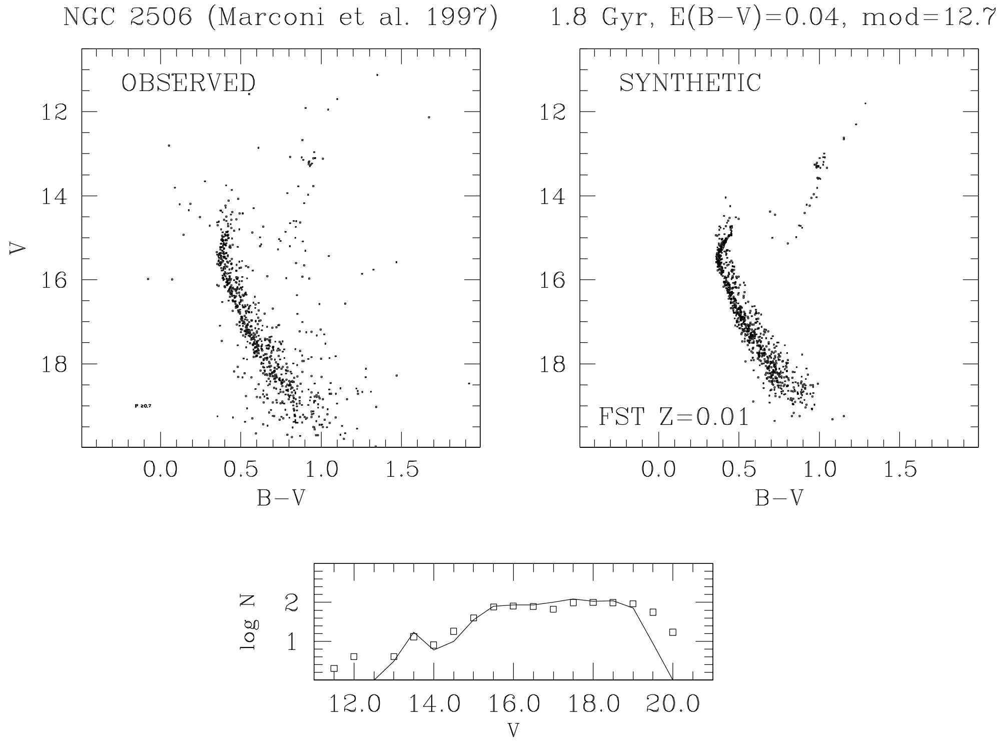

Fig. 1. Left panel: Observed CMD of NGC 2506. Right panel: synthetic CMD based on the FST evolutionary tracks by Ventura et al. (in prep.). Lower panel: observed (open circles) and synthetic (line) luminosity functions.

(for the most recent works see Bragaglia & Tosi 2003, Di Fabrizio et al. 2001 and references therein) and are presently analyzing a few more (e.g., NGC 6939: Andreuzzi et al., this conference).

We uniformly apply the technique of the synthetic colour magnitude diagrams (CMDs), developed by Tosi et al. (1991) and now largely adopted. Using evolutionary tracks of different authors and metallicities, we build synthetic CMDs with the same number of stars, photometric errors, and incompleteness factors of the observed ones, trying also to estimate the binary fraction. We then compare both CMD shapes and luminosity functions (see Fig. 1), and choose the best combination of age, distance, reddening and (approximate) metallicity for each model set. Since our results are based on various theoretical sets, we have a clear idea of the real uncertainties involved in parameters derivation. Generally, the best synthetic reproductions of the observed CMDs are obtained using models with overshooting.

This part of our study produces accurate distances (hence positions in the Galactic disk) and ages. We can therefore try to derive the radial Galactocentric metallicity gradient and its (possible) variation with time, important to choose among the existing chemical evolution scenarios. Fig. 2 illustrates this possibility, using information taken from Friel (1995). But one important ingredient is still missing: precise elemental abundances.

3. Our sample: spectroscopy

The optimal way to obtain precise and detailed chemical abundances is through high resolu-

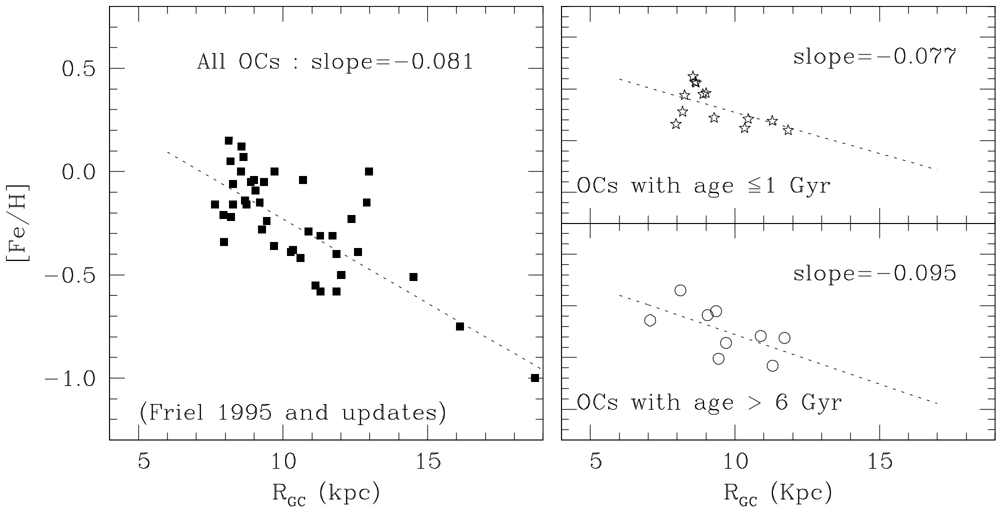

Fig. 2. Galactocentric radial abundance gradient, as derived from OC's. Left panel: if one takes all OC's in Friel (1995, and updates) regardless of their age, the indicated slope is found. Right panels: young and old OC's appear to define slightly different slopes.

tion spectroscopy. It's a time consuming and complex technique, but real progress in understanding our Galaxy requires the use of the most adequate means. Only about 30 OC's - 20 of which old - have ever been studied with high resolution spectroscopy (Gratton 2000). An even smaller number has detailed (i.e. other than [Fe/H]) elemental abundances, and here too the problem of homogeneous measurements exists.

We have recently begun to collect high resolution (R=30000-50000), high S/N (50-100) spectra for stars in old OC's, using FEROS@1.5m ESO, SARG@TNG, UVES@VLT. At the moment we have data for about 15 clusters, 11 of which have no previous metallicity determination: we will then be able to extend the existing sample by one third, and will produce homogenous metal abundances. First results have already been published in Carretta et al. (2000) and Bragaglia et al. (2001a,b). We are presently working to improve them by extensively using spectral synthesis, essential for such high metallicity, very crowded, spectra.

An important feature of our analysis is that not only abundances for OC's will be on a homogeneous scale, but they will be on the same scale of Globular Clusters and field stars, making any possible comparison really significant.

The immediate future for cluster star spectroscopy is represented by the new multifiber instrument FLAMES@VLT: high resolution spectra of more than 100 stars are acquired in one single shot. Some of the GTO time received by the Ital-FLAMES Consortium will be dedicated to OC's: it will be possible to observe both giant and main sequence stars in the same cluster, even for far OC's.

Finally, I want to mention another part of our study, only recently begun: membership determination through radial velocity measurements. In this case we have already obtained moderate resolution spectra of one cluster (Be 29, the most distant one) using the MOS facility of LRS@TNG, and have been able to separate true cluster members from field interlopers. More clusters, among which Be 17, one of the oldest, will follow. This information will be used both for choosing candidates for follow-up high resolution spectroscopy and for improving our photometric analysis, since we will be able to obtain "clean" CMDs, made only of sure cluster members.

4. Summary

From the photometric sample:

1- we derive accurate and homogeneous distances, ages, reddenings and (approximate) metallicities;

2- we study the radial abundance gradient (also by means of our new spectroscopic analysis), both at present time and in the past;

3- we test stellar evolutionary models.

From the spectroscopic sample:

1- we derive accurate abundances for Fe, α-elements and other key elements;

2- we put OC abundances on a homogeneous scale, the same of Globular Clusters and field stars;

3- we derive membership for cluster stars.

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