Searching for variable stars in Galactic Open Clusters

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Abstract. A long-term project, aiming at systematic search for variable stars in Galactic Open Clusters, was started at the Geneva Observatory in 2002. We have been observing regularly a sample of twenty-seven Galactic Open Clusters in the U, B, V Geneva filters. The goal is to identify and to study their variable stars, as well as the connection between the variable stars in a cluster and the cluster properties. We present the status of this work in progress, and show preliminary results for one of these clusters, IC 4651.

Keywords: clusters and associations; individual: IC 4651, stars: variable stars PACS: <Replace this text with PACS numbers; choose from this list: http://www.aip..org/pacs/index.html>

INTRODUCTION

All stars belonging to an Open Cluster (OC) are assumed to share the same age, chemical abundances, distance and reddening. The already listed 1200 OCs in the disk of our Galaxy (Lynga 1987; Dias et al. 2002) span a large interval in age and galactocentric distances: they have been used as an excellent tool to probe the structure and the evolution -both chemical and dynamical- of the Milky Way disk.

Stellar variability, whether due to intrinsic properties or geometrical effects, affects the light curve of stars at many phases of their evolution, with specific variability properties for each phase. This, together with the variety of variable star content from one cluster to another, provides independent measurements for the physical parameters of OCs. Yet, the connection between the types of variable found and the properties of the OC is not well know so far.

PROJECT

Long-term observations of a sample of twenty-seven Galactic OCs have been carried out in the U, B and V Geneva filters (see Cherix et al, 2006). Twelve OCs in the Southern Hemisphere have been observed with Euler-Cam, mounted on the 1.2m Euler Swiss Telescope at La Silla, Chile and fifteen OCs in the Northen Hemisphere OCs with Merope-Cam installed on the 1.2m Mercator Belgian telescope, in La Palma, Canary Islands, Spain. The field of view of the two cameras (Euler: $11.5' \times 11.5'$ '; Mercator: $6.5' \times 6.5'$) is centered on the cluster and contains cluster stars as well as Milky Way field stars.

The goal of the project is to map the whole variable star content in each cluster in our database. Our sam-

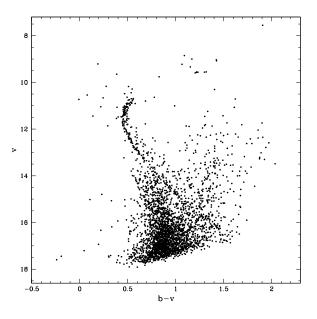


FIGURE 1. Color-Magnitude Diagram of IC 4651.

ple includes metal-poor (e.g. $\langle [Fe/H] \rangle = -0.52 \ dex$, NGC 2324) and metal-rich (e.g. $\langle [Fe/H] \rangle = 0.10 \ dex$, IC 4651) clusters, and spans from very young (e.g. log(age) = 7.160, NGC 3766) to older (e.g. log(age) = 9.325, NGC 7789) ages. In Table 1, we summarize some properties for the OCs included in this project. Literature data are taken from WEBDA, http://www.univie.ac.at/webda/presentation.html.

Data acquisition and data reduction are still in progress. For the Southern clusters we already collected more than 200 U, 200 B and 2000 V images on a time baseline of 7 years. A preliminary Color Magnitude

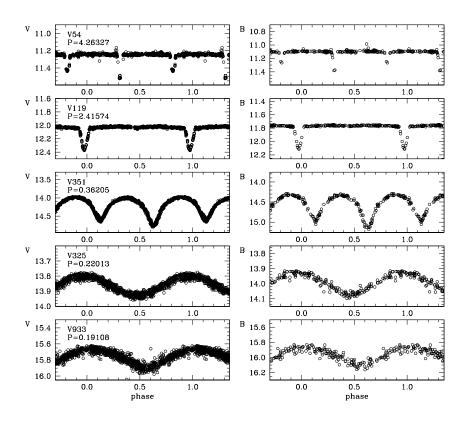


FIGURE 2. Folded light curves of some variable stars in the field of IC 4651. Periods are in days.

Diagram (CMD), not yet calibrated to any standard system, is shown in Fig.1 for the oldest cluster of our sample, IC 4651. Times series for Northern OCs include so far almost 1600 V image over a 5 year baseline.

DATA REDUCTION AND PRELIMINARY RESULTS

We developed a semi-automatic pipeline to prereduce and reduce all the images. Such a long time baseline includes a lot of changes in the performance of the telescope. To take these variations into account, the images have been reduced in groups according to the period of collection. In the prereduction process, great care has been devoted to the analysis of the flatfield images and the pre/over scan values in order to infer the best correction for each image. We perform PSF photometry with the DaophotII/Allstar (Stetson 1998, 1999) packages. For each image, we build a proper PSF, using at least one hundred selected stars chosen among the brightest and most isolated ones. All the reduced images are then aligned to a common reference list of stars in order to build the CMD and the time series for each star. Time series are then searched for objects showing variability. The time series of the candidate variables have been analyzed using two different codes. We used GrATis (Graphical Analyzer of Time Series; Di Fabrizio 1999; Clementini 2000) and Period04 (Lenz & Breger 2005). The first variable stars found so far have periods spanning from 0.19 to 53 days, including *bona fide* δ Scuti and binary stars. Several candidates show multi-periodic variability. In Fig. 2 we show folded light curves for some variable stars we identified.

CONCLUSIONS

Given the large time baseline, the project is well suited for long-term variability. An overall accuracy of a few mmag, plus the long time baseline, allows the identification of various kinds of variable stars, including small period and small amplitude ones. Preliminary analysis of the variable stars indeed confirms the potentialities of this project to identify variable stars and to use them to characterize the properties of OCs.

ACKNOWLEDGMENTS

We thank the Swiss National Science Foundation for the continuous support to this project.

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OpenCluster	RA	DEC	log(age)	$\langle {\rm [Fe/H]} \rangle^*$	Telescope
NGC 3766	11:36:14	-61:36:30	7.160	-	Euler
NGC 4103	12:06:40	-61:15:00	7.393	-	Euler
NGC 6755	19:07:49	+04:16:00	7.719	-	Mercator
NGC 7654	23:24:48	+61:35:36	7.764	-	Mercator
NGC 7039	21:10:48	+45:37:00	7.280	-	Mercator
NCG 5617 [†]	14:29:44	-60:42:42	7.915	-	Euler
NGC 6996	20:56:30	-54:13:06	8.000	-	Euler
NGC6067	16:13:11	-54.13:06	8.076	0.13	Euler
NGC3247	10:25:51	-57:55:24	8.083	-	Euler
NGC 2323	07:02:42	-08:23:00	8.096	0.02	Euler
NGC 1513	04:09:57	+49:30:54	8.110	-	Mercator
NGC 6705	18:51:05	-06:16:12	8.302	0.13	Mercator
NGC2437	07:41:46	-14:48:36	8.390	0.05	Euler
NGC3532	11:05:39	-58:45:12	8.492	-0.02	Euler
NGC 2194	06:13:45	+12:48:24	8.515	-	Mercator
NGC 1907	05:28:05	+35:19:30	8.567	-	Mercator
NGC2447	07:44:30	-23:51:24	8.588	0.03	Euler
NGC 2324	07:04:07	+01:02:42	8.630	-0.52	Mercator
NGC 1245	03:14:41	+47:14:12	8.704	0.10	Mercator
NGC 6811	19:37:17	+46:23:18	8.799	-	Mercator
NGC 1901**	05:18:15	-68:26:12	8.920	-	Euler
NGC 6134	16:27:46	-49:09:06	8.968	0.18	Euler
NGC 2420	07:38:23	+21:34:24	9.048	-0.26	Mercator
IC 4651	17:24:49	-49:56:00	9.057	0.10	Euler
NGC 7789	23:57:24	+56:42:30	9.235	-0.08	Mercator
NGC 6939	20:31:30	+60:39:42	9.346	0.02	Mercator
NGC 188	00:47:28	+85:15:18	9.632	-0.02	Mercator

TABLE 1. List of the twenty-seven OCs in the Geneva database. In bold, the eight clusters we have already reduced. References to previous work from the same database are in footnotes. Literature data are taken from WEBDA.

* dex † see Carrier 2009 ** see Cherix 2006