

# Looking 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 (OCs), 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 (hereafter  $U$ ,  $B$ ,  $V$ ). 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.** open clusters and associations: general, individual (IC 4651); stars: variable

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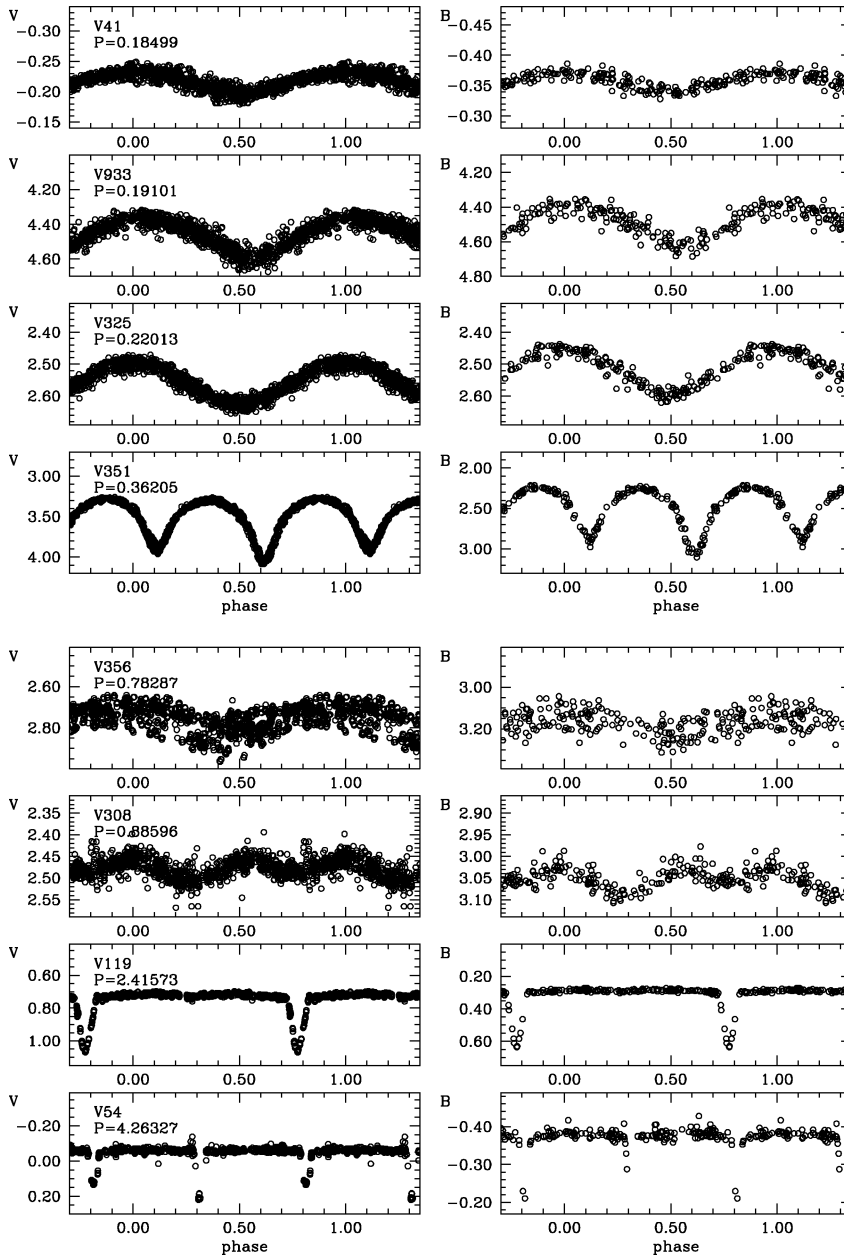
## 1. Introduction

Long-term observations of a sample of twenty-seven Galactic OCs have been carried out in  $U$ ,  $B$  and  $V$  (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 Northern 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. 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. In Table 1, we summarize some properties for the OCs included in this project, including coordinates, estimated age and metallicities. Time series for Northern OCs include so far almost 1600  $V$  image over a 5 year baseline.

The goal of the project is to map the whole variable star population in each cluster in our database. Stellar variability provides independent measurements for the physical parameters of OCs.

## 2. Data Reduction

We developed a semi-automatic pipeline to prereduce and reduce all the images. 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 Color Magnitude Diagram 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 studied using two different codes. We used GrATis (Graphical Analyzer of Time Series; Di Fabrizio 1999; Clementini 2000) and Period04 (Lenz & Breger 2005).



**Figure 1.** Differential magnitude folded light curves for the monoperiodic variable stars we identified in IC 4651. Periods are in days. Period of the variability increase from top to bottom.

The first open cluster to be analyzed has been IC 4651. IC 4651 is a quite old and metal rich open cluster. We found variable stars with periods spanning from 0.18 to more than 53 days, including *bona fide*  $\delta$  Scuti and binary stars. Several candidates show multi-periodic variability and variation of the period along the time series. In Fig. 1 we show differential magnitude folded light curves for the monoperiodic variable stars we identified.

**Table 1.** Basic information about the twenty-seven OCs in the Geneva database. In bold, the eight clusters we have already reduced. References to previous works from the same database are in footnotes. Literature data are taken from WEBDA.

Open Cluster	RA	DEC	log(age)	$\langle[\text{Fe}/\text{H}]\rangle$	Telescope
	(J2000)	(J2000)	(years)	(dex)	
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
NGC 5617 <sup>1</sup>	14 : 29 : 44	-60 : 42 : 42	7.915	—	Euler
NGC 6996	20 : 56 : 30	-54 : 13 : 06	8.000	—	Euler
<b>NGC6067</b>	16 : 13 : 11	-54.13 : 06	8.076	0.13	Euler
<b>NGC3247</b>	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
<b>NGC2437</b>	07 : 41 : 46	-14 : 48 : 36	8.390	0.05	Euler
<b>NGC3532</b>	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
<b>NGC2447</b>	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 <sup>2</sup>	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
<b>IC 4651</b>	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

Notes:

<sup>1</sup> see Carrier 2009

<sup>2</sup> see Cherix 2006

### 3. Conclusions

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. The analysis of the variable stars found in IC 4651 indeed confirms the potentialities of this project to identify variable stars and to use them to characterize the properties of OCs.

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