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Variable stars in the globular cluster NGC 2419

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Abstract. We have used DOLORES at the TNG to obtain B, V time series photometry of NGC 2419, one of the most distant and bright clusters in the Galactic halo. These data will be used to study its variable star population in order to check whether the cluster could be the relic of an extragalactic system accreted by the Milky Way. Using the Image Subtraction technique we have identified about 300 candidate variables, many of which are in the cluster central regions. Several of the variables appear to be RR Lyrae stars, but we detected variability also around the tip of the red giant branch, and in other regions of the colour-magnitude diagram. To improve the light curve sampling and to resolve variables in the cluster inner regions, the TNG data were combined with HST archive data. Preliminary results are presented on the light curves from the combined data set.

Key words. globular clusters: individual : NGC 2419- stars: variable: other -

1. Introduction

NGC 2419 is one of the most distant globular clusters (GCs) in the Milky Way ($R_{gc} \sim 90Kpc$), but is much more luminous than the other outer-halo Galactic GCs. In fact, with an absolute visual magnitude $M_V = -9.6$ mag (Harris 1996), NGC 2419 is among the five brightest clusters in the Galaxy. On the other hand, NGC 2419 cannot be considered an inner-halo cluster migrated out on an elliptical orbit, since its dynamical parameters (core radius: $r_c \sim 9pc$, and half-mass radius $r_h \sim 19pc$) are typical of an outer-halo cluster. According to the metallicity ([Fe/H] $\simeq -2.12$; Harris 1996) and the horizontal branch (HB) morphology, well populated from the red to the blue, NGC 2419 belongs to the most metal-poor group of known Galactic GCs. Harris et al. (1997) found that NGC 2419 and M 92 have the same age within 1 Gyr.

Previous studies on the variable star content in NGC 2419 date back to the work by Pinto & Rosino (1977) who collected photographic plates and performed "by eye" photometry. They discovered a modest population of variable stars (24 *ab*-, 6 *c*-type RR Lyrae

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stars and one type II Cepheid) in the cluster external regions. The average period of the *ab*-type RR Lyrae ($\langle P_{ab} \rangle = 0.654\ d$) qualifies NGC 2419 as an Oosterhoff type II (Oosterhoff 1939) cluster.

2. Our project: preliminary results

We have undertaken a new study of the variable star population of NGC 2419 based on accurate, deep, and high spatial resolution CCD photometry covering the entire cluster. B, V time-series photometry has been obtained with DOLORES at the TNG. The large field of view of DOLORES ($9.2' \times 9.2'$) allowed us to observe on a single shot all the known cluster RR Lyrae stars and the large majority of the light from NGC 2419.

Variable stars have been identified using the Image Subtraction technique provided by the package ISIS 2.1 (Alard 2000).

We found 283 candidate variables.

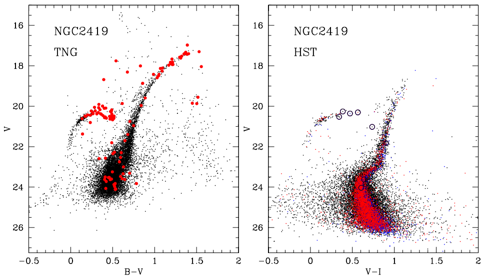

Fig. 1. Calibrated colour-magnitude diagrams of NGC 2419, using TNG (left panel) and HST-WFPC2 data (right panel).

To extend our study deeper inside in the cluster centre, and to obtain a better definition of the periods and light curves, the TNG data are being complemented with HST-WFPC2 F555W(V), F814W(I) and INT archive data. Homogeneous photometric reductions of the entire TNG+HST+INT data set are being performed with DAOPHOT-ALLSTAR-ALLFRAME (Stetson 1994, 1996). The left panel of Figure 1 shows the colour-magnitude diagram (CMD) of NGC 2419 from the TNG data. Candidate variables are marked by large filled circles (in magenta in the electronic edition of the journal). The cluster CMD from the HST-WFPC2 data is shown in the right panel of Figure 1. Finally, in Figure 2 we provide examples of light curves for variable stars we detected in NGC 2419. Our goals are to unveil the complete variable star population of NGC 2419 and fully characterize its pulsation properties, namely: light curves, periods, luminosities, amplitudes, etc. The comparison of both pulsation and evolutionary properties of NGC 2419 with those of Galactic Oosterhoff type II clusters and dwarf galaxies in the Local Group will provide hints on the nature of this cluster by investigating the possibility that this cluster could be the relic of the interaction of a vanished dwarf spheroidal galaxy and the Milky Way.

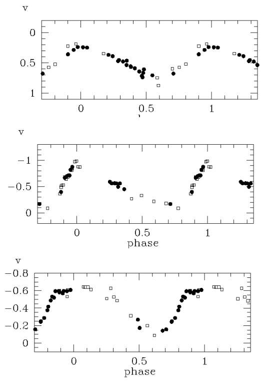

Fig. 2. Examples of light curves for a *c*-, an *ab*-type RR Lyrae star and a binary system in NGC 2419. Filled and open symbols are the TNG and the HST-WFPC2 data, respectively.

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