Mem. S.A.It. Vol. 79, 686

Memorie della

RR Lyrae stars in M31 globular clusters: B514

R. Contreras[1], L. Federici[1], G. Clementini[1], C. Cacciari[1], R. Merighi[1], K. Kinemuchi[2], M. Catelan[3], F. Fusi Pecci[1], M. Marconi[4], B. Pritzl[5], and H. Smith[6]

[1] Istituto Nazionale di Astrofisica–Osservatorio Astronomico di Bologna, Via Ranzani 1, I-40127 Bologna, Italy, e-mail: `rodrigo.contreras@oabo.inaf.it`
[2] Department of Physics and Astronomy, University of Wyoming, Laramie, WY 82071.
[3] Departamento de Astronomía y Astrofísica, Pontificia Universidad Católica de Chile, Av. Vicuña Mackenna 4860, 782-0436 Macul, Santiago, Chile
[4] Istituto Nazionale di Astrofisica–Osservatorio Astronomico di Capodimonte, via Moiariello 16, 80131 Napoli, Italy
[5] Macalester College, 1600 Grand Avenue, Saint Paul, MN 55105, USA
[6] Department of Physics and Astronomy, Michigan State University, East Lansing, MI 48824-2320, USA

Abstract. We present preliminary results of a variable star search in the metal-poor globular cluster B514 of the Andromeda galaxy (M31), based on Hubble Space Telescope Wide Field Planetary Camera 2 and Advanced Camera for Surveys observations. A large number of RR Lyrae stars have been identified for the first time in a globular cluster of M31. The average period of the RR Lyrae variables ($\langle Pab \rangle$ = 0.58 days and $\langle Pc \rangle$ = 0.35 days, for fundamental-mode and first-overtone pulsators, respectively) and the position in the period-amplitude diagram both suggest that B514 is likely an Oosterhoff I cluster, contrary to the general behaviour of the metal-poor globular clusters in the Milky Way, which show instead Oosterhoff type II pulsation properties.

Key words. Stars: variables: RR Lyrae – globular clusters: Individual (B514) – Galaxies: individual (M31) – Galaxy: globular clusters

1. Introduction

The Andromeda galaxy provides us with a unique opportunity to study the formation and evolution of a massive spiral galaxy other than the Milky Way (MW). van den Bergh (2000, 2006) suggested that M31 originated as an early merger of two or more massive metal-rich progenitors accounting for the galaxy wide range in metallicity (Durrell, Harris & Pritchet 2001) and age (Brown et al. 2003) compared to the MW.

The pulsation properties of the variable stars in the field and globular clusters (GCs) of M31 have the potential to provide essential insights on the galaxy formation and to trace the merging episodes that led to the galaxy assembling. The RR Lyrae stars, in particular, belonging to the old stellar population (t > 10 Gyr), were eyewitnesses to the first epochs of star formation in M31. Their mean periods along with the metallicities of the parent clus-

Send offprint requests to: R. Contreras ters can provide an independent estimate of the M31 cluster ages and, in turn, of the time scale of the M31 halo formation, by comparison with their MW counterparts.

In the MW all GCs which contain significant numbers of RR Lyrae stars sharply divide into two very distinct classes, the Oosterhoff types (Oosterhoff 1939), according to the mean pulsation periods of their RR Lyrae variables. Oosterhoff type I (OoI) GCs have $\langle Pab \rangle \simeq 0.56$ days, Oosterhoff type II clusters (OoII) have $\langle Pab \rangle \simeq 0.66$ days (Clement et al. 2001). This phenomenon is referred to as Oosterhoff dichotomy (Oosterhoff 1939). There is evidence that OoI and OoII clusters in the MW may have different kinematical and spatial distributions thus possibly resulting from different accretion or formation events in the halo. This is supported also by a difference in mean chemical abundance (OoII clusters being on average more metal-poor than OoI clusters) and possibly by a difference in age (metal-poor clusters being on average slightly older than the intermediate-metallicity ones), as suggested by van den Bergh (1993) and De Angeli et al. (2005). Whatever the mechanism, it is clear that the Oosterhoff dichotomy reflects conditions within the MW halo at the time of GC formation. The existence or absence of the Oosterhoff phenomenon among the M31 GCs therefore provides information on the halo formation processes and thus on the chemical/dynamical evolution history of the dominant galaxy of the Local Group. As part of an HST program (PI G. Clementini) we have observed GCs in M31 to study their variable star population. Here we present preliminary results for B514, a globular cluster located at a projected distance of ~ 55 Kpc from the M31 center, not far from the galaxy major axis (Galleti et al. 2005). The color magnitude diagram (CMD) indicates that B514 is a classical, old metal-poor globular cluster, with a metallicity [Fe/H] ~ −1.8 (Galleti et al. 2006). The integrated absolute magnitude M_V has been estimated of ~ −9.1 mag, and classifies the cluster among the brightest globulars of M31. Moreover, the half-light radius of ~ 5.4 pc is significantly larger than for other clusters of the same luminosity (Federici et al. 2007).

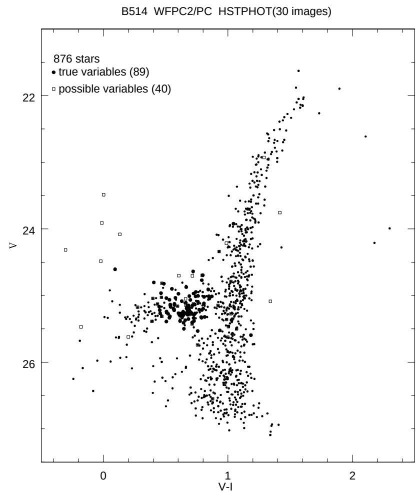

Fig. 1. B514 CMD, based on our HSTPHOT reduction of 30 WFPC2 images. Bona-fide RR Lyrae stars are indicated by filled circles and variable star candidates by open squares

2. Observational data and variable search results

Time series F606W, F814W observations of B514 were obtained with WFPC2@HST in June 2007 and combined with ACS/WFC archive data, for a total of 21 phase-points in each band. Data reduction was performed on the individual pre-reduced images using HSTPHOT and Dolphot/ACSPHOT photometry packages (Dolphin 2000). Variable star candidates were identified with VARFIND (custom software developed at the Bologna Observatory by P. Montegriffo). Periods and type classification were derived from the study of the light curves using GRATIS (custom software, by P. Montegriffo). Our B514 variable star sample includes 89 bona-fide RR Lyrae stars and 40 candidate variables for which we still lack a classification. The position of the variables on the cluster CMD is shown in Fig.1. In Fig.2 we show examples of the calibrated V and I light curves for two fundamental mode (RRab) and two first-overtone (RRc) RR Lyrae stars, respectively.

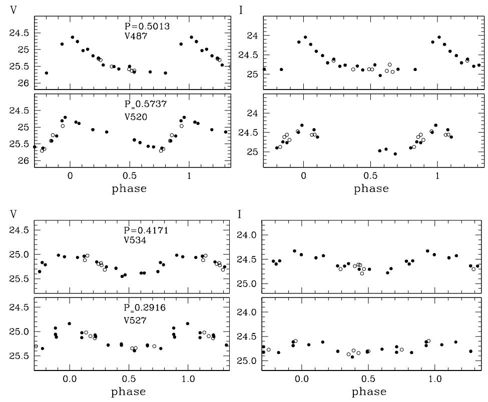

Fig. 2. *V*, *I* light curves for RRab (top panels) and RRc (lower panels) variables identified in our survey. Filled and open circles indicate WFPC2 and ACS data, respectively.

3. Discussion and conclusions

The mean periods of the confirmed 89 RR Lyrae stars in B514 are $\langle Pab \rangle$=0.58 days and $\langle Pc \rangle$ = 0.35 days for fundamental mode and first-overtone variables, respectively, suggesting a possible dominance of Oosterhoff type I.

The lower panel of Fig.3 shows the *V* band period-amplitude diagram of the B514 RR Lyrae stars plotted along with the Oosterhoff loci of the MW GCs by Clement & Rowe (2000) and Cacciari et al. (2005). The RR Lyrae stars in B514 are mostly found near the OoI relation, as also shown by the period histogram in the upper panel of Fig. 3. In conclusion, these preliminary results seem to show that B514 is a somewhat borderline OoI cluster. Thus it seems to follow a different rule than what is found in the MW, where metal-poor ([Fe/H]$\lesssim -1.7$) GCs containing RR Lyrae stars have Oosterhoff II type. However this indication is just preliminary and needs further study to be confirmed.

Acknowledgements. We warmly thank the Program Coordinator A. Roman, and the Contact Scientist M. Sirianni, of our HST program for their invaluable help with the Phase II and scheduling of the HST observations. This research was partially supported by MIUR under the scientific project 2004020323.

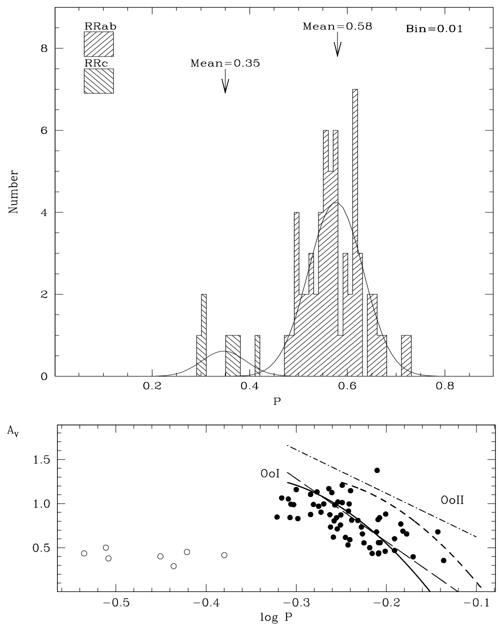

Fig. 3. *Upper panel:* Period histogram for the confirmed RR Lyrae stars in B514. *Lower panel:* Period-Amplitude diagram in the *V* band. RRab variables are shown by filled circles, RRc stars by open circles.

References

Brown, T.M., et al. 2003, ApJ, 592, L17
Cacciari, C., et al. 2005, AJ, 129, 267
Clement, C., et al. 2001, AJ, 122, 2587
Clement, C., & Rowe, J. 2000, AJ, 120, 2579
De Angeli, F., et al. 2005, AJ, 130, 116
Dolphin, A. E. 2000, PASP, 112, 1383
Durrell, P.R., Harris, W., & Pritchet, C.I. 2001, AJ, 121, 2557
Federici, L., et al. 2007, A&A, 473, 429
Galleti, S., et al. 2005, A&A, 436, 535
Galleti, S., et al. 2006 ApJ, 650, L107
Oosterhoff, P.Th. 1939, Observatory, 62, 104
van den Bergh, S. 1993, MNRAS, 262, 588
van den Bergh, S. 2000, The Galaxies of the Local Group (Cambridge: Cambridge Univ. Press)
van den Bergh, S. 2006, History of the Local Group in *The Local Group as an Astrophysical Laboratory*, ed. M. Livio et al., (Cambridge:Cambridge Univ. Press),p.1