Mem. S.A.It. Vol. 79, 701

Memorie della

Stellar populations of the newly discovered satellites of the Milky Way

M. Dall'Ora[1], G. Clementini[2], V. Ripepi[1], K. Kinemuchi[3], C. Greco[2,8], C. Kuehn[4], I. Musella[1], C. T. Rodgers[3], L. Di Fabrizio[5], T. C. Beers[4,6], M. Catelan[7], M. Marconi[1], B. J. Pritzl[9], and H. A. Smith[4].

[1] INAF – Osservatorio Astronomico di Capodimonte, Via Moiariello 16, I-80131 Napoli, Italy, e-mail: dallora@oacn.inaf.it
[2] INAF – Osservatorio Astronomico di Bologna, Italy
[3] University of Wyoming, Department of Physics and Astronomy, USA, Universidad de Concepcion, Departamento de Fisica, Chile, and University of Florida, Department of Astronomy, USA
[4] Department of Physics and Astronomy, Michigan State University, USA
[5] INAF – Fundacion Galileo Galilei, La Palma, Spain
[6] Joint Institute for Nuclear Astrophysics, Michigan State University, USA
[7] Pontificia Universidad Católica de Chile, Departamento de Astronomía y Astrofísica
[8] Observatoire de Geneve, Sauverny, Switzerland
[9] Department of Physics and Astronomy, University of Wisconsin Oshkosh, USA

Abstract. We have carried out an extensive observing campaign on the new dwarf spheroidal galaxies (dSphs) recently discovered by the SDSS, with the aim of characterizing their stellar populations and structural properties, as well as their variable star content. First preliminary results are presented for the Canes Venatici II, the Coma and the Ursa Major II dSphs, based on data collected at a variety of telescopes, and reaching each galaxy's Main Sequence Turn-Off (MSTO).

Key words. galaxies: dwarf - galaxies: stellar content - galaxies: individual (Canes Venatici II) - galaxies: individual (Coma) -galaxies: individual (Ursa Major II)

1. Introduction

In the λ-CDM hierarchical scenario of galaxies' formation, dSphs are usually seen as the possible "building blocks" of larger galaxies, such as the Milky Way (MW). In this framework, the MW Halo stellar population should show properties that are homogeneous with those of the MW dSph satellites (e.g. Grebel 2005). However, the ten known MW dSph satellites have stellar populations that show differences from the MW Halo stars, both in the chemistry (e.g. Beers et al. 2005) and in the properties of their variable stars (e.g. Catelan 2004, 2005). Moreover, their number is too small when compared with the predictions of the λ-CDM simulations (the so-called "missing satellites" problem, e.g. Moore et al. 1999). Very recently, on the basis of the SDSS

Send offprint requests to: M. Dall'Ora

data, several new MW dwarf satellites were discovered (e.g. Belokurov et al. 2007). These objects show very low effective surface brightnesses, making them much fainter than the previously known Local Group dSphs, and have unusual properties intermediate between those of globular clusters (GCs) and dSphs with old, metal-poor stellar populations. Our group is undertaking an extensive observational campaign, with the aim of characterizing their stellar populations and structural properties, as well as their variable stars content. These goals are pursued by comparing the observed Color-Magnitude Diagrams (CMD) with the predictions of the theory, and by analyzing the spatial distribution of the stellar populations. For each galaxy, time-series data are collected in order to search for variable stars, which are then used as tracers of the host stellar populations. Photometry has been performed following a homogeneous procedure, based on the ALLFRAME strategy (Stetson 1994). Here we present preliminary results for the Canes Venatici II (CVn II), the Coma, and the Ursa Major II (UMa II) dSphs, based on data collected with several telescopes, ranging from the 1.5 m to 4.2 m size, and reaching each galaxy's MSTO. Our results on the Bootes I and the Canes Venatici I dSphs were already published in Dall'Ora et al. (2006) and in Kuehn et al. (2007).

2. Current results

Coma. Deep Subaru data of this galaxy (Belokurov et al. 2007) disclose an irregular and extended shape, and the typical CMD of a single, old stellar population with metallicity [Fe/H] ~ -2. New deep time-series data were collected in the B, V, I bands at the WIRO 2.3 m and the Loiano 1.5 m telescopes. In the upper panel of Fig. 1 we show the galaxy $V-(B-V)$ CMDs. In the lower panel we show the spatial distributions of the Coma dSph stars, obtained by gaussian smoothing the *xy* plot of the measured sources. We confirm the strongly elongated shape of Coma. Moreover, the map seems to suggest a strong tidal stripping of the galaxy, and this hypothesis is also supported by the presence of a fundamental-mode RR Lyrae star (RRab), along the galaxy minor-axis, but well outside its main body.

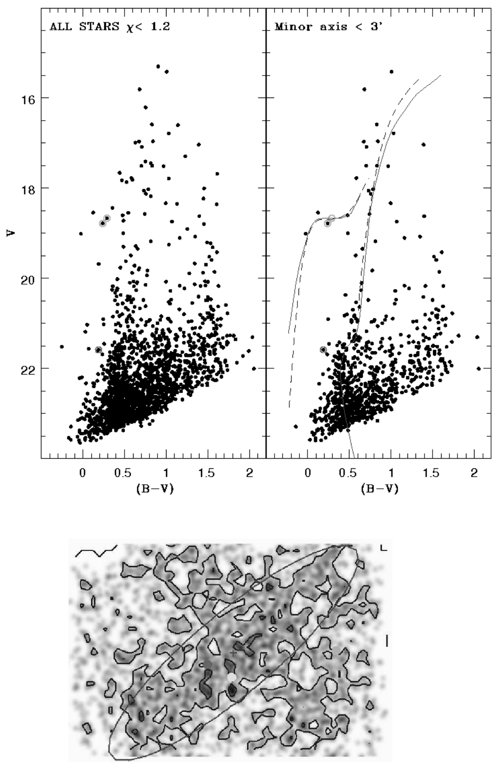

Fig. 1. *Upper Panels*: $V-(B-V)$ CMDs of the Coma dSph, over the whole body of the galaxy (left), and along the galaxy minor axis (right). Solid and dashed lines mark the ridge lines of the Galactic GCs M3 and M15, respectively, corrected for the distance and the reddening of Coma. Circled points mark the three detected variable stars (two RR Lyrae and one SX Phoenicis star). *Lower Panel*: spatial density map of the Coma dSph stars.

Canes Venatici II. Discovered by Belokurov et al. (2007), this galaxy has a very low metal abundance ([Fe/H] ~ -2.31, Simon & Geha 2007). The galaxy central density contours are circular (Belokurov et al. 2007), but there is evidence for a possible Southern extension. Data for CVn II were collected at the WHT 4.2 m and the WIRO telescopes in the B, V, I bands. The periods

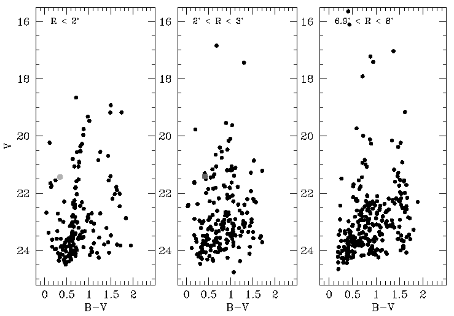

Fig. 2. $V-(B-V)$ CMDs of CVn II, obtained in three annuli located at increasing distance from the galaxy center.

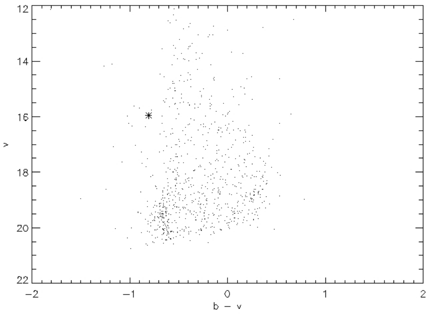

Fig. 3. Uncalibrated $v-(b-v)$ CMD of UMaII dSph.

of the two RR Lyrae found so far (0.75 days for the RRab star and 0.36 days for the first overtone – RRc – star) seem to suggest an Oosterhoff II system. Fig. 2 shows the galaxy $V-(B-V)$ CMDs with increasing the distance from the galaxy center.

Ursa Major II. Originally discovered by Grillmair (2006), it was recognized as a dSph by Zucker et al. (2006) on the basis of deep Subaru data. It could be the progenitor of the so-called "Orphan Stream" (Fellhauer et al. 2007). Our data for UMa II were collected at the Lowell 1.8 m, the WIRO, and the Loiano telescopes, in the B, V, I bands. The instrumental $v-(b-v)$ CMD (Fig. 3) shows a poorly populated Horizontal Branch and strong contamination by foreground stars. The CMD also shows the only bona-fide RR Lyrae variable confirmed so far. The data analysis, still in progress, will address the age and spatial distribution of the UMa II stars, as well as the properties of its 6 candidate variable stars.

3. Conclusions

A homogeneous analysis of our whole dataset remains to be done, but we can draw some general conclusions. First, with the exception of CVn I (Kuehn et al. 2007), the observed galaxies are generally characterized by a single old population. Second, all the galaxies analyzed so far host some RR Lyrae stars, typical of old (> 10 Gyr) populations, and have a period distribution compatible with Oosterhoff II or Oosterhoff-intermediate systems. However, up to now only for Bootes I (Dall'Ora et al. 2006; Siegel 2006) and for CVn I (Kuehn et al. 2007) do we have enough variables to draw firm conclusions about this point. Finally, the spatial distributions of the stars are generally elongated or distorted, suggesting the presence of strong tidal interactions with the Milky Way.

References

Beers, T. C., et al. 2005, From Lithium to Uranium: Elemental Tracers of Early Cosmic Evolution, 228, 175

Belokurov, V., et al. 2007, ApJ, 654, 897

Catelan, M. 2004, IAU Colloq. 193: Variable Stars in the Local Group, 310, 113

Catelan, M. 2005, ArXiv Astrophysics e-prints, arXiv:astro-ph/0507464

Dall'Ora, M., et al. 2006, ApJ, 653, L109

Fellhauer, M., et al. 2007, MNRAS, 375, 1171

Grebel, E. K. 2005, IAU Colloq. 198: Near-fields cosmology with dwarf elliptical galaxies, 1

Grillmair, C. J. 2006, ApJ, 645, L37

Kuehn, C., et al. 2007, ArXiv e-prints, 709, arXiv:0709.3281

Moore, B., Ghigna, S., Governato, F., Lake, G., Quinn, T., Stadel, J., & Tozzi, P. 1999, ApJ, 524, L19

Simon, J. D., & Geha, M. 2007, ApJ, 670, 313

Siegel, M. H. 2006, ApJ, 649, L83

Stetson, P. B. 1994, PASP, 106, 250

Zucker, D. B., et al. 2006, ApJ, 650, L41