Star formation history of the Carina dwarf galaxy (preliminary results)

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1 Introduction

A series of about 60 B, V exposures centered on the Carina dwarf galaxy were collected, by sampling each band every 9 minutes (over three consecutive nights), by two of us (E.B. and V.C.) with the WFI ($28' \times 28'$) at the ESO-MPI 2.2 m. The Carina dwarf galaxy belongs to the Local Group, and was discovered in 1977 on UK Schmidt plates (Cannon, Hawarden & Tritton 1977).

The main aim of this project is to supply a detailed analysis of both static and variable stars (RR Lyrae, Anomalous Cepheids) in a complex stellar system. In fact, we know that Carina experienced at least three main star formation episodes, at about 15, 7 and 3 Gyr from the present, with the 7 Gyr episode which yielded at least 50 % of its population (Hurley-Keller, Mateo & Nemec 1988). Recent spectroscopic measurements suggest a mean metallicity of [Fe/H] $= -1.99 \pm 0.08$ (Smeker-Hane et al. 1999).

In the following, we present some preliminary results of our investigation.

2 The color-magnitude diagram

Figure 1 shows the *instrumental* color-magnitude diagram based on the data collected during *one* of the three nights of observation (we coadded 21 frames per chip, reaching about 10,000 sec of exposure for each band). An average number of about 40,000 stars were detected.

Data plotted in Figure 1 show that our photometry seems to be complete roughly two magnitudes below the turn-off. The sub giant (SG) branch region clearly discloses the age difference between the different stellar populations in Carina. The occurrence of a clear split between the SG branches suggests that the star formation episodes were followed by long periods of quiescence as suggested by Hurley-Keller et al. (1988). As a whole, we find that the star formation history (SFH) of Carina resembles much more the "episodic" SFH of the Fornax dwarf galaxy (Buonanno et al. 1999) than the "almost-continue" SFH of the Leo I dwarf galaxy (Caputo et al. 1999) As far as HB stars is concerned, we confirm the occurrence of two distinct HBs (Smecker-Hane et al. 1994), a blue one, typical of the old, metal-poor Galactic globular clusters, and a red clump, cooler and brighter than old HB stars, typical of intermediate age stellar population. A close inspection of the Red Giant Branch shows evidence of a sequence of stars running bluer than the most populated branch, which would suggest a mix between intermediate age red giant stars and old low mass

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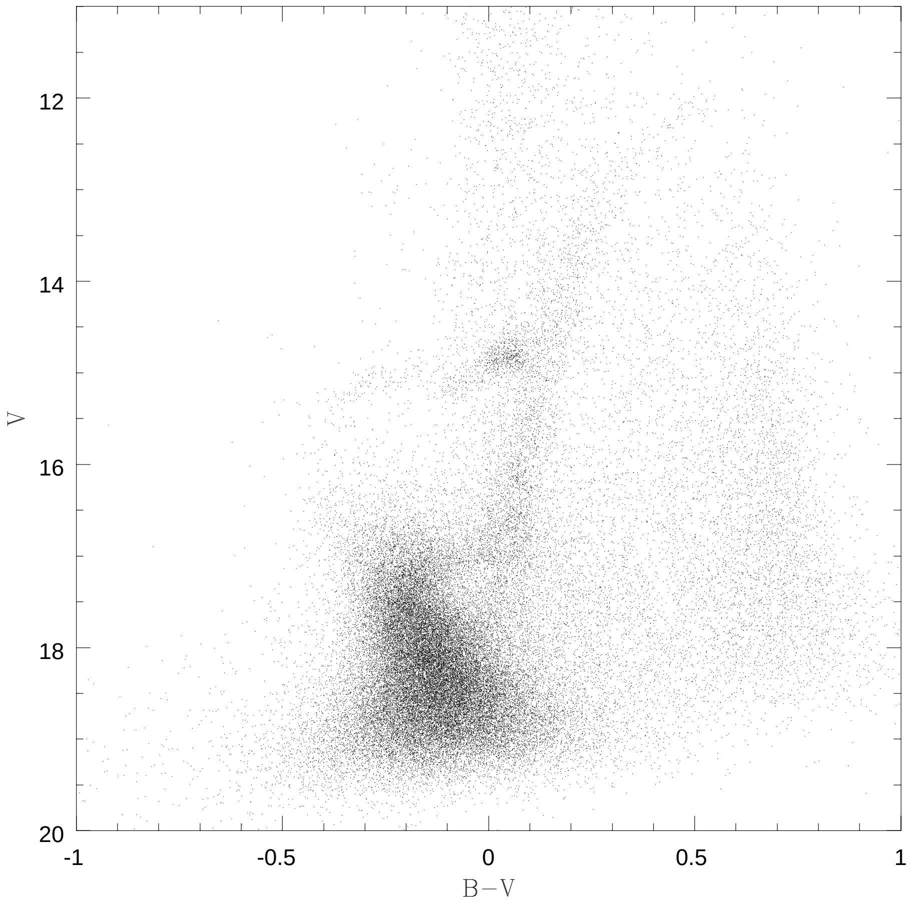

Figure 1: The instrumental color-magnitude diagram of Carina dwarf galaxy

Asymptotic Giant Branch stars (see also Smecker-Hane et al. 1994). We also find background Galactic stars with colors redder than (B-V)=0.

3 Radial distribution of the HB stellar components

Figure 2 shows the comparison of the isodensity contours of the Carina galaxy (thin lines) with old (left panel) and intermediate age (right panel) HB stars (thick lines) . We adopted the two distinct types of HB stars to trace the spatial distribution of young and old stellar populations. The three levels refer to 20%, 40% and 80% of the central maximum density respectively. Note that the covered field is about 30' wide.

This figure discloses the evidence that *old and intermediate age HB stars present substantially different spatial distributions.* This finding confirms preliminary results (Smecker-Hane et al. 1994) obtained on the basis of a smaller stellar sample. The offset in the maximum of the density map relative to the red HB-clump is located about 7.5' south from the center of the Carina galaxy, along its major semiaxis. On the other hand, one can note that the *old HB population traces closely the overall morphology of the galaxy.*

In order to quantify the difference in the spatial distribution of HB stars we performed a Kolmogorov-Smirnov test. We found that the old metal-poor HB stars present the same spatial

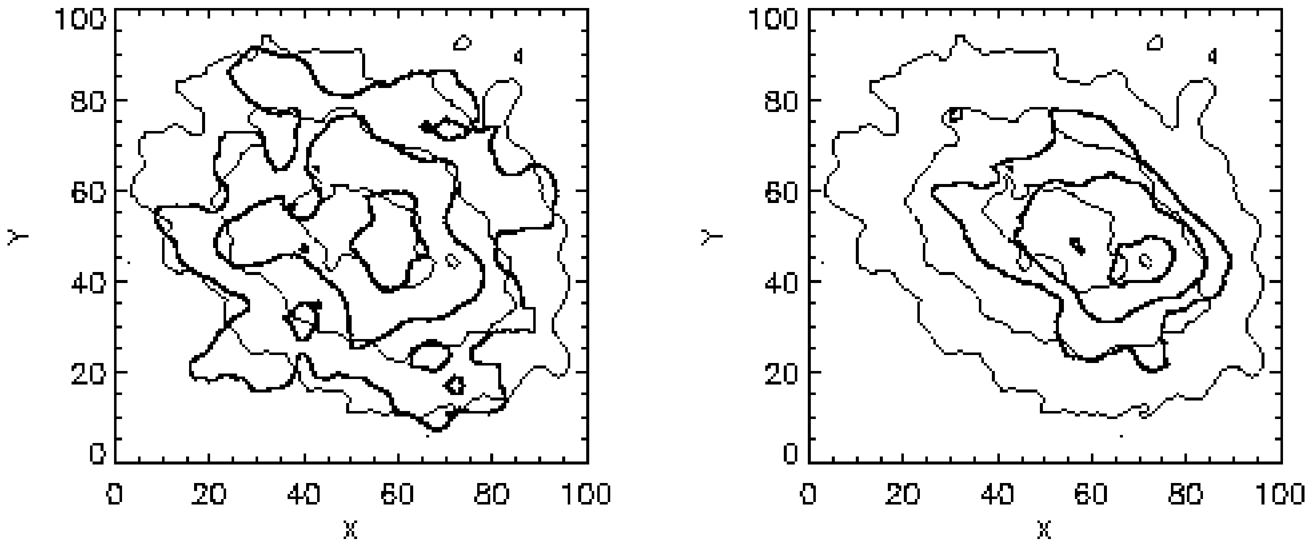

Figure 2: Left panel: isodensity contours of the old, metal poor HB stellar component (thick lines) superimposed to those ones of the galaxy; Right panel: The same as the left one, but the thick lines refer to the red clump HB stars.

distribution of the Red Giant stars (probability of 93 %). The application of the same test to *old HB* and *Red Clump stars* suggests that the spatial distribution of these stars are significantly different (probability 1 %).

On the basis of these preliminary results we can drive the following conclusions:

(1) old and intermediate age stellar populations in Carina present substantially different spatial distributions; **(2)** at variance with the bulk of dwarf galaxies in the Local Group, the intermediate age stellar population is *not* centrally concentrated.

4 Pulsational properties

Together with the study of Carina CMD, one of the main goals of our investigation is to study the pulsation properties of variable stars. Thanks to the observing strategy we adopted, we plan to address the following scientific problems:

(a) to supply a detailed search of *double mode* RR Lyrae (i.e., radial variables which are simultaneously pulsating in both fundamental and first-overtone modes). The detection of these objects is crucial to provide an independent estimate of both mass and luminosity (Bono et al. 1996); **(b)** to provide a complete census of RR Lyrae stars , and in turn, to map their spatial distribution; **(c)** to measure the spread in apparent magnitude of RR Lyrae and therefore to constrain the occurrence of a spread in the metallicity distribution of the old stellar population; **(d)** to derive a precise distance estimate by adopting the Period-Mv diagram (Caputo et al. 2000) of c type RR Lyrae (first overtone variables) ; **(e)** to constrain the mass of RR-Lyrae variables by adopting the *Bailey diagram*, i.e. period vs. pulsation amplitude (Bono et al. 1987)

As a template, Figure 3 shows B and V light curves for one of the "new" RR-Lyrae stars we found in our field of Carina. Data plotted in this figure show that the light curves are well sampled, not only along the decreasing branch but also on the rising branch. This feature will allow us to derive accurate estimates of both mean magnitude and colors of the entire RR Lyrae sample. Even

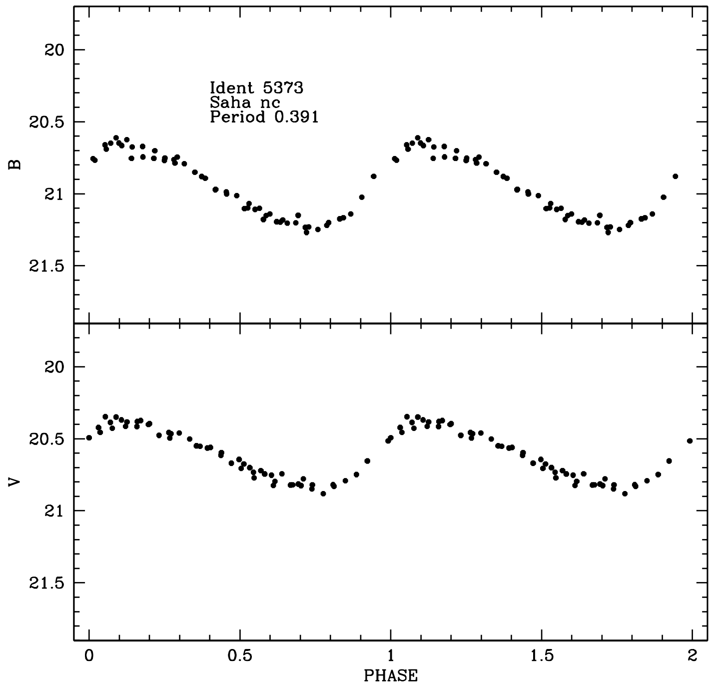

Figure 3: B and V curves of a "new" RR Lyrae star in Carina. The labels in the top panel show our identification ('Saha nc' means 'not classified' by Saha et al. 1986) as well as the pulsational period.

though the search for variable stars has been performed only on a small area, preliminary results suggest that the sample of RR Lyrae originally detected by Saha, Monet & Seitzer (1986) can be substantially increased.

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