The Star Formation History in NGC 1705

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Abstract

We present our results on the star formation history in the Blue Compact Dwarf Galaxy NGC 1705 obtained comparing synthetic colour-magnitude diagrams (CMD) with HST optical and near-infrared photometry.

1 Introduction

Determining the star formation history (SFH) in irregular galaxies is important to understand some issues connected with galaxy formation and evolution at high redshifts. First of all, their low level of evolution, in terms of low metallicity and high gas content, makes them very similar to primeval galaxies, thus useful tools to get information about primordial galaxy conditions and Big-Bang nucleosynthesis products. Among the Irregulars, the Blue Compact Dwarf galaxies have been suggested to be the local candidates for the faint blue galaxy population seen at high redshifts. In order to study in details the contribution of these systems to the faint blue galaxy excess, it is important to infer their SFH over a large look-back time. The analysis of CMDs, where stars are distributed depending on their evolutionary phase, represents the most direct way to derive strict constraints on the SFH.

2 The method of synthetic colour-magnitude diagrams

In order to infer the SFH in the Blue Compact Dwarf Galaxy NGC 1705 we produced synthetic CMDs making use of a Monte Carlo simulation code (Tosi et al. 1991; Greggio et al. 1998) based on homogeneous sets of stellar evolutionary models. In particular we adopted the Padova tracks at two metallicities, $Z = 0.004$ and $Z = 0.0004$ (Fagotto et al. 1994a, b): the first value corresponds to the metallicity derived from HII regions spectroscopy (Storchi-Bergmann, Calzetti, Kinney 1994), while we used the lower metallicity tracks to reproduce the first episodes of SF, probably occured in a very low metal content enviroment.

In order to derive constraints on the SF process and on the IMF, we compared the performed simulations with the observed optical and near-infrared CMDs (F555W, F814W, F110W and F160W bands) for a central region of the galaxy around the super star cluster (SSC). The reference data consist only of the 1822 objects photometred in both NIC2 and PC bands by Sabbi et al. (2001): in this way we can be sure that all the objects populating our diagrams are real stars, and not blends or spurious detections. The data are shown in Fig.1, alone and superimposed to the Padova stellar tracks.

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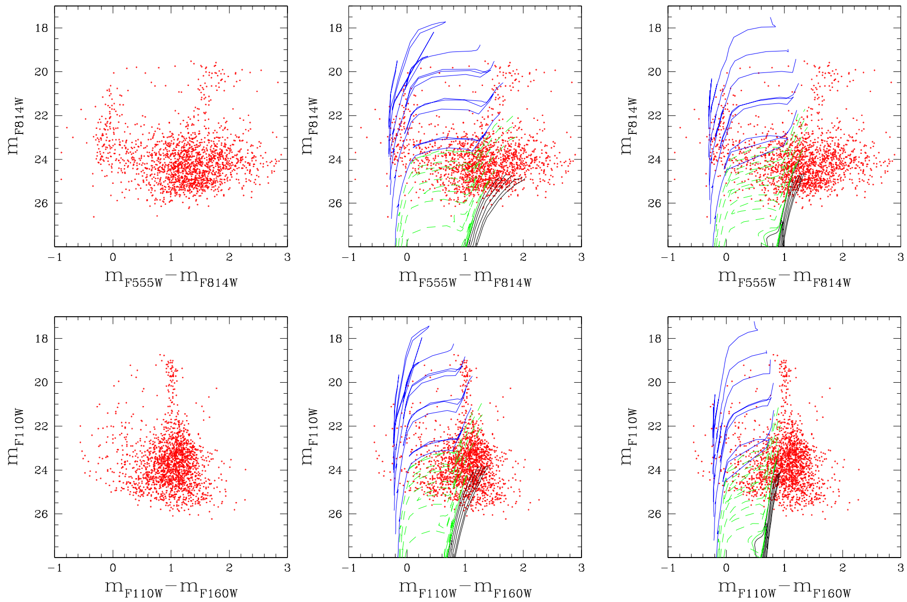

Figure 1: Top: optical CMDs for the 1822 stars photometred in both NIC2 and PC bands (left), with Padova tracks at $Z = 0.004$ (centre) and with the tracks at $Z = 0.0004$ (right). Bottom: the same for near-infrared diagrams. At the brightest magnitudes, the tracks with continuous line correspond to high masses stars ($6\ M_\odot \leq M \leq 120\ M_\odot$), dashes are for intermediate masses stars ($1.9\ M_\odot \leq M \leq 6\ M_\odot$), continuous lines at the faintes magnitudes are for low masses stars ($M \leq 1.8\ M_\odot$).

In each simulation a SFH is modelled: the starting epoch, the duration of the SF episode, the SF law (constant or exponentially decreasing) and the IMF slope are free parameters. The number of stars populating each synthetic diagram must be equal to the observed one. Both the continuous star formation case and the bursting scenario have been tested.

The models that best reproduce the observations, in terms of main features of the diagrams and LFs, provide constraints on the SFH parameters, as the number of SF episodes, their starting epochs and their durations, the star formation rates (SFRs), the IMF.

We ran simulations testing both flat ($\alpha = 1.8$) and steep ($\alpha = 2.6$) IMF (where Salpeter's slope is 2.35), constant and decreasing SF law, continuous and episodic SF processes.

The method can provide significant results if all the observational biases are correctly taken into account. We estimated the photometric error distributions, the blend probability and the completeness factors performing appropriate tests with artificial stars. Then we reproduced the observational uncertainty in the simulations, in order to compare the synthetic diagrams directly with the observed ones.

Anyway, it will be worth to model the diagrams also considering different sets of tracks to have an estimate of the theoretical uncertanity.

3 Simulations

We present only some synthetic CMDs obtained in the case of $\alpha = 1.8$ (steeper IMFs seem to be in less agreement with the observations).

In the left panels of Fig.2 the case of a single episode of constant SF started 15 Gyr ago is presented. It is clear, both from the distribution of the stars in the diagrams and from the comparison between the observed and synthetic LFs, that such a scenario can't reproduce the observational data.

Also one single very young burst occurred from 10 to 15 Myr ago (right panels of Fig. 2), in which all the observed 1882 stars are simulated, is in disagreement with the empirical CMDs. This single episode of SF is not able to reproduce the less massive and oldest population observed in the left panels of Fig.1.

The best results, obtained adopting an IMF slope $\alpha = 1.8$, are shown in Fig.3 . Here the synthetic diagrams result from the simulation of different episodes of star formation. The scenario we propose is:

- (10-15) Myr, with SFR= $3 \cdot 10^{-2}$ $M_\odot$ yr^{-1}, corresponding to 0.125 $M_\odot$ yr^{-1} kpc^{-2};
- (0-50) Myr, with SFR= $3 \cdot 10^{-3}$ $M_\odot$ yr^{-1}, corresponding to 0.012 $M_\odot$ yr^{-1} kpc^{-2};
- (50-1000) Myr, with SFR= $2 \cdot 10^{-2}$ $M_\odot$ yr^{-1}, corresponding to 0.083 $M_\odot$ yr^{-1} kpc^{-2};
- (1-15) Gyr, SFR $\sim 10^{-2}$ $M_\odot$, corresponding to 0.04 $M_\odot$ yr^{-1} kpc^{-2}.

The oldest population has been modelled adopting two different metallicities: we used the tracks at $Z = 0.004$ to simulate the SF occured in the range (1-8) Gyr ago, and the tracks of very low metallicity ($Z = 0.0004$) for the episode (8-15) Gyr ago. As different distributions of the same number of stars between the two oldest episodes produce no relevant differences in the obtained synthetic CMDs (as the simulations in the left and right panels of Fig. 3 show) we can just infer an average SFR for the SF during the first 14 Gyr. We plan to run new simulations accounting for the photometric error in a more accurate way, in order to derive further constraints on the SF process at the first epochs.

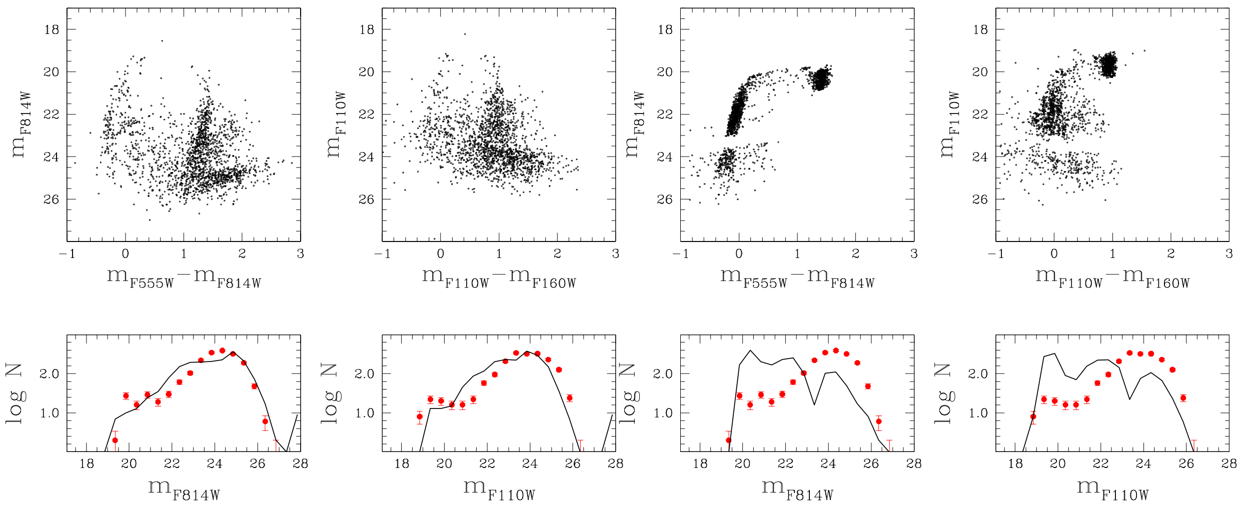

Figure 2: Left panels: synthetic CMDs and LFs obtained with Padova tracks at $Z = 0.004$ in the case of a single episode of constant SF activity, started 15 Gyr ago and still ongoing. The adopted IMF slope is $\alpha = 1.8$. The resulting SFR is $\simeq 10^{-2}$ $M_\odot$ yr^{-1}. Right panels: synthetic CMDs and LFs obtained simulating the 1822 observed stars in one single young burst occurred from 15 to 10 Myr ago. $\alpha = 1.8$. The resulting SFR is equal to $\sim 6 \cdot 10^{-1}$ $M_\odot$ yr^{-1}.

4 Results on the SFH and IMF

From the simulations performed so far we can summarize some preliminary conclusions:

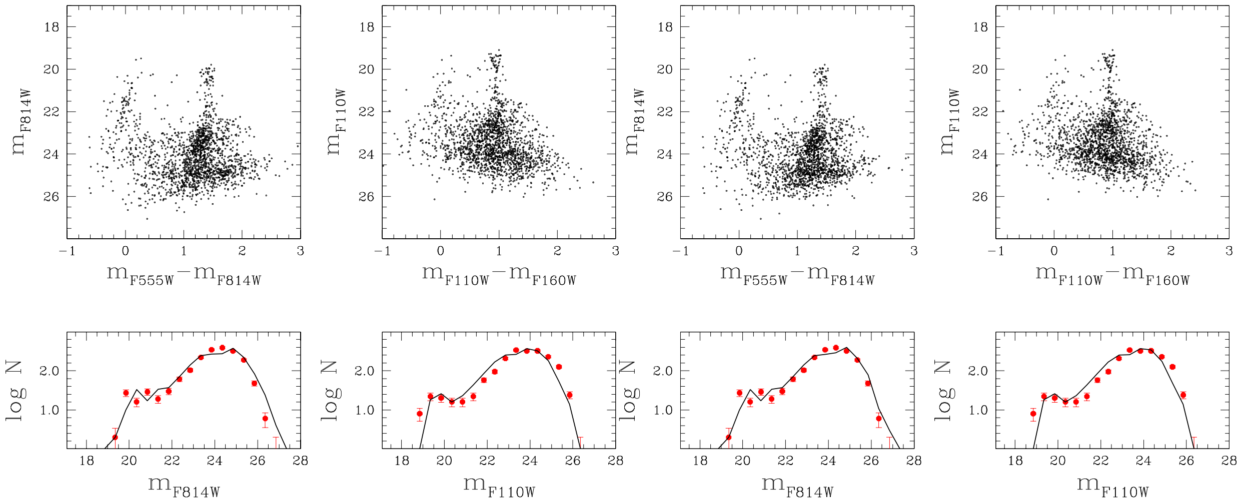

Figure 3: The best agreement with observation is achieved modelling more than one single episode of SF. The three youngest episodes simulated are: – (10-15) Myr, SFR $\simeq 3 \cdot 10^{-2}$ $M_\odot$ yr^{-1} – (0-50) Myr, SFR $\simeq 3 \cdot 10^{-3}$ $M_\odot$ yr^{-1} – (50-1000) Myr, SFR $\simeq 2 \cdot 10^{-2}$ $M_\odot$ yr^{-1}. Instead, the two oldest episodes have been reproduced with different distributions of the total number of red giants. Left panels: – (1-8) Gyr, SFR $\simeq 10^{-2}$ $M_\odot$ yr^{-1} – (8-15) Gyr, ($Z = 0.0004$), SFR $\simeq 10^{-2}$ $M_\odot$ yr^{-1}. Right panels: – (1-8) Gyr, SFR $\simeq 6 \cdot 10^{-3}$ $M_\odot$ yr^{-1} – (8-15) Gyr, ($Z = 0.0004$), SFR $\simeq 3 \cdot 10^{-2}$ $M_\odot$ yr^{-1}.

- Together with the signes of a recent SF activity, the blue compact galaxy NGC 1705 shows also the presence of a stellar population $10 \div 15$ Gyr old. It means that the SF activity started at the earliest epochs and is still ongoing.
- The scenario of a single episode from the oldest epochs to now doesn't reproduce well our observations. The best agreement with the data is achieved simulating different episodes of SF, where periods of significant activity are separated by more quiescent phases.
- The synthetic diagrams favour an IMF slope rather flat, since the simulations that best reproduce the observations adopt $\alpha = 1.8$.

References

Fagotto, F., Bressan, A., Bertelli, G., Chiosi, C. 1994, A&A, 105, 29
Fagotto, F., Bressan, A., Bertelli, G., Chiosi, C. 1994, A&A, 104, 365
Origlia, L., Leitherer, C. 2000, AJ 119, 2018
Greggio, L., Tosi, M., Clampin, M., De Marchi, G., Leitherer, C., Nota, A., Sirianni, M. 1998, ApJ 504, 725
Tosi, M., Greggio, L., Marconi, G., Focardi, P. 1991, AJ 102, 951
Sabbi, E., Aloisi, A., Bellazzini, M., Greggio, L., Leitherer, C., Montegriffo, P., Tosi, M. 2001, this volume
Storchi-Bergmann, T., Calzetti, D., Kinney, A. 1994, ApJ 429, 572