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Star formation in blue compact dwarf Galaxies

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Abstract. Blue compact dwarf galaxies (BCDGs) are dwarfs undergoing current burst of star formation (SF). In our work, we determine the ages of the underlying old stellar population to be ∼ 4 Gyr that is dominating the mass of the galaxy, underlying the current burst of SF. An intermediate population of ∼ 500 Myr which dominates the stellar light from the galaxy is also detected. The burst of SF at the present epoch spans ∼ 10 Myr as estimated from various age estimators like Hα, diagnostic diagrams and colour-colour diagrams. BCDGs undergo a burst of SF for a longer duration (of about a few 100 Myr to a Gyr) followed by a short/long quiescence. The amount of column density of localized neutral hydrogen required for the current burst to occur seems to be 10^{21} cm^{-2}. This could be the threshold required for SF. Radio continuum emission reveals that the emission is coincident with the star forming regions. The star formation rates (SFR) estimated from Hα match well with the SFR estimated using non-thermal radio emission for individual star forming regions, but are ∼ 6 – 7 times less as compared to the SFR calculated from far-IR (FIR) emission.

Keywords : star forming regions; spectrum of star forming regions; Hα photometry; general - galaxies: dwarfs, blue compact dwarf galaxies, galaxies: stellar content

1. Introduction

Blue compact dwarf galaxies (BCDGs) are low luminosity, compact systems, spectroscopically characterized by a faint, blue optical continuum accompanied in most cases, by intense emission lines. UV spectra of these galaxies show a continuum steeply rising towards blue. BCDGs undergo a few or several bursts of SF followed

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by a longer quiescent period and what we are seeing as a BCDG is an intense young burst of SF in an older galaxy. Here we study the SF and star formation histories (SFHs) of a few BCDGs.

2. Observations and data reduction

Optical *UBVRI* and Hα imaging of 11 BCDGs and spectroscopy of the bright star forming regions in 11 BCDGs are obtained with 2m Himalayan Chandra Telescope using Himalayan Faint Object Spectrograph Camera (HFOSC). Radio continuum observations at 610 MHz and neutral H I line observations are obtained for 5 BCDGs from Giant Meterwave Radio Telescope (GMRT).

3. Results

3.1 Spectroscopy of the bright knots

The spectra of bright star forming knots or the central knots of BCDGs are shown in the Fig.1 (left panel). The oxygen lines are used for calculating gas phase abundances; these spread over wide range, log(O/H) + 12 = 7.9-8.5, implying these galaxies not to be metal-poor systems. Solar oxygen abundance is assumed to be 8.66. The median value of oxygen abundance of these BCDGs is around 8.4. The diagnostic diagram of [1] (refer right panel of Fig.1) is employed to estimate the ages and metallicity of these star forming regions. Ages of the young burst in star forming regions of these BCDGs lie in the range 1-4 Myr.

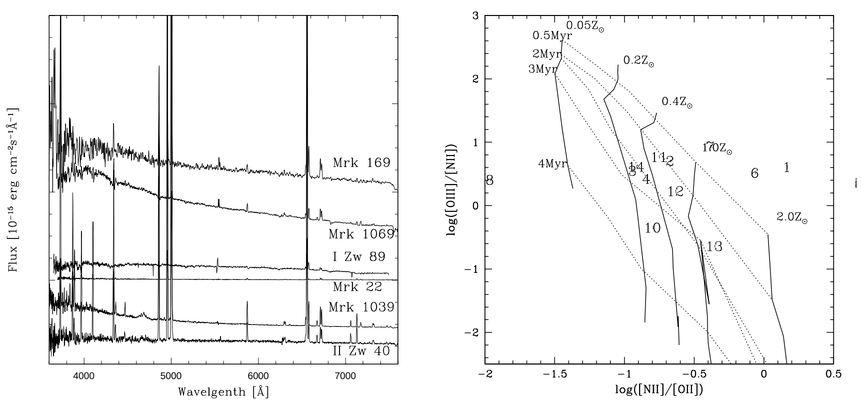


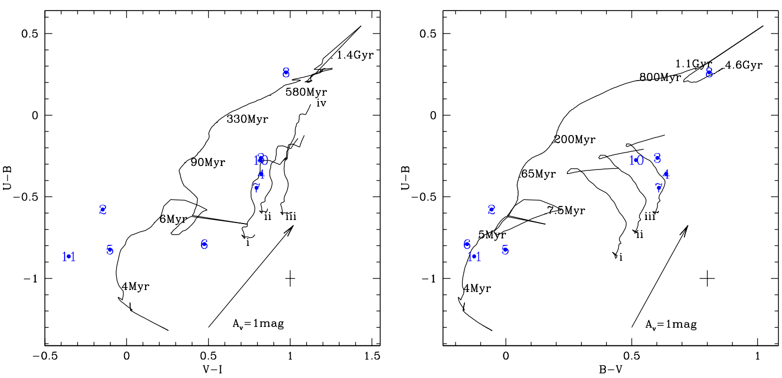
Figure 1. (Left) Spectroscopy of the bright star forming regions of BCDGs. (Right) Diagnostic Diagram of log($\frac{[OIII]}{[NII]}$) vs log($\frac{[NII]}{[OII]}$) for 11 star forming knots in BCDGs are also shown.

3.2 Hα studies

The star formation rate (SFR) calculated for individual star forming knots using Hα images are in the range 0.001-0.8 $M_\odot yr^{-1}$, and for the entire galaxy SFR is $\sim 0.1 - 1.0$ $M_\odot yr^{-1}$. Total number of O stars giving rise to observed Hα luminosity is estimated to be a 100-1000 stars. The ages of the young bursts obtained from Hα equivalent width (Eqw) are between 3-14 Myr, unlike 1-4 Myr calculated from the diagnostic diagram. The sizes of these ionized regions as measured from Hα is $0.3 - 2.5$ kpc and ionized gas masses vary in the range $0.1 - 20$ $M_\odot$.

3.3 UBVRI broad band photometry

Fig. 2 shows the colour-colour diagram of 11 BCDGs. The colours plotted are integrated colours of the BCDGs. Solid curves in Fig. 2(a) and (b) represent Starburst99 evolutionary model tracks for instantaneous starburst with Salpeter IMF and metallicity $Z = 0.008$. The colours of these galaxies are much redder than the Starburst99 evolutionary model tracks. The small curves in $(U - B)$ vs $(V - I)$ plot (left panel) and $(U - B)$ vs $(B - V)$ plot (right panel) in Fig.2 are obtained after mixing young population of age between 2-9 Myr + intermediate population of age 200-900 Myr + an old population of age $\sim$ 4 Gyr (Ramya, Sahu, Prabhu 2009). These populations are mixed at various fractions f, where $f_1 = 0.2 - 0.5\%$ is the fraction of young to



$U - B$ vs. $V - I$ $\quad$ $U - B$ vs. $B - V$

Figure 2. (a) colour-colour diagrams of 14 BCDGs. Solid curves represent Starburst99 evolutionary tracks. (b) Long curves are Starburst99 single population models; the short curves are based on mixed population. The short curves are created by mixing younger 2-9 Myr + intermediate 200-900 Myr + 4 Gyr population. It is noticed that most of the galaxies show a mixture of population. Four galaxies, namely, Mrk 1039 (numbered as 3) , Mrk 303(5), and UM 167(9) show a dominant population of 5-7 Myr only, while II Zw 82(1) is aged in the range 800 Myr to 2.7 Gyr.

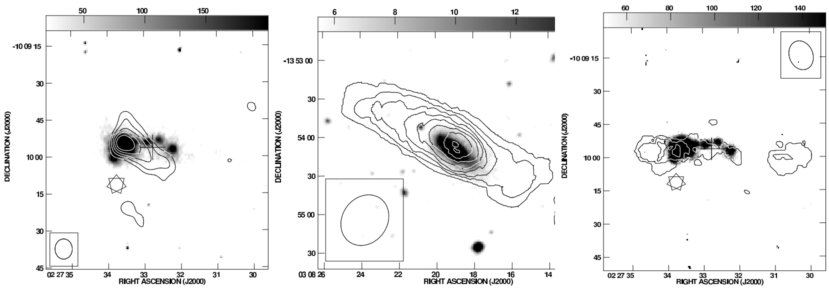


Figure 3. The radio continuum 610 MHz (left figure) emission superposed on the optical grayscale Hα image of BCDG Mrk 1039. The non-thermal emission is coincident with the brightest star forming region of the galaxy. Centre figure shows the low resolution ($\sim 40''$) H I map superposed over optical grayscale *B* band image of Mrk 1069. The extent of H I emission is about 6 times the optical size of the galaxy. Right figure displays the high resolution H I emission of Mrk 1039 coincident with the grayscale Hα image.

old population and $f_2 = 0.5 - 5\%$ is the fraction of intermediate to old population. BCDGs that fall into this region are Mrk 900(numbered as 3), Mrk 908(4), Haro 20(7) and UM 005(10). The three galaxies Mrk 1039 (numbered as 3), Mrk 303(5), and UM 167(9) show a dominant population of $5 - 7$ Myr only, while II Zw 82(1) could be a clear case of post-starburst galaxy with age in the range $0.8 - 2.7$ Gyr.

3.4 Radio continuum and H I emission

Multifrequency radio continuum and 21cm H I (Fig.3) observations of five BCDs reveal interesting aspects of SF as seen from the radio wavebands. The radio continuum emission from Mrk 1039 (Fig.3), Mrk 1069 and I Zw 97 (relatively isolated galaxies) is confined to massive H II regions. This indicates that the SF has recently been triggered. Star formation rate (SFR) calculated from 610 MHz emission is in the range 0.01-0.1 $M_\odot$ yr^{-1}; this is similar to the SFR estimated from optical Hα imaging but is about 6 times less when compared to the SFR estimated from FIR (Ramya, Kantharia & Prabhu 2011).

4. Conclusion

An attempt has been made to constrain various kinds of dominant population in the BCDGs using the mixed population model. The fraction of old and intermediate population is seen to be higher in most of the galaxies when compared to young stars. We have used the diagnostic diagrams to obtain the ages of these star forming regions. A difference in the ages of young bursts, estimated using Hα Eq. (3-14 Myr) and diagnostic diagram (1-4 Myr), is noticed suggesting that the current episode of SF spans a time of $\sim$ 10 Myr. The radio continuum emission is coincident with the bright H II regions indicating that the non-thermal emission which we are sampling is from the supernovae that occurred in star forming regions. The 21cm H I observations of the observed BCDs show atomic gas extending as much as 1.1-6 times the optical size; the threshold for burst of SF to occur seems to be $\sim 10^{21}$ cm^{-2} as revealed by high resolution H I maps. Star formation in BCDGs occurs in the form of bursts that last for a longer duration of time (about a few 100 Myr to a Gyr), occuring at various locations in the galaxy followed by a short/long quiescence.

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