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OXYGEN ABUNDANCES IN LOW SURFACE-BRIGHTNESS GALAXIES*

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INTRODUCTION

Recent theories[1,2] predict that some protogalaxies, in low-density environments of the field, are contracting and interacting so slowly that global star formation can be delayed until today. These systems should be gas rich and have low surface-brightness. Blue compact galaxies (BCGs), and other compact HII region galaxies currently experiencing a burst of star formation, are good candidates of truly young galaxies (in the sense that global star formation recently has been initiated). If they really are young, they ought to have a recent phase when their brightness was much lower than in the bursting phase. No claims of observations of such proto-BCGs exist. Observations of galaxies in their juvenile phases would undoubtedly be of great interest, e.g. the determination of the primordial helium abundance would improve. A proper place to search for young nearby galaxies could be among blue low surface-brightness galaxies (BLSBGs) in the local field.

The study of low surface-brightness galaxies (LSBGs) as a group began relatively recently. They are galaxies with extraordinary properties both as individuals[e.g.3,4] and as a group[e.g.5]. A few years ago we started an optical study of a sample of BLSBGs[6] (the sample galaxies have B-R < 0.5; typical B-R for normal E-Sdm types range from 1.7-0.9[7]) selected from the ESO/Uppsala catalogue. Here I report results of spectroscopic observations obtained on a subsample - 8 galaxies - of our selection. The HII region oxygen chemical abundances and its relation to the blue absolute magnitude and surface-brightness is investigated.

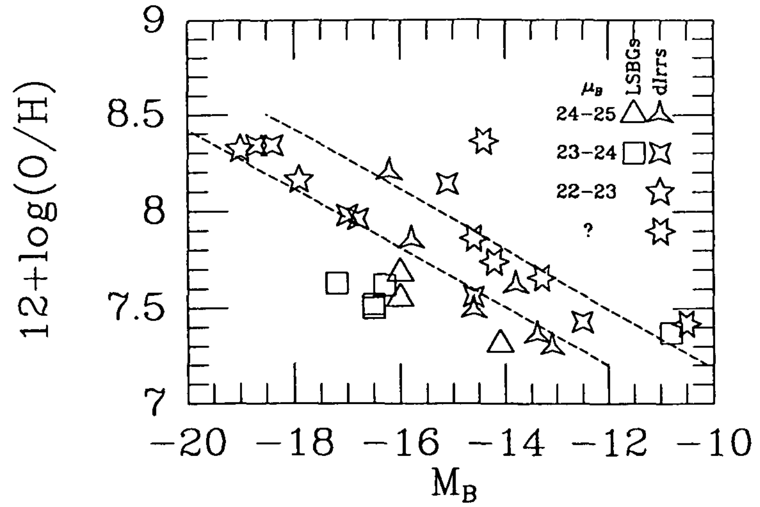

Figure 1. Absolute blue magnitude (M_B) - oxygen abundance (12+log(O/H)) plot, for nearby dwarf irregulars[11] (stars) and our data (triangles and squares). The uncertainties are 0.3-0.4 mag. at constant 12+log(O/H) and 0.2-0.3 dex at constant M_B. The dashed lines corresponds to the 1σ deviations of the nearby dwarf sample. Different symbols indicate the mean surface-brightness in mag. arcsec^{-2} (μ_B; the average surface-brightness inside the 25 mag. arcsec^{-2} B isophote).

OBSERVATIONS

We have obtained EFOSC spectra of 8 galaxies at the 3.6m telescope at ESO in 1989 and 1992. The wavelength region studied was 3700-7000 Å in low-dispersion mode. The resulting resolution using a slit ~ 1.5 arcsecons wide is ~ 13 Å. Integration times ranged from 900 to 10800 seconds.

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* Based on observations collected at the European Southern Observatory, La Silla, Chile

The magnitudes[8] are from CCD imagery at the Danish 1.5m and the 2.2m telescopes at ESO in 1989 and 1991, and from the 2.5m Nordical Optical Telescope at La Palma in 1990.

The galaxies display low surface-luminosity nebular emission regions. They have distances of 2-40 Mpc and dimensions ~ 1-30 kpc (however, ~ 75 % of the galaxies have distances ~ 20 Mpc and dimensions ~ 10 kpc).

OXYGEN ABUNDANCES

The majority of the galaxies are to faint to show the [OIII]λ 4363 emission line, which is necessary for the derivation of the electron temperature (and subsequently the chemical abundances). Instead I use the empirical method[9,10], based on the $R_{23} = (\lambda3727+\lambda4959+\lambda5007)/H\beta$ ratio, to estimate the oxygen abundance. This method should yield a 12+log(O/H) determination with an accuracy of 0.2 dex, for low abundance regions[10].

The global empirical HII region oxygen abundances of the eight galaxies thus derived (2, 3, 4, 4, 4, 5, 6 and 6 per cent of the solar) are very low for galaxies of their type. This becomes apparent if we compare them with nearby dwarf irregulars[11] in an absolute blue magnitude - oxygen abundance diagram (Fig 1.). Most of our objects lie well below the relation seen for the dwarfs (the dashed lines corresponds to the 1σ deviation for the dwarfs). One explanation for the observed M-Z relation is that the gas is expelled in dwarfs, due to supernova and stellar winds. The location of the BLSBGs in the diagram seems to speak against this scenario. It has been proposed[12] that a surface brightness - metallicity relation is more indicative of the chemical status of a galaxy than the M-Z relation is. As can be seen in Fig. 1 (where different symbols indicate the surface brightness) there is some tendency for higher surface-brightness galaxies to have a higher abundance. But such a relation is apparently insufficient to explain the large overall dispersion in the M-Z plane, it seems as if another parameter must be taken into account. Conditions rarely considered are the star formation history or the age of the stellar populations.

In two of the three galaxies where the [OIII]λ 4363 emission line could be measured we find that the abundance is a factor of ~ 2 higher compared to the empirical values. This may be due to lower effective temperatures (T_{eff}), of the stars in the HII regions, than we assumed (the derived abundance, at constant R_{23}, in low abundance HII region models[10] depends on T_{eff}). A high mass cut off in the IMF would lower the T_{eff}. Low column densities of the gas, a condition expected in LSBGs, could make massive star formation inefficient[13].

CONCLUSIONS

The eight blue low surface-brightness galaxies studied all have empirical oxygen abundances below 7% of the solar value, in a few cases approaching the lowest values ever found for galaxies of their size. They break the tight M-Z relation for nearby dwarf irregulars. Their low abundances could be due to either galaxy youth or an anomalous star formation history. However, preliminary comparisons, for a few galaxies, of the BV*i* colours with spectral evolutionary models[14] result in ages > 2 Gyrs.

References

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