Dwarf galaxies in the nearby Lynx-Cancer void: photometry, colours and ages

Simon Pustilnik, Alexei Kniazev, Yulia Lyamina and Arina Tepliakova

Abstract The nearby Lynx-Cancer void is a good laboratory to study the effect of very rarefied environment on the evolution of the least massive dwarf galaxies. A recently compiled sample of this void's galaxies includes about one hundred objects with M_B in the range –12 to –18 mag. Good quality images are available in the SDSS database for $\sim$80% of the sample. Their u,g,r,i,z photometry allows one to derive galaxy stellar mass (and, incorporating HI data, gas mass-fraction) and ages of visible stellar populations, and hence, the epoch of their formation (first SF episode). We present the first photometric results of the ongoing study of the Lynx-Cancer void.

1 Objectives

The best probes of possible effects of environment on galaxy evolution and formation should be the most fragile, least massive dwarfs. We compiled the largest and deepest sample of dwarfs, falling within the nearby Lynx-Cancer void ([8], Pustilnik & Tepliakova, 2010, MNRAS, submitted): about a hundred objects with M_B down to –12 mag. (see left panel of Fig. 1 for the void galaxies' M_B distribution).

The main goal of this study is to look for the evolutionary parameters of the void's galaxies and compare them with parameters of their counterparts in denser environment. For this we perform the spectroscopy of HII regions in void galaxies to derive the oxygen abundances. We also observe these galaxies in HI 21-cm line to derive their total gas masses. Combining this data with SDSS photometry we obtain the evolutionary parameter f_{gas} – the ratio of gas mass to the whole baryonic mass. As a part of the ongoing project, we examine $u-g, g-r, r-i$ colours of outer parts of the void galaxies from their SDSS images. Comparing them with PEGASE model evolutionary tracks, we derive estimates on ages of stellar populations. We also analyse the Surface Brightness (SB) profiles of void galaxies [5], to obtain

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the distribution of $\mu_{0,B}^{ext,i}$, B-band central SB corrected for the Galaxy extinction and inclination.

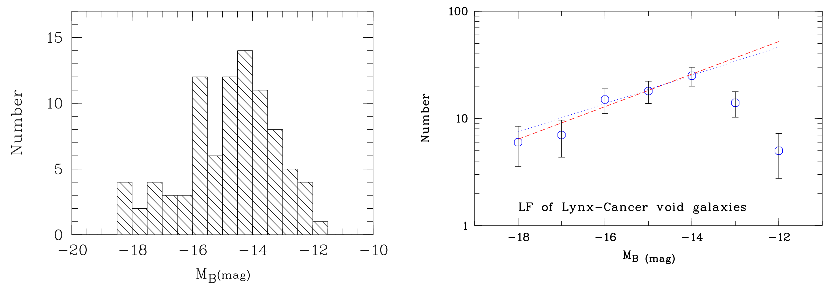

Fig. 1 *Left:* The distribution of absolute blue magnitudes M_B for Lynx-Cancer void galaxies. *Right:* The shape of the raw luminosity function of this void galaxies. The two lines show fits by Schechter function on the range M_B of –14.0 to -18.0 mag for two adopted values of M_B^*: the standard: –20.2 mag. (dotted, α=–1.33), and the reduced value, suitable for voids, –19.2 mag. (dashed, α=–1.38). The Hubble constant is adopted 73 km s^{-1} Mpc^{-1}.

2 Results

2.1 Colours

In Fig. 2, for 47 L-C void galaxies with SDSS images we show *ugr* colours of their outer parts in comparison to PEGASE [3] evolutionary tracks for two extreme Star Formation (SF) laws: instantaneous SF and continuous SF with constant SFR. Both tracks for the standard Salpeter and the Kroupa [6] IMFs are used for comparison. The adopted metallicity parameter, z=0.002, matches the range 0.0004–0.004 typical of void dwarfs. The great majority of the studied galaxies show a sizable amount of old stellar populations, corresponding to continuous SF with ages of T=10–15 Gyr. Only for 4 dwarfs do the outer region colours correspond to ages T$\sim$1–3 Gyr. For 5 more galaxies, the oldest visible population has T$\sim$4–7 Gyrs. Galaxies with ”small” ages also appear to be the most metal-poor and gas-rich.

2.2 LSBG population

More than a half of the Lynx-Cancer void galaxies (mainly the faint end) were identified as a result SDSS spectroscopy. The latter was limited by the higher SB galaxies. Namely, it missed more than 50% of objects with the observed $\mu_{0,B} > 23.2$

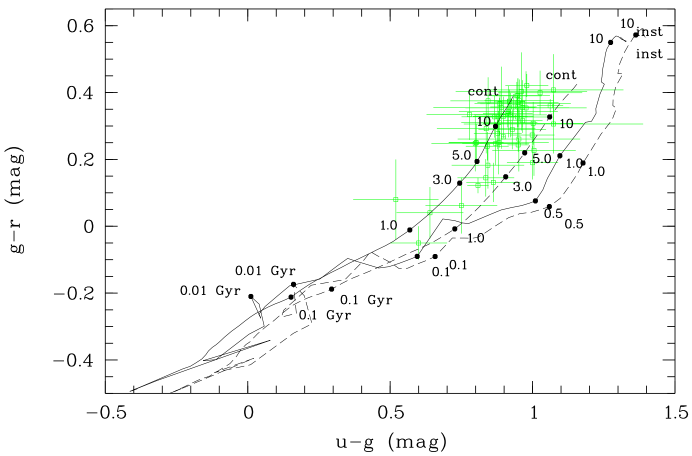

Fig. 2 The *ugr* colours of the outer parts of 47 Lynx-Cancer void galaxies are shown in comparison to the PEGASE evolutionary tracks for two IMFs - Salpeter (solid lines) and Kroupa (dashed lines) and two extreme SF laws - instantaneous and continuous with constant SFR. Numbers along the tracks indicate the time elapsed since the beginning of SF episode. The great majority of the void galaxies show *ugri* colours consistent with the cosmological ages T$\sim$10–15 Gyr typical of other galaxies. Only four galaxies show no traces of stars with T>1–3 Gyr. Five more galaxies show colours for stars with intermediate ages, of T$\sim$4–7 Gyr.

mag sq.arcsec^{-2} (Pustilnik & Tepliakova, 2010, MNRAS, submitted; as recalculated for purely exponential discs from the estimates in [1]). On the other hand, since $\mu_{0,B}$ is related to galaxy luminosity (e.g., [2]), one expects that LSBGs could be the main population of voids. In Fig. 3, we show the distribution of $\mu_{0,B}^{ext,i}$ (corrected for the Galaxy extinction and inclination) for 61 Lynx-Cancer void galaxies examined so far. Their values of $\mu_{0,B}$ were transformed from the respective g and r values using [7]. The fraction of LSBGs (that is, with $\mu_{0,B}^{ext,i} > 23.0$) in this subsample appears ~ 0.5 and is quite representative of the whole sample selected this way. Due to the evident selection effects, the significant part of the void LSB dwarfs remains undisclosed. This is the challenge for both observers and for CDM N-body simulations of void galaxy population.

2.3 Luminosity function

The luminosity function (LF) of void galaxies is an important parameter for comparing predictions of cosmological models of galaxy and structure formation. To date, the Lynx-Cancer void galaxy sample is significantly larger than for any other individual void. Therefore, even the preliminary information on this raw LF (see Fig. 1,Right) is of interest. For $M_B > -13.5$, the significant loss (presumably due to

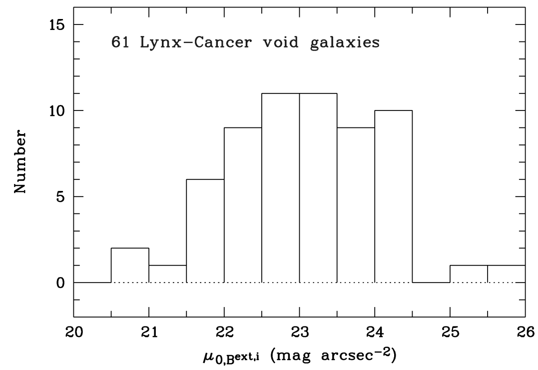

Fig. 3 The distribution of the central SB ($\mu_{0,B}^{ext,i}$) for 61 L-C void galaxies. For galaxies with the sizable central SF region or "buldge" we accepted the central SB of the underlying disc. About a half of galaxies belong to the low SB regime: $\mu_{0,B}^{ext,i} >$ 23 mag arcsec^{-2}. However, many of them passed through the SB threshold for SDSS spectroscopy due to the significant inclination-related brightening. Many others have no SDSS spectra, but have the known velocities/distances either from HI observations or from the photometry of resolved stars.

selection effects) of faint galaxies is seen. However, for M_B range of –14.0 to –18.0, the fitting of LF by Schechter function works well and results in the power-law index $\alpha \sim$–1.33 to –1.38$\pm$0.06, depending on the adopted value of M_B^*. This slope is close to that for the LF of SDSS galaxies from the study [1], uncorrected for the SB selection effect.

3 Unusual dwarfs in Lynx-Cancer void

In the course of the study of this void galaxy sample, several of the most metal-poor galaxies with 12+log(O/H) $\leq$ 7.30 were uncovered. They include SDSS J0926+3343 (7.12) [10], DDO 68 (7.14) [9, 4], J0737+4724 (7.24), J0812+4836 (7.28) [4], J0852+1350 (7.28). The three former galaxies show no tracers of stellar populations with T $>$1–3 Gyr. Additionally, we found two LSBDs (J0723+3622 and SAO 0822+3545) with unknown metallicities with overall blue colours, indicating ages T $\sim$1–3 Gyr. The statistical significance of this finding will be addressed in a forthcoming paper. But such unusual concentration of the most metal-poor and 'unevolved' dwarfs suggests on a sizable effect of void environment on galaxy evolution.

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