THE NATURE OF BLUE COMPACT DWARF GALAXIES

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The studies of blue compact dwarf (BCD) galaxies at the Main Astronomical Observatory of the National Academy of Sciences of Ukraine are reviewed. The following problems are discussed: 1) the importance of BCDs for cosmological studies; 2) properties of extremely metal-deficient BCDs; 3) a primordial helium abundance and the baryon mass fraction in the Universe; 4) heavy element abundances in large samples of BCDs; 5) properties of massive stellar populations; 6) properties of the oldest stellar populations; 7) the evolutionary status of BCDs.

The question of whether there are young star-forming galaxies in the local universe, is for the first time of considerable interest for the galaxy formation and cosmological studies. There are several reasons for this. First, the Cold Dark Matter models predict that low-mass dwarf galaxies could still be forming at the present epoch because they originate from density fluctuations considerably smaller than those giving rise to the giant galaxies ones. Thus, the existence of young dwarf galaxies in the local universe would put strong constraints on the primordial density fluctuation spectrum. Second, while much progress has been made in finding large populations of galaxies at high ($z \geq 3$) redshifts, truly young galaxies in the process of forming remain elusive in the distant universe. The spectra of those far-away galaxies generally indicate the presence of a substantial amount of heavy elements, implying previous star formation and metal enrichment. Thus, it is important to have examples of bona fide young galaxies in the local universe because they can be used as laboratories for studying star formation and chemical enrichment processes in environments that are sometimes much more pristine than those in the known high-redshift galaxies. Moreover, their proximity allows studies of their structure, metal content, and stellar populations with the sensitivity, precision, and spatial resolution that faint distant high-redshift galaxies do not allow. Finally, in the hierarchical model of galaxy formation, large galaxies result from the merging of smaller structures. These building-block galaxies are too faint and small to be studied at high redshifts, while we stand a much better chance of understanding them if we can find local examples.

The blue compact dwarf (BCD) galaxies are the best candidates for being truly young galaxies. Therefore, their detailed studies can shed light on the properties of distant primeval galaxies. They allow also to derive one of the important cosmological parameters, the baryon mass fraction in the Universe, using the helium abundance obtained from spectroscopic observations of BCDs. Such studies were carried out at the Main Astronomical Observatory during the period 1986–2004 in collaboration with researchers from different countries. The main results of these studies were published in the following papers:

a) on the properties of extremely metal-deficient BCDs – in [1, 10, 12, 15–17, 19, 30–32, 35, 36, 40–42, 44–47];

b) on the primordial helium abundance determination – in [9, 11, 22, 23, 26, 28, 29, 38];

c) on heavy element abundances in large samples of BCDs – in [20, 21, 24, 39, 43];

d) on the properties of massive stellar populations – in [1, 3, 13, 14, 18, 19, 37];

e) on the properties of the oldest stellar populations and on the evolutionary status of BCDs – in [2, 4–8, 10, 25, 27, 31–34, 42, 44, 46].

[1] *Fricke K., Izotov Y., Papaderos P., et al.* An Imaging and Spectroscopic Study of the Very Metal-deficient Blue Compact Dwarf Galaxy Tol 1214–277 // Astron. J.–2001.–**121**, N 1.–P. 169–181.

[2] *Guseva N., Izotov Y., Papaderos P., et al.* The evolutionary status of the low-metallicity blue compact dwarf galaxy SBS 0940+544 // Astron. and Astrophys.–2001.–**378**, N 2.–P. 756–776.

[3] *Guseva N., Izotov Y., Thuan T.* A Spectroscopic Study of a Large Sample Of Wolf–Rayet Galaxies // Astrophys. J.–2000.–**531**, N 2.–P. 776–803.

[4] *Guseva N., Papaderos P., Izotov Y., et al.* Spectroscopic and photometric studies of low-metallicity star-forming dwarf galaxies. I. SBS 1129+576 // Astron. and Astrophys.–2003.–**407**, N 1.–P. 75–90.

[5] *Guseva N., Papaderos P., Izotov Y., et al.* Spectroscopic and photometric studies of low-metallicity star-forming dwarf galaxies. II. HS 1442+4250 // Astron. and Astrophys.–2003.–**407**, N 1.–P. 91–104.

[6] *Guseva N., Papaderos P., Izotov Y., et al.* Spectroscopic and photometric studies of low-metallicity star-forming dwarf galaxies. III. SBS 1415+437 // Astron. and Astrophys.–2003.–**407**, N 1.–P. 105–120.

[7] *Guseva N., Papaderos P., Izotov Y., et al.* Pox 186: An ultracompact galaxy with dominant ionized gas emission // Astron. and Astrophys.–2004.–**421**, N 2.–P. 519–528.

[8] *Hunt L., Thuan T., Izotov Y.* New Light on the Stellar Populations in I Zw 18: Deep Near-Infrared Imaging // Astrophys. J.–2003.–**588**, N 1.–P. 281–298.

[9] *Izotov Y., Chaffee F., Foltz C., et al.* Helium Abundance in the Most Metal-deficient Blue Compact Galaxies: I ZW 18 and SBS 0335–052 // Astrophys. J.–1999.–**527**, N 2.–P. 757–777.

[10] *Izotov Y., Chaffee F., Foltz C., et al.* A Spectroscopic Study of Component C and the Extended Emission around I Zw 18 // Astrophys. J.–2001.–**560**, N 1.–P. 222–235.

[11] *Izotov Y., Chaffee F., Green R.* The ^{4}He Abundance in the Metal-deficient Blue Compact Dwarf Galaxies Tol 1214–277 and Tol 65 // Astrophys. J.–2001.–**562**, N 2.–P. 727–736.

[12] *Izotov Y., Chaffee F., Schaerer D.* Deep spectroscopy of the low-metallicity blue compact dwarf galaxy SBS 0335–052 // Astron. and Astrophys.–2001.–**378**, N 2.–P. L45–L48.

[13] *Izotov Y., Dyak A., Chaffee F., et al.* Spectrophotometry of Blue Compact Galaxies with Broad Emission Lines: Evidence for High-Velocity Gas Motion // Astrophys. J.–1996.–**458**, N 2.–P. 524–532.

[14] *Izotov Y., Foltz C., Green R., et al.* I ZW 18: A New Wolf–Rayet Galaxy // Astrophys. J.–1997.–**487**, N 2.–P. L37–L40.

[15] *Izotov Y., Guseva N., Lipovetsky V., et al.* Unusually low heavy-element abundance found in the blue compact dwarf galaxy SBS0335–052 // Nature–1990.–**343**, N 1.–P. 238–240.

[16] *Izotov Y., Guseva N., Lipovetsky V., et al.* New blue compact dwarf galaxies with low heavy-element abundances // Astron. and Astrophys.–1991.–**247**, N 2.–P. 303–306.

[17] *Izotov Y., Lipovetsky V., Chaffee F., et al.* SBS 0335–052, A Probable Nearby Young Dwarf Galaxy: Evidence Pro and Con // Astrophys. J.–1997.–**476**, N 2.–P. 698–711.

[18] *Izotov Y., Noeske K., Guseva N., et al.* Discovery of the high-ionization emission line [Ne V] λ3426 in the blue compact dwarf galaxy Tol 1214–277 // Astron. and Astrophys.–2004.–**415**, N 1.–P. L27–L30.

[19] *Izotov Y., Papaderos P., Guseva N., et al.* Deep VLT spectroscopy of the blue compact dwarf galaxies Tol 1214–277 and Tol 65 // Astron. and Astrophys.–2004.–**421**, N 2.–P. 539–554.

[20] *Izotov Y., Schaerer D., Charbonnel C.* On Ionization Effects and Abundance Ratios in Damped Lyα Systems // Astrophys. J.–2001.–**549**, N 2.–P. 878–890.

[21] *Izotov Y., Stasińska G., Guseva N., Thuan T.* Abundance patterns in the low-metallicity emission-line galaxies from the Early Data Release of the Sloan Digital Sky Survey // Astron. and Astrophys.–2004.–**415**, N 1.–P. 87–94.

[22] *Izotov Y., Thuan T.* Reexamining the Helium Abundance of I ZW 18 // Astrophys. J.–1998.–**497**, N 1.–P. 227–237.

[23] *Izotov Y., Thuan T.* The Primordial Abundance of ^{4}He Revisited // Astrophys. J.–1998.–**500**, N 1.–P. 188–216.

[24] *Izotov Y., Thuan T.* Heavy-Element Abundances in Blue Compact Galaxies // Astrophys. J.–1999.–**511**, N 2.–P. 639–659.

[25] *Izotov Y., Thuan T.* Hubble Space Telescope Observations of the Cometary Blue Compact Dwarf Galaxy UGC 4483: A Relatively Young Galaxy? // Astrophys. J.–2002.–**567**, N 2.–P. 875–891.

[26] *Izotov Y., Thuan T.* Systematic Effects and a New Determination of the Primordial Abundance of ^{4}He and dY/dZ from Observations of Blue Compact Galaxies // Astrophys. J.–2004.–**602**, N 1.–P. 200–230.

[27] *Izotov Y., Thuan T.* Deep Hubble Space Telescope/ACS Observations of I Zw 18: a Young Galaxy in Formation // Astrophys. J.–2004.–December 1; preprint [`astro-ph/0408391`].

[28] *Izotov Y., Thuan T., Lipovetsky V.* The primordial helium abundance from a new sample of metal-deficient blue compact galaxies // Astrophys. J.–1994.–**435**, N 2.–P. 647–667.

[29] *Izotov Y., Thuan T., Lipovetsky V.* The Primordial Helium Abundance: Systematic Effects and a New Determination // Astrophys. J. Suppl.–1997.–**108**, N 1.–P. 1–39.

[30] *Kniazev A., Pustilnik S., Masegosa J., et al.* HS 0822+3542 – a new nearby extremely metal-poor galaxy // Astron. and Astrophys.–2000.–**357**, N 1.–P. 101–110.

[31] *Lipovetsky V., Chaffee F., Izotov Y., et al.* SBSG 0335–052W: an Extremely Low Metallicity Dwarf Galaxy // Astrophys. J.–1999.–**519**, N 1.–P. 177–184.

[32] *Noeske K., Guseva N., Fricke K., et al.* The cometary blue compact dwarf galaxies Mkn 59 and Mkn 71. A clue to dwarf galaxy evolution? // Astron. and Astrophys.–2000.–**361**, N 1.–P. 33–52.

[33] *Papaderos P., Izotov Y., Fricke K., et al.* On the age of the nearby blue compact dwarf galaxy SBS 0335–052 // Astron. and Astrophys.–1998.–**338**, N 1.–P. 43–55.

[34] *Papaderos P., Izotov Y., Thuan T., et al.* The blue compact dwarf galaxy I Zw 18: A comparative study of its low-surface-brightness component // Astron. and Astrophys.–2002.–**393**, N 2.–P. 461–483.

[35] *Pustilnik S., Brinks E., Thuan T., et al.* VLA H I Line Observations of the Extremely Metal-Poor Blue Compact Dwarf Galaxy SBS 0335–052 // Astron. J.–2001.–**121**, N 3.–P. 1413–1424.

[36] *Pustilnik S., Kniazev A., Pramskij A., et al.* HS 0837+4717 – a metal-deficient blue compact galaxy with large nitrogen excess // Astron. and Astrophys.–2004.–**419**, N 2.–P. 469–484.

[37] *Schaerer D., Guseva N., Izotov Y., Thuan T.* Massive star populations and the IMF in metal-rich starbursts // Astron. and Astrophys.–2000.–**362**, N 1.–P. 53–68.

[38] *Stasińska G., Izotov Y.* Collisional excitation of hydrogen and the determination of the primordial helium abundance from H II regions // Astron. and Astrophys.–2001.–**378**, N 2.–P. 817–825.

[39] *Stasińska G., Izotov Y.* Modeling the emission line sequence of H II galaxies // Astron. and Astrophys.–2003.–**397**, N 1.–P. 71–85.

[40] *Thuan T., Bauer F., Papaderos P., Izotov Y.* Chandra Observations of the Three Most Metal Deficient Blue Compact Dwarf Galaxies Known in the Local Universe, SBS 0335–052, SBS 0335–052W, and I Zw 18 // Astrophys. J.–2004.–**606**, N 1.–P. 213–220.

[41] *Thuan T., Izotov Y.* Nearby Young Dwarf Galaxies: Primordial Gas and Lyα Emission // Astrophys. J.–1997.–**489**, N 2.–P. 623–635.

[42] *Thuan T., Izotov Y., Foltz C.* The Young Age of the Extremely Metal-deficient Blue Compact Dwarf Galaxy SBS 1415+437 // Astrophys. J.–1999.–**525**, N 1.–P. 105–126.

[43] *Thuan T., Izotov Y., Lipovetsky V.* Heavy element abundances in a new sample of low-metallicity blue compact galaxies // Astrophys. J.–1995.–**445**, N 1.–P. 108–123.

[44] *Thuan T., Izotov Y., Lipovetsky V.* Hubble Space Telescope Observations of the Unusual Blue Compact Dwarf Galaxy Markarian 996 // Astrophys. J.–1996.–**463**, N 1.–P. 120–133.

[45] *Thuan T., Lecavelier des Etangs A., Izotov Y.* Far Ultraviolet Spectroscopic Explorer Observations of the Blue Compact Dwarf Galaxy Markarian 59 // Astrophys. J.–2002.–**565**, N 2.–P. 941–951.

[46] *Thuan T., Izotov Y., Lipovetsky V.* Hubble Space Telescope Observations of the Blue Compact Dwarf SBS 0335–052: A Probable Young Galaxy // Astrophys. J.–1997.–**477**, N 2.–P. 661–672.

[47] *Vanzi L., Hunt L., Thuan T., Izotov Y.* The near-infrared view of SBS 0335–052 // Astron. and Astrophys.–2000.–**363**, N 2.–P. 493–506.