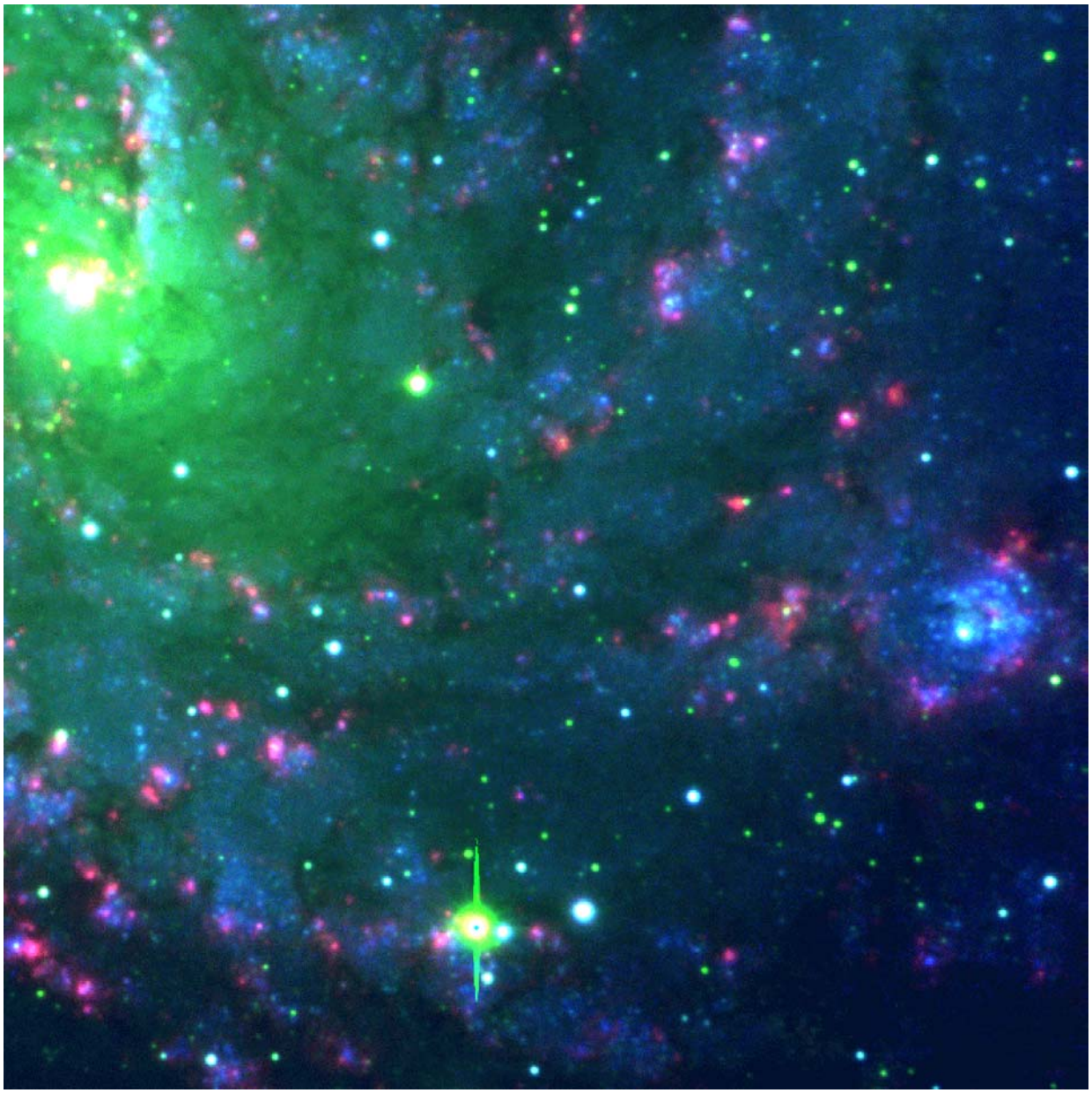
The peculiar stellar complex or a dwarf star-forming galaxy?

Yu.N.Efremov

Moscow, Sternberg Astronomical Institute

The isolated round stellar complex was discovered by Hodge (1967) at Western outskirt of the spiral galaxy NGC 6946. It was independently redicovered by Larsen and Richtler (1999) with NOT. They who described the complex as the bubble-like structure of 600 pc in size. It includes a number of stellar clusters, one of which is outstanding by its size and luminosity.

The complex was studied with the HST and Keck-I data (Larsen et al. 2001, 2002). From the velocity dispersion inside the largest young populous cluster, its age (13 Myr) and luminosity (Mv = -13) the consistent values , 10^6 suns, for the photometric and dynamic masses of the cluster were obtained, which suggest the cluster is bound and will look like the classical globular cluster after few Gyrs. The parameters of this cluster are quite similar to those of the star superclusters, which are found to be numerous in interacting and star-burst galaxies. The complex hosts at least 18 bright clusters. It looks like the relic of the local burst of the star formation, which was most active 30-5 Myr ago (Larsen et al., 2002).



Long-slit spectroscopy of the complex was obtained with BTA and Keck-I telescopes in 2000 (Efremov et al., 2002). Three cross-sections of the complex were obtained, Vr curves demonstrating many disturbances, including the dip which might be the fast expanding semishell with nothing in its center. The radial velocity of the supercluster and the bulk of complex HII gas is 150 km/s, by ~ 20 km/s higher than the local velocity of the HII outside the complex. Some features of the radial velocities curves across the complex might be interpeted as demonstrating the gradient compatible with the slow rotation of the complex. The presence of gas vortices inside the complex is also not excluded (Efremov, 2002).

One more strange property of the complex is its sharp Western edge (in the visible light) which forms the regular arc with the opening angle (at the center of the complex) about 130 degree. Along this edge the wide arc of the highest extinction was found, and later on the K-band image with the Keck telescope (S.Larsen, unpublished) demonstrated the absence of the sharp Western

rim, thus confirming its appearance in the visible light was due to the arc-shaped dust cloud along the Westerm edge of the HO.

The following ideas on the complex origin were discussed recently -

1) it is the pecular complex inside the NGC 6946 galaxy with the enhanced rate of star formation in the recent past. The position of the complex at the tip of the short piece of the spiral arm (or a spur) is favorable to the formation of the large regions of star formation. Providing this be the case, the dust arc at the West of the complex must be due to the pressure from the supercluster (Elmegreen et al. 2000).
The complexes with the high SFR (superassociations), though having no other peculiarities, are known at the tip of spiral arms in a few other galaxies. However it is unclear why such complexes are very rare at the arm tips, and why the pressure from the supercluster was so anisotropic. It is strange that the dust arc was formed only at the side of the lower external gas density. Another strange thing is why there is no HI hole/superbubble around the complex, the supercluster inside which being the most suitable by age and luminosity to form such a supershell. The numerous supershells are known in NGC 6946 galaxy yet the complex is outside all of them (being, anyway, near the tip of the large elliptical hole - Efremov, 2002).

2) Otherwise the complex might be the result of the oblique infall of a HVC, from East to West, to the gas disk of NGC 6946 and the complex and the regular gas-dust arc along the its western edge were formed in result (Efremov et al. 2002). The regular magnetic field known to exist in NGC 6946 might prevent the formation of supershell after such an impact, according the theory of HVC impacts (Santillan et al. 1999). The high pressure arising in result of collision of the shock waves after impact is favorable to the formation of the massive bound cluster, according the general theory (e.g. Elmegreen and Efremov, 1997).

However the strong objections are also against this scenario. The radial velocities of the complex and supercluster are only by 20-30 km/s larger then the local velocity of the NGC 6946 rotation from HII data (Efremov et al. 2002). This, as well as the Western dust arc, implies plausibly the small inclination of the impacting cloud trajectory in respect to the NGC 6946 plane and considering the location of the complex at the galaxy West outskirts, is is strange the cloud has not impacted closer to its center. This could suggest that its total velocity was very high.

3) There is also the third possibility (Yu.Efremov, unpublished). The complex might be in fact the blue dwarf compact galaxy (BDCG) which fast moves to the West through the gas halo of NGC 6946 or, more plausibly, through the IGM of the NGC 6946 group. This group which includes seven dwarf irregular galaxies, was discovered recently by Karachenttsev et al. (2000). Moreover, according their results, three galaxies most lose to NGC 6946 in sky, have the velocities (126, 127 and 132 km/s), rather similar to the latter (150 km/s). Thus, the radial velocity data alone cannot either prove or disprove the hypothesis the complex being the BCDG. The velocity of the dynamical center of NGC 6946 is 47 km/s.

Anyway, the super star cluster are common in the BCDGs and also some of these galaxies have the cometary shape, connected plausibly with the fast movement trough the IGM. In M81 group two small galaxies are known to be shaped by the ram pressure of the IGM -

these are the outer isodenses of HI in Ho II galaxy and the stellar edge of DDO 165 galaxy (Efremov 2001, 2002). In the same group there is the BCDG UGC 4483 which has the cometary shape and the YMC is in its head (Izotov and Thuan, 2002).

If the complex is the foreground BCDG with the low gas content it is then quite natural that no features in ISM are seen in its position (Walsh et al., 2002). However, the normal O/H abundance (Efremov et al. 2002) might be considered the objection against the BCDG hypothesis, because most of the latters are known to have the low abundance. However, no data on Fe/He abundance are available. The signs of rotation are faint or absent in the HII velocity profiles of the complex (Efremov et al. 2002), but non-rotating BCDG are known (such as VII Zw 403, Silich et al., 2002). As in these galaxies, the ionized gas in the complex reveals many velocity disturbances which looks like the uncomplete HII shells.
More data on this unique complex are necessary. Its origin may shed light to the present-day origin of massive bound clusters in about "normal" surroundings..

References

Efremov Yu.N. Astron. Rep., 2001, 46, 791.
Efremov Yu.N., 2002, astro-ph/0206408.
Efremov Yu.N., Pustilnik S.A., Kniazev A.Y., et al. 2002, AAp, 389, 855.
Elmegreen B.G., Efremov Yu.N., 1997, ApJ, 480, 235.
Hodge P.W. 1967, PASP, 79, 297.
Izotov Yu.I, Thuan T.X., 2002, ApJ , 567, 875.
Karachentsev I.D., Sharina M.E., Hutchmeier W.K., 2000, AAp, 362, 544.
Larsen S., Richtler T., 1999, AAp, 345, 59.
Larsen S., Brodie J.P., Elmegreen B.G. et al. , 2001, ApJ, 556, 801.
Larsen S., Efremov Yu.N., Elmegreen B.G., 2002, ApJ, 567, 896.
Silich S., Tenorio-Tagle G., Munoz-Tunon C., Cairos L.M., 2002, AJ, 123, 24.

Santillan A., Franco J., Martos M., and Kim J. 1999, ApJ, 515, 657.

Walsh W., Beck R., Thuma G., et al., 2002, AA, 388, 7.