CENTERS OF STAR FORMATION IN THE NUCLEI OF GALAXIES

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Nuclei of galaxies are the phenomena intimately connected with the structure of galaxies, their origin and evolution. Spectral and photometrical characteristics and therefore the stellar population of the most nuclei of normal galaxies are like that of central regions or bulges (Walker, 1962, 1964; Vorontsov-Velyaminov, 1965, 1968). Processes of star formation in the nuclei must be considered together with the problem of formation of the central regions (bulges) or even of all galaxies as a whole.

The term "galactic nucleus" is usually applied to the central region (or center of symmetry) having the maximum stellar density (maximum surface brightness) and dimensions less than 100 pc (dimension of a globular cluster). The observational evidence of star formation at the present epoch is related to the nuclear regions within radii of 100-1000 pc or more. Information about the physical condition of the gas and about star formation just in the center of galaxies ($\lesssim$ 1 pc) can be obtained only by theory. The red colour of the central star cluster of normal galaxies is evidence that star formation in this region is practicallv finished.

The nuclear region as a central stellar cluster in any galaxy must have been formed mainly at an early stage of galaxy creation. The age of the nuclei we must count from the moment of condensation of the first-generation stars. According to Huchra's (1976) investigation the age of all galaxies is approximately the same and equal to 1-2 10^{10} years, because even the bluest and most compact of them contain up to 50% of very old stars. We observe the old stars (globular clusters) in the nuclear regions of all nearby spiral galaxies. The differences in colour of the central parts of galaxies are caused by differences in the rate of star formation (Searl et al. 1973).

In the most cases the colour of nuclei of normal galaxies is red and therefore corresponds to their old age. But there is much observational evidence of young stars or region of star formation existing near the nuclei. Hot-spot nuclei are the most noticeable in

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this regard. They contain blue compact regions and emitting HII patches indicating the existence of young stars. Morgan (1958) was the first to consider the hot-spot nuclei in normal galaxies. A classification of fifteen galaxies with peculiar amorphous or complex nuclei were given by Sersic and Pastoriza (1965). Peculiar nuclear regions of normal galaxies were studied by Vorontsov-Velyaminov (1968) and by Nazarova (1974). An interesting example of a pair of interacting spirals is NGC 4038/39. The nuclei of these galaxies were recently studied by Dobrodij and Pronik (1979). In both galaxies the red nucleus has a blue component. It is highly interesting that bifurcation of the nuclei has occurred along the interconnecting line and that the blue components are located on the inner side of this chain.

The problem of star formation in giant elliptical and dwarf blue E-galaxies was considered by van den Bergh (1975). Searl and Sargent (1975) have previously suggested that star formation in dwarf irregular galaxies takes place by burst. It is very probable that star formation in dwarf ellipticals can also occur in bursts (van den Bergh, 1975; Huchra, 1977). Indications of recent bursts of star formation have been found in NGC 3077. A burst of rapid star formation is currently taking place in the elliptical galaxy NGC 5253 (van den Bergh, 1975). About a dozen blue knots are grouped around the center of this galaxy. An image-tube spectrum of the brightest of these knots shows an early-type absorption-line spectrum (van den Bergh, 1972).

The bursts of star formation in nuclear regions of giant elliptical galaxies (such as NGC 1275 and NGC 5128) may be accompanied by explosive events in their nuclei. Thus the integrated colour of the region near the dark band of NGC 5128 is bluer than that of the areas near the poles. A number of bright blue knots are located just outisde of its equatorial dark band (see photo published by Rickard, 1971). UBV observations of these knots show that these objects are either reddened OB clusters or knots of emission nebulosity (van den Bergh, 1975).

Another example of a burst of star formation in a giant elliptical galaxy is given by NGC 1275 (Per A). The image-tube spectra of the region located 5" to the south of the nucleus (van den Bergh, 1975) and the 3" knot to the northeast of the nucleus (Metik and Pronik, 1979) show an A-type absorption-line spectrum. It is quote obvious that the active nucleus of NGC 1275 is surrounded by a region showing a burst of star formation. The most striking evidence is that near the nucleus of NGC 1275, and even rather far from it, there are many blue knots, especially in the southeast direction. It is not quite clear why the knots in the outer part of this galaxy show a spiral arm-like form.

The point of view that violent explosive events in the nuclei trigger star formation in nuclear regions was supported by the observations (Kronberg et al., 1972) of M82, the nucleus of which is surrounded by a dozen young superclusters of stars with the absolute magnitude $M_V = -15^m$.

Do the nuclei of spiral galaxies containing hot spots have an eruptive nature too? The observed usual red colour of the central cluster and the absence of any remnants of an explosion do not support such a point of view.

The cause of recent star formation must be the same in all cases: in irregular galaxies, near the nuclei of elliptical and spiral galaxies, and within the spiral arms. One of the necessary conditions of star formation is a sufficient amount of gas and dust. There is a strong dependence between the amount of hydrogen mass and the colour of galaxies (Dean and Davies, 1975). A lot of gas in some galaxies has remained not only because of the low rate of star formation during their history but also because of the prevalence of extremely high mass stars among the condensed ones.

The formation of massive stars leads to the non-effective transformation of interstellar matter into stars, because the stars lose a considerable portion of their mass during evolutionary processes. The hot massive stars heat up the gas clouds, thereby favoring the formation of new massive stars. It is possible that tidal actions of neighboring galaxies or massive nuclei lead to the formation of massive stars too.

REFERENCES

Dean T. and Davies, R.: 1975, Mon. Not. Roy. Ast. Soc. 170, 503.
Dobrodij O. and Pronik, I.: 1979, Izv. Kromsk. astrofiz. obs. 60, 66.
Huchra, J.: 1977, Astrophys. J. 217, 928.
Kronberg, P., Pritchet, C., and van den Bergh, s.: 1972, Astrophys. J. 173, L47.
Metik, L. and Pronik, I.: 1979, Astrofizika 15, 37.
Morgan, W. W.: 1958, Publ. Ast. Soc. Pac. 70, 364.
Nazarova, L.: 1974, Izv. Krimsk. astrofiz. obs. 52, 71.
Rickard, I.: 1971, E.S.O. Annual Report.
Searl, L. and Sargent W.: 1972, Astrophys. J. 173, 25.
Searl, L., Sargent W., and Bagnuolo, W.: 1973, Astrophys. J. 179, 427.
Sersic, J. and Pastoriza, M.: 1965, Publ. Ast. Soc. Pac. 77, 287.
van den Bergh, S.: 1972, Roy. Ast. Soc. Canada, 66, 237.
van den Bergh, S.: 1975, "Structure and Evolution of Galaxies," ed. G. Setty, Reidel, Dordrecht-Holland, p. 1.
Vorontsov-Velyaminov, B.: 1965, Russian Astron. J. 42, 1168.
Vorontsov-Velyaminov, B.: 1968, "Nonstable Phenomena in Galaxies," I.A.U. Symp. No. 29, Byrakan, 106.
Walker, M.: 1962, Astrophys. J. 136, 695.
Walker, M.: 1964, Astronom. J. 68, 744.