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# Vorontsov-Velyaminov' nests: what are they?

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**Abstract.** We give a short review of optical observations of the objects classified by Vorontsov-Vel'yaminov as "nests" of galaxies, describing their luminosity, color, structure and star formation properties. Some ideas on the nature of single dwarf "nests" are discussed.

## 1. Introduction

The term "nests" was introduced into extragalactic astronomy by Vorontsov-Vel'yaminov (VV). He defined nests as objects which look like systems of several galaxies in contact or nearly in contact, often surrounded by common luminous (stellar) haze. There are more than 200 objects in his Atlas of interacting galaxies (Vorontsov-Velyaminov, 1959, 1977), which satisfy this definition. Most of them never attracted any attention before being cataloged.

VV considered the nests and similar looking objects (for example, tight chains of galaxies) as unstable fragmenting systems, giving birth to normal galaxies, but he understood quite well the necessity of individual study of the objects to clarify their nature. Indeed, VV searched for interacting objects, using paper prints of Palomar Sky atlas, where the images of galaxies are usually overexposed; hence morphological classification of strange looking galaxies was highly preliminary. Individual observations of some nests and related objects were the topics of observational programs, carried out in the late 1970's and the 1980's at the Special Astrophysical Observatory in Russia (SAO RAN) (spectral observations and photography), at the Crimean Observatory of the Sternberg Astronomical Institute (spectra and integral photometry), and in Byurakan observatory in Armenia (photographic observations of selected objects). Some nests were also investigated by Western astronomers — attractive images of more than a dozen VV nests were included by H. Arp in his "Atlas of peculiar galaxies" (Arp, 1966). Good examples are Arp 155 = VV 55, Arp 149 = VV 564 and Arp 279 = VV 587. Most of them appeared to be interacting or disrupted pairs instead of tight groups. Curiously, only a few nests are members of Hickson Compact groups.

## 2. Luminosities and colors

The luminosity distribution of the nests is shown in Figure 1*a*.



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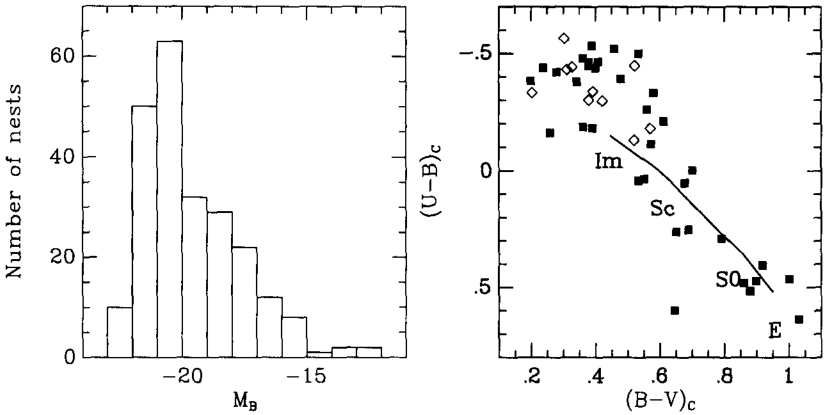


Figure 1. Photometrical properties of the nests. Right panel: Luminosity distribution; Left panel: Position of the nests in a two-color diagram. The thin line shows the normal color sequence for galaxies of different Hubble types.

Distances to the nests were found from their redshifts (adopting $H_0 = 75$ $\mathrm{km\,s^{-1}\,Mpc^{-1}}$) or were taken as the distances to groups of galaxies for the possible group members. The peak of the distribution occurs at $M_B = -20$ to $-21$. Observations of individual objects revealed that most of the high luminosity galaxies are tight pairs or mergers. On the contrary, the low luminosity tail of the histogram contains many single late-type galaxies which may appear on the (overexposed) Palomar prints as tight groups due to their inhomogeneous structure.

Color estimates show that practically all low luminous objects are very blue (see the two-color diagram Figure 1*b*, where the objects with $M_B > -18$ are marked by diamonds). As one can see from the diagram, the nests possess different stellar populations, covering the whole color range of galaxies. The reddest nest is VV 543. Its systemic velocity from the literature is circa 1400 $\mathrm{km\,s^{-1}}$, which implies it is a dwarf elliptical system ($M_B \approx -16$). However recent observations (Zasov et al., 2000) revealed a possible misprint in the original work, where the redshift was determined: the correct value was found to be $\approx 14,000$ $\mathrm{km\,s^{-1}}$, so this system does not violate the general rule: all low luminous nests are blue. Moreover, some of them are shifted above the normal color sequence, which gives evidence that we are seeing a burst of star formation.

## 3. Kinematics, structure and stability of the nests

In many cases only kinematic measurements may prove that a given nest is a single object, rotating as a whole (see for example Arkhipova 1981, 1987a, 1987b, 1988, Sulentic, 1980). Observations showed that the single nests usually possess growing rotation curves, typical for low luminous irregular galaxies. As an example, Figure 2 shows the line-of-sight velocity distribution parallel with the Hα brightness distribution along the main body of VV 432 obtained from recent observations at 6m telescope (Zasov et al., 2000).

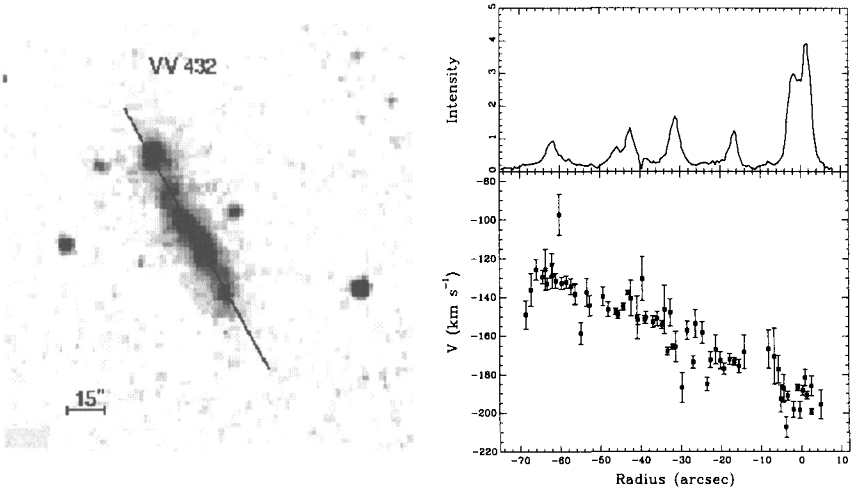


Figure 2: The nest VV 432. Left panel : position of the slit, crossing the nest. Top right: distribution of Hα brightness along the slit; bottom right : line-of-sight velocity distribution along the slit

VV 432 is a slowly rotating dwarf galaxy with active star formation and a "normal" mass to luminosity ratio, which excludes its instability.

A great majority of the nests seem to be gravitationally bound, judging from their $M_{tot}/L_{pg}$ ratios, which are quite normal for galaxies (see Table 1), although in some cases the estimates of masses are very unreliable, so the ratio needs to be verified. The only nest with a discordant redshift of one of its components is VV 543, as mentioned above. This nest consists of a luminous red elliptical galaxy and a small BCG in contact with it (in projection). The systemic velocity of the blue component exceeds the velocity of the elliptical by about 1600 $\mathrm{km\,s^{-1}}$, so we can consider this nest as a gravitationally unbound system. One may propose that in this case we have an optical pair of distant galaxies.

Although in many cases more detailed investigation is needed to check the multiplicity of a given nest, it is evident that most of the observed nests are either single objects or strongly interacting pairs/mergers. A fraction of systems with three or more dynamically decoupled components hardly exceeds 10 to 20%. Among the systems listed in Table 1 such objects are VV 564 (=Arp 449 =IC 803), VV 644 (=IC 2184) and probably VV 243 (=Arp 195). The best example of robust multiple system is VV 644 (=IC 2184) (see Figure 3 ), which is a compact group of five or six blue dwarf galaxies with the mean systemic velocity $V_r \approx$ 3700 $\mathrm{km\,s^{-1}}$, located within a circle of 15 kpc diameter (Vorontsov-Vel'yaminov et al., 1980). In this case we have a unique compact bound group of several dwarf galaxies with intense star formation, evidently induced by their tidal interaction.

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Table 1. Parameters of the nests (from observations at SAO RAN)

| VV number | Object Type | $M_B$ | $M_{tot}/L_{pg}$ |
|---|---|---|---|
| 125 | Single Scd | −18 | 2 |
| 131 | Single or pair | −17 | 4: |
| 136 | Pair | −21 | 3 - 6 |
| 148 | Single | −17 | 4 |
| 243 | Pair or triplet | −22 | >10 |
| 270 | Pair | −17.5 | 4 |
| 273 | Pair of dwarfs? | −16.5 | 8: |
| 432 | Single dwarf | −16 | 2 |
| 497 | Single dwarf | −15.5 | 4 |
| 498 | Single dwarf | −16.5 | 1: |
| 499 | Single dwarf | −12.5 | 5 - 12 |
| 543 | Pair (optical?) | −20 | - |
| 544 | Single or Pair | −18.3 | <1 |
| 558 | Single dwarf | −11 | >10 |
| 559 | Single | −18 | 17 |
| 564 | Pair or triplet | −20 | 7 |
| 566 | Single | −19.5 | 3 |
| 574 | Single dwarf | −12 | 2: |
| 575 | Single | −19.5 | 2: |
| 587 | Single dwarf | −17 | 4 |
| 615 | Pair | −19 | 1: |
| 644 | Comp.group | −20 | 0.3: |
| 731 | Pair or triplet | −21 | >0.5 |
| 747 | Single dwarf | −14 : | >10 |

## 4. Star formation in the nests

As the two-color diagram shows, active star formation (SF) takes place in many of the nests, especially in the low luminosity ones . An unusually strong burst of SF takes place in VV 644, mentioned above. This system is very bright in the far infrared and in the ultraviolet. According Börngen and Kalloglyan (1974), the overall color index is $U - B = -0.37$, although it differs from one component to another. Its FIR luminosity is close to the optical luminosity since $\log(L_{40-120m\mu}/L_B) = -0.05$ (Calzetti et al. 1995). This system is possibly in a process of merging: according to Vorontsov-Vel'yaminov et al. (1980), the velocity dispersion of galaxies is very small (44 $\mathrm{km\,s^{-1}}$), and mass to luminosity ratio is extremely low ($M/L_{pg} \approx 0.3$), partially due to the enhanced blue luminosity.

Unlike what is usually observed in dIrr galaxies, intense SF in clumpy dwarf galaxies is concentrated in a few regions with diameters of about 0.5 to 1 kpc, which may easily be taken for separate components of a nest. Three possible scenarios may be proposed to explain their observed properties.

- Dwarf nests are normal gas-rich Irr galaxies which we observe in a stage of spontaneously developed star forming activity. The formation of the extended bright emission regions may be a result of some inner mechanism — either stochastic mechanism of self-induced SF in a dwarf system (Gerola et al. 1980), or (if star formation is induced by large-scale gravitational instability) due to a large Jeans wavelength (and Jeans mass $M_J$) of the fastest growing perturbations in slowly rotating gas-rich galactic discs. Indeed, in the case of threshold gravitational instability of a thin rotating disc with a surface gas density $\sigma_g$ we have $M_J \sim \sigma^3/\Omega^4$. In a

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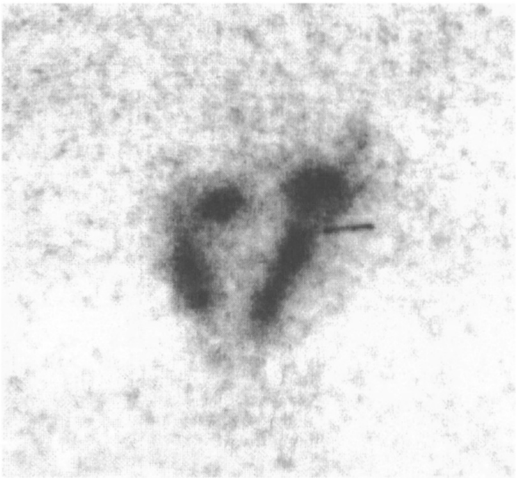

Figure 3. The "nest" VV 644 (from Vorontsov-Vel'yaminov et al., 1980)

simplified way, this relationship enables us to propose that the most massive condensations (superclouds) should form in slowly rotating gas-rich galaxies.

- Star formation in single nests is enhanced by the outer tidal perturbations due to gravitational interaction with the neighboring galaxies. Indeed, as preliminary analysis shows, in most cases the observed nests have luminous neighbors within a projected distance of several hundred Mpc.

- Some clumpy dwarf nests are relatively young under-evolved galaxies, experiencing one of the first burst of star formation. In this case one can expect them to have a lower metal abundance than what follows from the metallicity-luminosity or metallicity-mass relationships for normal dwarf galaxies. The work which is in progress now at SAO RAN is aimed at measuring the [O/H] abundance in the sample of nests, which will allow us to verify this proposition. The lowest abundance was found recently for VV 432: O/H $\approx 1/22$ of the solar value (Zasov et al. 2000).

## 5. Conclusions

Vorontsov-Velyaminov' nests and systems of similar appearance in the Atlas of Interacting Galaxies (multiplicity of which is not evident from the Palomar prints) are a very inhomogeneous group of objects. More than a third of them are single late-type galaxies (usually of low luminosity) with active star formation. Most of the other objects are strongly interacting or merging pairs. Triplets or multiple systems are very rare among the nests, although they also exist. Particular interesting are the clumpy dwarf nests, which are experiencing a burst

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of star formation, which may give a key to understanding the mechanisms of formation and evolution of dwarf galaxies.

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