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# Environmental density of galaxies from SDSS via Voronoi tessellation

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**Abstract.** The aim of our work was to determine the environmental density of galaxies from SDSS DR9 using the Voronoi tessellation. We constructed the 3D Voronoi tessellation for the volume-limited galaxy sample within 0.02< $z$ <0.1 and $-24 < M_r < -20.7$ using an inverse volume of Voronoi cell as a parameter describing the local environmental density of a galaxy. It allowed us to inspect the morphology - density relation. We obtained that the early type galaxies prefer to reside in the Voronoi cells of smaller volumes (i.e. dense environments) than the late type galaxies, which are located in the larger Voronoi cells (i.e. sparse environments).

**Keywords.** methods: data analysis; surveys; galaxies: fundamental parameters, general

## 1. Introduction

The morphology of galaxies as well as their mass, color, gas content, star formation rate, and metallicity depend on the environment: a fraction of the early type (red) galaxies is higher in regions with elevated concentrations of galaxies, while the late (blue) type galaxies predominate in the general field (Dressler 1980; Einasto *et al.* 2003, Blanton *et al.* 2005). In this work we determined the environmental density of galaxies from SDSS DR9 using the Voronoi tessellation method.

## 2. The sample and the Voronoi tessellation method

We have compiled the sample of 124,000 galaxies from the spectroscopic SDSS DR9 limiting it by the absolute magnitude $-24 < M_r < -20.7$ and redshift $0.02 < z < 0.1$ (Dobrycheva 2013). We divided this sample on the early type (E+S0) galaxies and late type (S+Irr) galaxies using the color (g-i) and inverse concentration indices R50/R90 according to the criteria proposed by Melnyk *et al.* (2012): ($0.95 < g - i < 1.5$ and $0 < R50/R90 < 0.4$) for E+S0; ($0 < g - i < 0.95$, $0 < R50/R90 < 0.6$) and ($0.95 < g - i < 1.5$, $0.4 < R50/R90 < 0.6$) for S+Irr.

To determine the environmental density of galaxies we used the Voronoi tessellation method because it detects effectively both spherical and prolongate large-scale structures (Melnyk *et al.* 2006, Elyiv *et al.* 2009, Vavilova *et al.* 2009, Zaninetti 2010, Way *et al.* 2011, Scoville *et al.* 2013). The Voronoi tessellation operates with only the positions and radial velocities of galaxies for dividing the entire 3D space containing galaxies into elementary volumes. Those of the elementary volumes, which are located closer to a given galaxy than to the remaining galaxies, form the volume of the Voronoi cell for this galaxy. The galaxy itself becomes the nucleus of this cell. Thus, after applying the

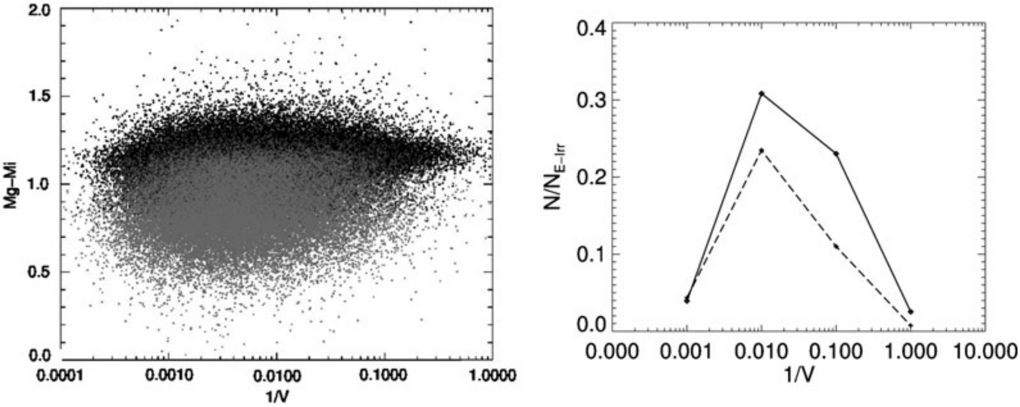


**Figure 1.** Left: The dependence of galaxy color on the inverse volume of the Voronoi cells for early (black dots) and late (gray dots) type galaxies. Right: The distributions of early (solid line) and late (dashed line) type galaxies by the inverse volume of the Voronoi cells.

Voronoi tessellation we obtain the distribution of volumes of the Voronoi cells (each cell contains one nucleus/galaxy). The local environmental density for given galaxy (or its concentration) is described by the inverse volume of its Voronoi cell: $n = 1/V$.

## 3. Results

The dependence of galaxy color on the inverse volume of the Voronoi cells $(1/V)$ for E+S0 (black dots) and S+Irr (gray dots) galaxies are presented in Fig. 1 (left). One can see, there is a general tendency that the early type galaxies are located in higher density regions than the late type galaxies. The same conclusion may be obtained from the inspection of Fig. 1 (right), where the distribution of galaxies by the inverse volume $(1/V)$ for the early and late types are shown. The number of galaxies in each bin is normalized by the total number of galaxies. We see also that most of the bright galaxies belongs to the early types. The mean values of $1/V$ for E+S0 and S+Irr types galaxies are $0.02{\pm}0.05$ and $0.01{\pm}0.04$, respectively.

We follow this research with the aim to consider the evolution of early and late type galaxies with redshift and luminosity in details. The accentuation will be pointed to the fractions of fainter satellites ($M_r$ >-20.7) of galaxies, which are located in the neighborhood of galaxies from the studied sample.

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