Comparison of the Correlation Functions of Bright and Faint Galaxies

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Abstract

It is a generally accepted assumption that correlation is independent of absolute magnitude. We choose two samples from the CfA galaxy catalogue: *bright galaxies* with magnitudes $M \leq -19.16$ and *faint galaxies* with $M \geq -17.16$. We have found that the bright galaxies are *significantly stronger* correlated than the faint galaxies. In the most characteristic range of separations the ratio of pair-frequencies is nearly constant: $(\xi_{bright}(r) + 1)/(\xi_{faint}(r) + 1) = 2.15 \pm 0.1$ for 2 Mpc $\leq r \leq$ 8 Mpc.

1 Motivation

The main question is the following:

Does the correlation of galaxies depend on absolute magnitude?

If we had a large volume-limited catalogue of *bright* and *faint* galaxies in the same region, we could answer this question easily. Unfortunately we do not. Thus we have to try to find the answer based on the known catalogues. The result should be important to check the theories of galaxy evolution.

2 Data

The CfA redshift catalogue was used for the investigation. This magnitude-limited catalogue ($m \leq 14.5$) within the geometrical boundaries $b \geq 40°$; $\delta \geq 0°$ or $b \leq -30°$; $\delta \geq -2.5°$ contains 2381 galaxies.

Throughout this article we will use $H_0 = 100\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$.

3 The luminosity function

The luminosity function can be approximated by the Schechter form:

$$\Phi(M)\,dM = \frac{2}{5}\ln(10)\cdot\Phi^*\cdot\left[10^{0.4(M^*-M)}\right]^{\alpha+1}\cdot\exp\left[-10^{0.4(M^*-M)}\right]\,dM\,, \qquad (1)$$

where $M^* = -19.16$ and $\alpha = -0.96$ for $v_r \geq 300\ \mathrm{km\,s^{-1}}$.

The numerical parameters of the luminosity function were determined by Efstathiou *et al.* (1988). The most important parameter for us is M^* because the following definitions are based on its value.

We call a galaxy *bright* if its absolute magnitude is less than M^*, and *faint* if its absolute magnitude is larger than $M^* + 2$.

Fig. 1 shows the best fitting Schechter function.

4 The selection function

The selection function of *bright* and *faint* galaxies can be derived from the luminosity function by the simple formula:

$$p(x) \propto \int_{M_{min}(x)}^{\infty} \Phi(M)\,dM\,, \qquad (2)$$

where $M_{min}(x)$ is the minimal magnitude which can be observed from the distance x.

Figures 2 and *3* show that we cannot find any region where the selection functions are approximately the same, thus we have to estimate the correlation function of *bright* and *faint* galaxies separately.

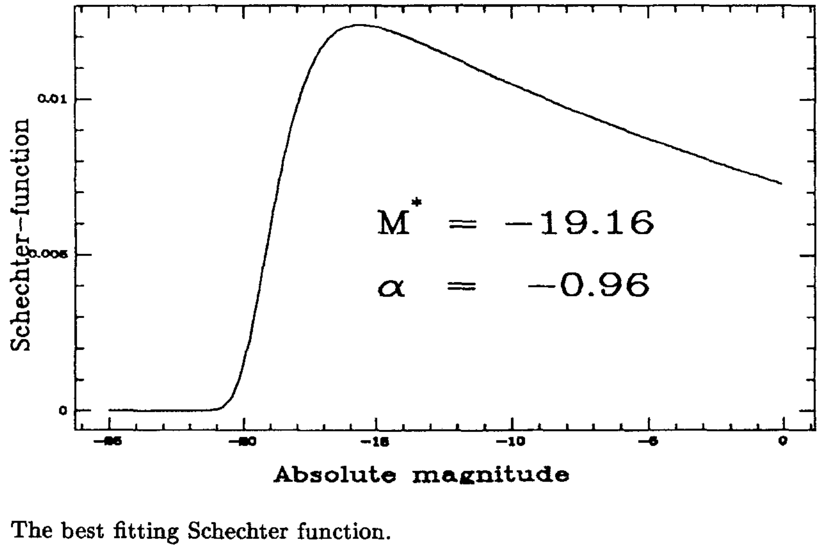

Fig. 1. The best fitting Schechter function.

5 Estimation of the correlation functions

Several random catalogues were generated using the luminosity function. The *bright* and *faint* galaxies were picked out separately and the following estimation was used:

$$\xi(r) \approx \frac{\langle DD \rangle_r}{\langle DR \rangle_r} - 1 \,. \tag{3}$$

The symbol $\langle \quad \rangle_r$ means weighted number of *Data* – *Data* and *Data* – *Random* pairs whose distances are r. Every pair was weighted with $1/\big(p(x_1) \cdot p(x_2)\big)$, where x_1 and x_2 denote the distances from us. To avoid large errors coming from small values of $p(x)$ we cut the samples where $p(x)$ decreases to 0.1. This method simulates volume limited samples.

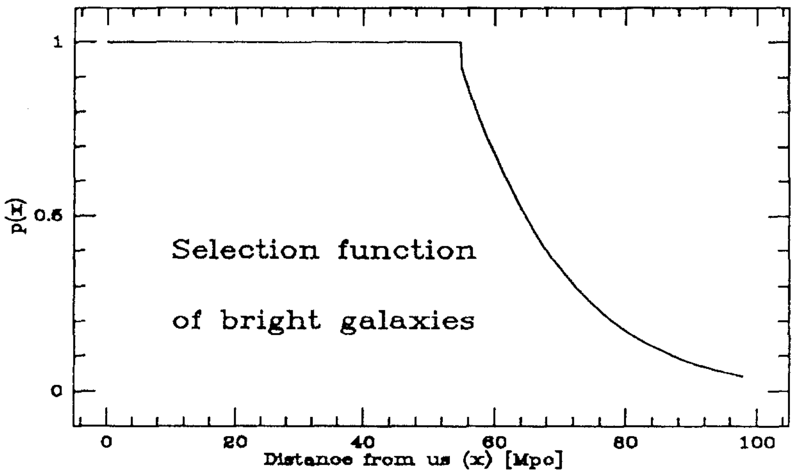

Fig. 2. The selection function of *bright* galaxies.

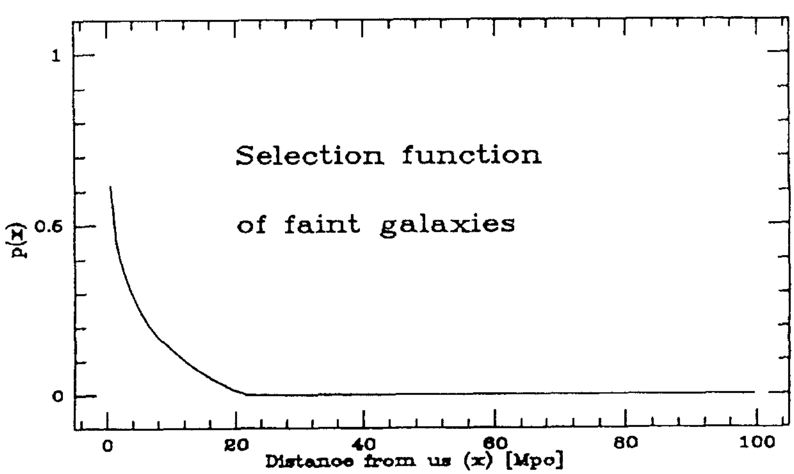

Fig. 3. The selection function of *faint* galaxies.

6 Result

The estimated correlation functions are plotted in *Fig. 4.* Note that the correlation function of *faint* galaxies breaks at about 8 Mpc because of its distance limit.

Let $\chi(r)$ be defined as follows:

$$\chi(r) = \frac{1 + \xi_{bright}(r)}{1 + \xi_{faint}(r)} \,. \tag{4}$$

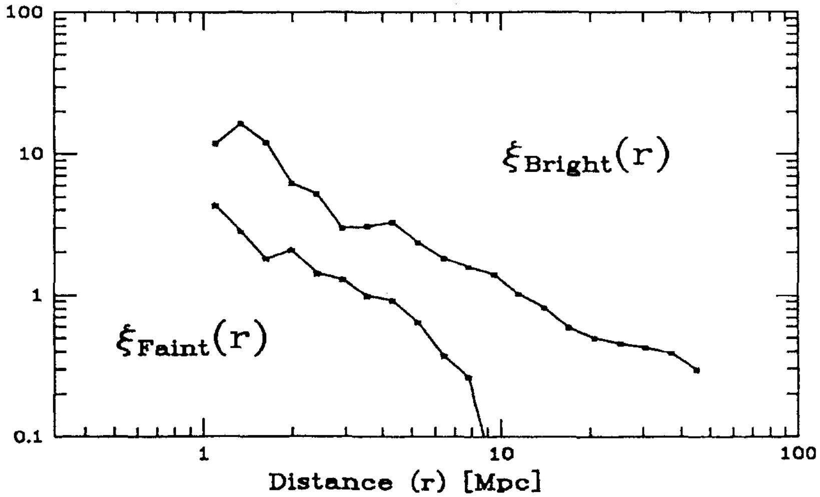

Fig. 4. The spatial correlation functions of *bright* and *faint* galaxies.

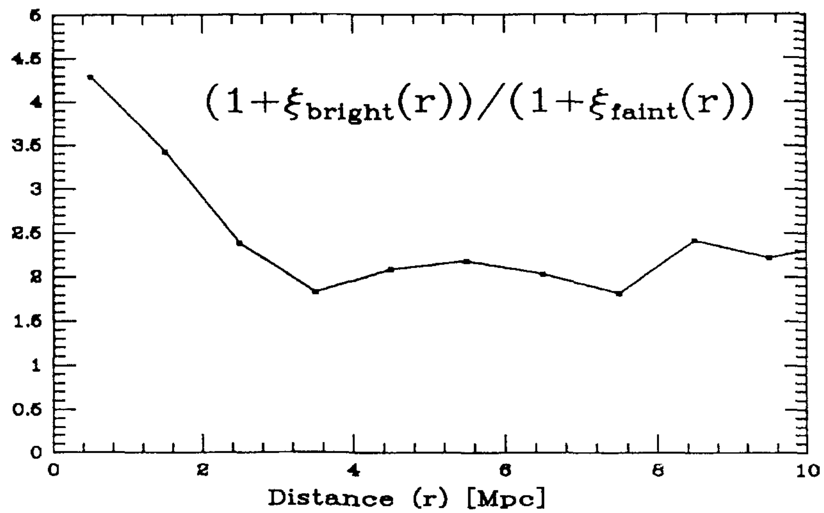

Fig. 5. Ratio of the normalized *bright* and *faint* pair frequencies.

Then we can establish (*Fig. 5*) that

$$2.5 < \chi(r) < 4.5 \qquad r < 2\,\mathrm{Mpc}\,,$$

and

$$\chi(r) = 2.15 \pm 0.1 \qquad 2\,\mathrm{Mpc} < r < 8\,\mathrm{Mpc}\,.$$

Above 10 Mpc ξ_{faint} is too noisy to estimate the ratio.

The constant ratio for distances 2 – 8 Mpc is interesting, but our most important result is that on small scales the *bright* galaxies are significantly stronger correlated than the *faint* galaxies. This contradicts the widespread and accepted assumption that correlation is independent of absolute magnitude.

Further studies are necessary to obtain a final answer.

References

Efstathiou, G., Ellis, R.S., Peterson, B.A., 1988. *Mon. Not. R. astr. Soc*, **232**, 431.