The Galaxy Luminosity and Selection Functions of the NOG sample

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Abstract. In order to map the galaxy density field on small scales in the local universe, we use the Nearby Optical Galaxy (NOG) sample, which is currently one of the largest, nearly complete, magnitude-limited ($B \leq 14$ mag), all-sky sample of nearby optical galaxies ($\sim 6400$ galaxies with $cz < 5500$ km/s). We have corrected the redshift-dependent distances of these galaxies for non-cosmological motions by means of peculiar velocity field models.

Relying on group assignments and on total B magnitudes fully corrected for internal and Galactic extinctions, we determine the total and morphological-type specific luminosity functions for field and grouped galaxies using their locations in real distance space.

The related determination of the selection function is meant to be an important step in recovering the galaxy density field on small scales from the NOG sample. Local galaxy density parameters will be used in statistical studies of environmental effects on galaxy properties.

1. Introduction

We use the Nearby Optical Galaxy (NOG) sample to reconstruct the galaxy density field in the local universe. This sample is an all-sky, magnitude-limited sample of nearby galaxies (with $cz < 5500$ km/s), which is nearly complete down to the limiting total corrected blue magnitude $B=14$ mag and comprises 6392 galaxies, of which 2789 objects are members of galaxy systems (with at least three members). The completeness level of the NOG sample limited to $|b| > 15^\circ$ (5832 galaxies) is estimated to be $\sim 80\%$.

The redshift-dependent distances of the field galaxies and galaxy systems have been corrected for non-cosmological motions by means of peculiar velocity field models (Marinoni et al. 1998a). Specifically, we employed two independent models: i) a semi-linear approach which uses a multi-attractor model (with Virgo, Great Attractor, Perseus-Pisces Supercluster and Shapley Concentration) fitting the Mark III peculiar velocity catalog (Willick et al. 1997); ii) a modified version of the optical cluster 3D-dipole reconstruction scheme by Branchini & Plionis (1996).
2. The Total Galaxy Luminosity Function

Adopting Turner’s (1979) method we evaluate the total galaxy luminosity function (LF) for for field and grouped galaxies, using their location in real distance space. Since the NOG sample comprises both bright and nearby galaxies, systematic errors in the determination of the LF are likely to minimized.

We find that the galaxy LF is well described by a Schechter function with $\alpha \sim -1.1$, a low normalization factor $\Phi^* \sim 0.006\,\text{Mpc}^{-3}$, and a particularly bright characteristic magnitude $M_B^* \sim -20.7\, (H_0 = 75\,\text{km}\,\text{s}^{-1}\,\text{Mpc}^{-1})$ (see Marinoni et al. 1998b for details). Our $M_B^*$-value is brighter, on average, by 0.4 mag than previous results, because, referring to total magnitudes corrected for Galactic extinction, internal extinction, and K-dimming, better represent the galaxy light.

The exact values of the Schechter parameters of the LF slightly depend on the adopted velocity field models (see Fig. 1), but peculiar motion effects are of the order of statistical errors; at most, they cause variations of 0.08 in $\alpha$ ($\sim 1\sigma$ error) and 0.2 mag ($\sim 2\sigma$ error) in $M_B^*$.

The presence of galaxy systems in the NOG sample does not affect significantly the field galaxy LF. Environmental effects on the total LF are proved to be marginal. The LF of the galaxy members of the richest systems tends to show a slightly brighter value of $M_B^*$, which gives some evidence of luminosity segregation with density.

3. The Morphological–Type Dependence of the Luminosity Function

We also evaluate the morphological type-specific LFs. The morphological types are available for almost all NOG galaxies.

The LF of E+S0 galaxies does not differ significantly from that of spirals. But the E galaxies clearly decrease in number towards low luminosities (with $\alpha \sim -0.5$), whereas the number of late-type spirals and irregulars rise steeply towards the faint end (with $\alpha \sim -2.3$ – -2.4). This behaviour hints at an upturn of the total LF in the unexplored faint end (at $M_B > -15$). In Fig. 2 we show a comparison between our type–specific LFs with those obtained from the CfA2 (Marzke et al. 1994) and the Stromlo–APM (Loveday et al. 1992; see also Driver, Windhorst & Griffiths 1995) samples.

As regards the morphological type–dependence of the LF, our results better agree with those derived from the CfA2 and SSRS2 (Marzke et al. 1998) samples than with the ones obtained from the Stromlo-APM survey. Moreover, the dependence of the LF on the morphological type appreciably differs from its dependence on the galaxy spectral classification as given by the LCRS (Bromley et al. 1998) and Autofib redshift survey (Heyl et al. 1997).
Figure 1. We compare the best-fitting Schechter functions obtained from six galaxy distance models: the Hubble relations evaluated in the CMB and LG frames, the multi–attractor models fitted on the total and spiral (Mark III∗) sets of Mark III data, the cluster dipole model, and a modified version of this model which includes a local Virgocentric infall. The inset shows the corresponding 1σ error contours for the joint distribution of errors of the Schechter parameters $\alpha$ and $M_B^*$. 
Figure 2. For the E–S0, Sabc, Sd–Im galaxies, we show the NOG LFs (solid line) (with true distances based on the multi-attractor model fitted on Mark III data) and the corresponding LFs obtained from the CfA2 (Marzke et al. 1994) (dotted–dashed line) and the Stromlo–APM (Loveday et al. 1992; see also Driver, Windhorst & Griffiths 1995) (dashed line) samples.
4. Local Galaxy Density and Environmental Effects

Underpredicting the observed galaxy number counts (e.g., Ellis 1997) at bright magnitudes ($B \sim 18$ mag), where little galaxy evolution is observed for the bulk of the galaxy population, our relatively low local normalization, which can not be biased low by photometric problems or by incompleteness of the sample, suggests that the nearby universe is underdense in galaxies (by a factor $\sim 1.5$).

Although the galaxy LF, as well as the intimately related selection function of the NOG sample, appear to be little sensitive to peculiar motion effects, these effects have a quite large impact on the local galaxy density, especially on the smallest scales.

We are calculating the local galaxy density of each galaxy in terms of the number density of neighbouring galaxies. This is done by smoothing every galaxy with a Gaussian filter (Giuricin et al. 1993; Monaco et al. 1994) and by correcting the incompleteness of the sample at large distances through the selection function of the sample. The main goal of this line of research is to use small-scale density parameters to analyze environmental effects on the properties of nearby galaxies.

References

Branchini, E. & Plionis, M. 1996, ApJ, 460, 569.
Bromley, B. C., Press, W. H., Lin, H. & Kirschner, R. P. 1998, preprint astro-ph/9711227.
Driver, S. P., Windhorts, R. O. & Griffiths, R. E. 1995, ApJ, 453, 48.
Ellis, R. S. 1997, ARA&A, 35, 389.
Giuricin, G., Mardirossian, F., Mezzetti, M. & Monaco, P. 1993, ApJ, 407, 22.
Heyl, J., Colless, M., Ellis, R. S. & Broadhurst, T. 1997, MNRAS, 285, 613.
Loveday, J., Peterson, B. A., Efstathiou, G. & Maddox, S. J. 1992, ApJ, 390, 338.
Marinoni, C., Monaco, P., Giuricin, G. & Costantini, B. 1998a, ApJ, 505, 484
Marinoni, C., Monaco, P., Giuricin, G. & Costantini, B. 1998b, ApJ, in press.
Marzke, R. O., da Costa, L. N., Pellegrini, P. S. & Willmer, C. N. A. 1998, ApJ, 503, 617.
Marzke, R. O., Geller, M., Huchra, J. P. & Corwin, Jr., H. G. 1994, AJ, 108, 437.
Monaco, P., Giuricin, G., Mardirossian, F. & Mezzetti, M. 1994, ApJ, 436, 576.
Turner, E. L. 1979, ApJ, 231, 645.
Willick, J. A., Courteau, S., Faber, S. M., Burstein, D., Dekel, A. & Strauss, M. A. 1997, ApJS, 109, 333.