Properties of 513 isolated galaxies in the Local Supercluster

I. D. Karachentsev and D. I. Makarov
Special Astrophysical Observatory Russian Academy Sciences, Nizhnij Arkhyz, Russia

V. E. Karachentseva
Main Astronomical Observatory, National Academy of Sciences of Ukraine

O. V. Melnyk
Astronomical Observatory, Kiev National University, Ukraine

Abstract. We introduce the first entire-sky catalog of the most isolated nearby galaxies with radial velocities $V_{LG} < 3500$ km/s. This kind of cosmic “orphans” amount to 4% among all known galaxies within the same velocity range. We describe a criterion of isolation applied to select our sample, the “Local Orphan Galaxies”, and discuss their basic optical and HI properties.

1 Introduction

The main goal of our project is to derive a representative sample of nearby isolated galaxies useful for testing galaxy evolution in low density regions of the Local universe. At present, there are only two all-sky samples of isolated galaxies: a list of 197 galaxies in the Local Volume ($= LV$, $D < 10$ Mpc) with negative tidal indexes (Karachentsev et al., 2004), and a catalog of 3227 2MASS-selected isolated galaxies (Karachentseva et al., 2010 = 2MIG) compiled in a similar manner as the catalog of isolated galaxies on the northern sky (Karachentseva, 1973 = KIG). Both the last catalogs have a typical depth of $\sim 80$ Mpc. To fill up the gap between LV and 2MIG, we create a new sample of “Local Orphan Galaxies” situated in the Local Supercluster within $D < 45$ Mpc.

2 Initial data and the isolation criterion

We tested on isolation $\sim 10500$ galaxies with radial velocities in the Local Group rest frame $V_{LG} < 3500$ km/s situated at galactic latitudes $|b| > 15^\circ$. First, we cleaned spurious data arrived from automated sky surveys: SDSS, 2dF, 6dF, DEEP2, etc., then determined $B$-magnitudes and morphological type if absent. The observed $H, I, R, V, B$-band magnitudes were transformed into $K_s$ ones to derive the $K$-band luminosity of the galaxies. We bound the galaxies in systems based on the following algorithm, which took into account individual properties of galaxies. Thus, two arbitrary galaxies were considered as a pair if their mutual
radial velocity $V_{ik}$ and projected separation $R_{ik}$ satisfy the condition of negative total energy:

$$V_{ik}^2 R_{ik} / 2GM_{ik} < 1,$$

where $M_{ik}$ is the total mass of the pair. We use also the second condition that the pair components locate inside their “zero-velocity” sphere:

$$\pi H_0^2 R_{ik}^3 / 8GM_{ik} < 1,$$

where $H_0$ is the Hubble constant. Here we determined masses of galaxies from their $K$-band luminosity, assuming one and the same ratio

$$M/L_K = \kappa \left( M_{\odot} / L_{\odot} \right)$$

with a dimensionless parameter $\kappa = 6$. This quantity corresponds to the mean cosmic ratio of dark-to-luminous matter.

We identified all pairs satisfying conditions (1)–(3) and then grouped all pairs with a common component into a single entity. As a result, we created the catalogs of binary galaxies (Karachentsev & Makarov, 2008), triple galaxies (Makarov & Karachentsev, 2009), and members of groups (Makarov & Karachentsev, 2010). This algorithm leaves 46% of galaxies as not clusterized, “field” ones. Apparently, the higher adopted quantity $\kappa$, the lower fraction of field galaxies. Increasing the $\kappa$ in 40 times, we derived a fraction of isolated galaxies to be 10%. Finally, we applied to them the Karachentseva’s (1973) criterion of isolation and obtained the sample of 513 Local Orphan Galaxies (LOGs). Our subsequent spectral observations of neighbouring galaxies around the LOGs manifest (Melnyk et al., 2009) that most of them turn out to be background objects with a median difference of radial velocities $+9400$ km/s regarding to LOGs. We conclude that our sample amounts to (85-90)% true, spatially well isolated galaxies.

3 Some properties of the LOG sample

Distribution of the isolated galaxies on the sky in equatorial coordinates is shown in Fig.1.
Isolated Galaxies in the Local Supercluster

The sky distribution looks quite smooth without prominent over- and under-densities in the regions of known clusters/voids. Fig.2 presents the distribution of radial velocities of the galaxies within bins of 250 km/s. The shaded histogram is for galaxies detected in IRAS. Spatial distribution of LOGs in cartesian Galactic coordinates (Fig.3) exhibits only a moderate clumpiness seen on a scale of 5-10 Mpc.

The sample of LOGs is dominated by flat, bulgeless galaxies (Fig.4). About 75% of the sample are late type objects (T >Sc) with a peak at T = 8 (Sdm). Notice that the LOG galaxies seen in IRAS have a wider peak at T = 4 – 6. Being the distance limited (but not flux-limited) sample, the LOG catalog is over-represented by dwarf galaxies in comparison with KIG and 2MIG samples.

Fig.5 demonstrates distribution of LOGs according to their $K$-magnitudes and HI-fluxes in the logarithmic scale. The diagonal lines indicate the total gas-to-stellar mass ratio equal to: 0.01, 0.1, 1, 10 and 100. Most of the LOGs are gas-rich galaxies with the median $M_{\text{gas}}/M_{\text{star}} \sim 1$.

The E and S0 galaxies, like their nearest representator NGC 404, amounts to a minor (4%) fraction of LOGs. They stand out against normal E and S0 galaxies situated in groups and clusters by a low median luminosity ($M_B = -17^{m}6$) and the presence of gas and dust.

We found among LOGs about 20 objects having peculiar structures: distorted/asymmetric shape or tails that can be interpreted as a result of recent merging or current interaction with a massive invisible body (dark sub-halo). Such well isolated but peculiar objects deserve closer attention to understand their kinematics and structure.

Figure 2. Distribution of LOGs on radial velocities with respect to the Local Group centroid. Galaxies detected in IRAS are shaded.

Figure 3. Spatial distribution of LOGs in projection into Galactic plane coordinates.
Figure 4. Histogram of morphological type distribution for the LOG sample. Galaxies detected in IRAS are shaded.

Figure 5. Logarithm of HI- flux (in Jy km/s) vs. K- magnitude for the LOGs (dots). Galaxies with upper limits of HI- fluxes are shown by open triangles. Diagonal lines indicate different levels of gas-to-stellar mass ratio.

Acknowledgments. This work has been supported by Russ-Ukr grant 09-02-90414, Ukr-Russ grant F28.2/059, RFBR grant 07-02-00005 and RFBR-DFG grant 06-02-04017.

References

Karachentseva V.E., 1973, Communic. Special Astrophys. Obs., 8, 3 (=KIG)
Karachentseva V.E., Mitronova S.N., Melnyk O.V., Karachentsev I.D., 2010, this volume (=2MIG)
Karachentsev I.D., Makarov D.I., 2008, Astrophysical Bulletin, 63, 320
Karachentsev I.D., Makarov D.I., Karachentseva V.E., Huchtmeyr W.K., 2004 AJ, 127, 2031 (=LV)
Makarov D.I., Karachentsev I.D., 2009, Astrophysical Bulletin, 64, 24
Makarov D.I., Karachentsev I.D., 2010, Astrophysical Bulletin, in preparation
Melnyk O.V., Karachentseva V.E., Karachentsev I.D., Makarov D.I., Chilingarjan I.V., 2009, Astrofizics, 52, 203