Number Count of 2MRS Galaxies in the J, H, K Bands

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Abstract

The Copernican principle has been the motivation for the present study on the number density of galaxies. In this work we have carried out a number count of galaxies in the 2MRS catalog in the K, H and J bands. The results presented here have obtained on volume-limited samples with equal widths or redshift bins. The main result of this study is the number count of galaxies which have been plotted in concentric spherical shells with the observer at the center. The obtained result in the three bands show a similar behavior up to a distance of 1.7×10^2 Mpc and behave differently from there on.

Keywords: *Number Count - J, H, K Band - 2Mass Redshift Survey - Copernicious Principal.*

1 Introduction

The Copernican principle states that the Earth is not at a preferred position in the universe, thus one might study if observational data are consistent with this assumption? The importance of the principle is closely connected to the Cosmological principle, stating that the universe must be homogeneous and isotropic. In recent years many authors have discussed the question if the principle holds, cf. (Labini 2010; Jia et al. 2008; Uzan 2009; Uzan et al. 2008; Caldwell et al. 2008; February et al. 2013) .However they have not explicitly studied whether the Copernican principle stands up to observational tests.

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2 The Database

We chose the 2MRS (2Mass Redshift Survey) for the purpose of our study. This catalog is currently one of the most comprehensive surveys of the galaxies, which has been compiled in the near infrared. For the completion of this survey, the spectra of some of the around a million galaxies of the original 2Mass (2 Micron All Sky Survey) have been taken, and the recession velocity has been measured at three wavelengths, (J 1.24 μm), (H 1.66 μm), (K_s 2.16 μm). The resulting catalog, at which our study was aimed, comprises a number of 43533 galaxies, for each 25 parameters have been reported in the data. For our analysis the following parameters are relevant: Identity code, right ascension and declination, galactic coordinates, the photometric magnitude in the J, K, H bands together with their errors, galaxy type, redshift (or recession velocity) and its error. Other parameters such as distance, apparent magnitude, distance modulus, . . . for each galaxy have been calculated in the analysis, as detailed in the next section. (cf. Huchra et al. 2011; Tekhanovich et al. 2016)

3 Data analysis and calculations

In order to obtain the number counts and the corresponding number densities, we have assumed concentric circles with the Milky Way at the center. The spaces between two such spheres are consecutive spherical shells, defining the examination volumes. After applying the selection criteria, we have counted the galaxies in each spherical shell, determining the number density of the galaxy types at each distance. Thus in this section we describe how the calculations are made and the selection criteria are applied. Part 1 deals with the calculation of the distance, part 2 the volume, the volume-limiting schemes, and accordingly the denominator of the number counts. Part 3 describes the way the magnitude limits have been applied to calculate the numerator of the number counts and in part 4 the results and the diagrams are presented. (cf. Shafieloo et al. 2010; Stefanon et al. 2013)

3.1 Distances

Given the redshifts of each galaxy z, we require a relation to convert the redshifts to a distance, which we take from eq. 10 in Riess et al. 2004 and Bassett et al. 2015 as:

$$d_l(z) = \frac{cz}{H_0}\big[1 + \frac{1}{2}(1 - q_0)z - \frac{1}{6}(1 - q_0 - 3q_0^2 + j_0)z^2 + \mathcal{O}(z^3)\big] \qquad (1)$$

Here H_0 and j_0 are the Hubble and the jerk parameters, respectively. Here the values $H_0 = 70.8\ km.Mpc^{-1}.s^{-1}$. and $j_0 = 1$ have been assumed according to Pop Lawski 2006. $\mathcal{O}(z^3)$ denotes terms of third and higher orders in the Taylor expansion. q_0 is the deceleration parameter, determined by $\frac{1}{2}\Omega_m - \Omega_\Lambda$. The values which we have entered here are 0.6911 and 0.3089 (cf. Springel et al. 2006; Riess et al. 2004) and thus added two columns to the original catalog.

3.2 Volume

For the calculation of the number density as a fraction of number divided by volume, we need to subdivide the total volume according to distance of the farthest galaxy in the catalog. If we draw concentric spheres with the milky way at the center, each with a radius of ca. 12.7 Mpc larger than the previous one, there will be around 40 spheres up the furthest point. Then we take the volume between two consecutive spheres as a shell.

The shell volumes are calculated as:

$$V(spher) = V_s|_{d_2} - V_s|_{d_1} = \frac{4}{3}\pi d_1^3 - \frac{4}{3}\pi d_2^3. \tag{2}$$

The conic volumes which have to be excluded are:

$$V(roll) = \frac{(S|_{d_2} - S|_{d_1})}{2} \times (d_2 - d_1), \tag{3}$$

With $S_d = 2\pi d \times D$ and $D = \frac{d\times\theta('')}{206205}$ finally giving:

$$V(\text{each l}) = V(spher)|_l - V(roll)|_l. \tag{4}$$

Taking into account the part of the sky obscured by dust in the Milky Way, the conic volume representing the zone of avoidance, and consequently, a conic section must be subtracted from each spherical shell. The subtracted conic sections and the distribution of the galaxies in declination and right ascension are shown in Figures 1 and 2 respectively. The volumes of the spherical shells takes into account the distances and the corresponding position angles of the galaxies.

3.3 Magnitudes

The number of galaxies in each shell represents the numerator of the number density fraction. Thus the number of the galaxies in each shell has to be normalized. The normalization is carried out by taking into account the magnitude limit as the criterion. For the determination of the critical magnitude limit in each shell, we take the galaxy with highest absolute magnitude and calculate the corresponding apparent magnitude by the relation:

$$m_k = M_k + 5\log_{10}(d_l) + 25 + e_k \tag{5}$$

where e_k is error.

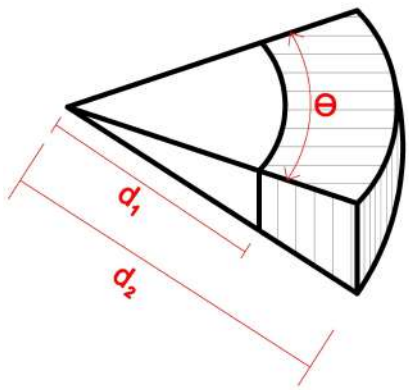

Figure 1: Volume determination

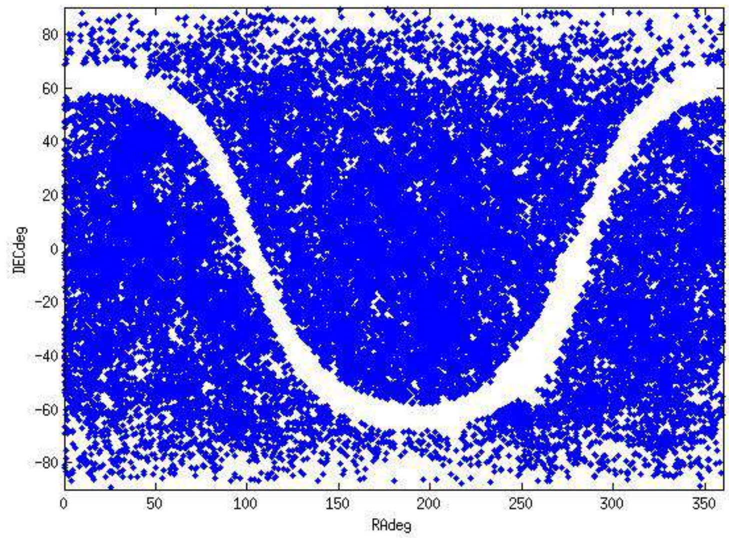

Figure 2: Angular distribution of galaxies

We take m_k as the as the critical magnitude limit of that shell Riess et al. 2004 . If a galaxy fulfills the condition $m_k < m_g$ the galaxy with the magnitude is kept and otherwise excluded. This procedure ensures that galaxies in each shell are selected with the same limit in absolute magnitude, in other words each shell is a volume-limited subsample. This procedure is repeated for all three wavelengths.

3.4 Results

We have obtained the number of galaxies in each shell according to the above described procedure separately. This procedure is repeated for all three wavelengths J, H, K. The number densities of each shell have been

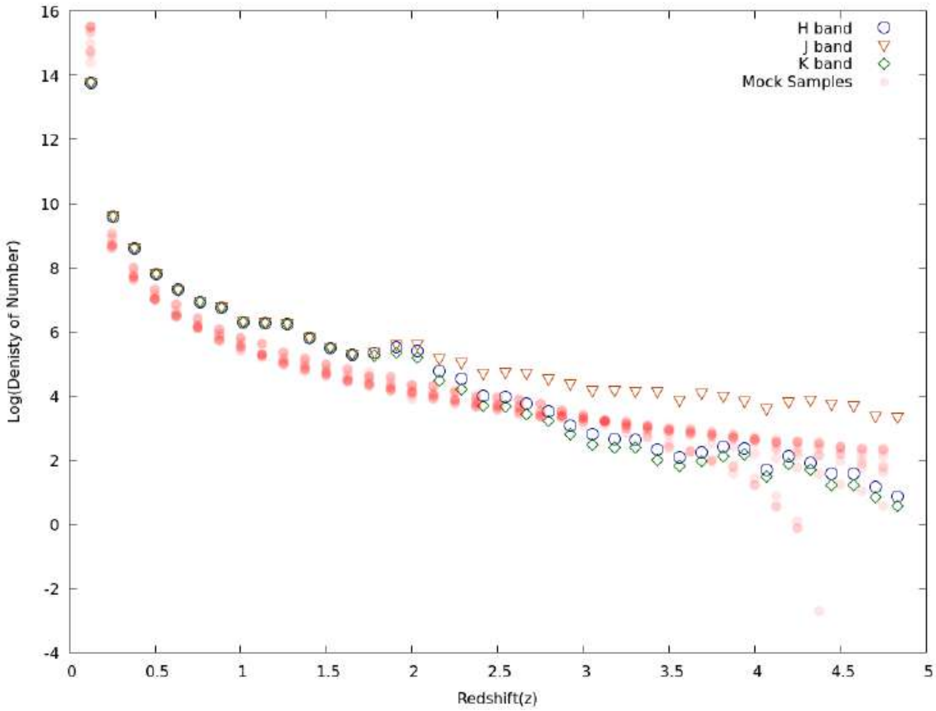

Figure 3: Density of Numeber in J, K, H Band and Mock Sapmles

plotted against the mean redshift of each shell in figure 3, and has been compared to corresponding mock distributions. The first step in the generation of mock samples is a 3 dimensional distribution of points with x, y, z coordinates between 0 and 1, which are created with a random number generator. On this basis we create a 3 dimensional map of mock galaxies, each with a right ascension, a declination and a luminosity. Different from the positions, the luminosities are generated with a distribution to comply with the Schechter function(cf. Singh et al 2016):

$$\Phi(M)dM = 0.4\log(10)\Phi_{*}10^{0.4(M_{*}-M)(\alpha-1)}e^{-10^{0.4(M_{*}-M)}}dM \quad (6)$$

The normalization is:

$$\Phi_{*} = 0.002(h_{0.5})^{3}MPc^{-3} \pm 10\%$$

With the magnitude is:

$$M_{*} = -21.0 + 5\log_{10}(h_{0.5}) \pm 0.25$$

And the slope parameter is:

$$\alpha = 1.20 \pm 0.1.$$

4 Conclusions and discussion

According to the results obtained in the three wavelengths as shown in figure 3 we conclude that this data may be used for the study of the Copernican principle. Such a study requires a comparison of real data from the 2MRS with repeatedly generated mock catalogs, with the same selection criteria as the observations. Mock catalogs can be designed conforming to the Copernican principle or to violate it in some certain predefined way. This study is currently underway.

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