Cosmology Tutorial 1

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1

$$f = \frac{L}{4\pi r^2} \tag{1}$$

and differentiating

$$\frac{df}{dr} = -\frac{L}{2\pi r^3} \tag{2}$$

Number density $= \frac{1}{r}$ so

$$N = \frac{4}{3}\pi r^3 \times \frac{1}{r} \tag{3}$$

$$N = \frac{4\pi r^2}{3} \tag{4}$$

and differentiating

$$\frac{dN}{dr} = \frac{8\pi r}{L} \tag{5}$$

dividing equation 5 by equation 2 gives

$$\frac{dN}{df} = \frac{-48\pi^2 r^4}{L} \tag{6}$$

so that

$$\frac{dN}{df} \propto r^4 \tag{7}$$

$r^2 \propto f^{-1}$ so that

$$\frac{dN}{df} \propto f^{-2} \tag{8}$$

Therefore $\alpha = -2$. $dlnf = \frac{1}{f}df$ so that

$$\mathcal{N} = \frac{dN}{dlnf} = f\frac{dN}{df} \tag{9}$$

which gives $\mathcal{N} \propto f^{-1}$ and so

$$log\mathcal{N} = -logf + const \tag{10}$$

This is linear so measuring stellar fluxes would allow an observer to determine if the distribution was homogeneous.

2

The NRAO VLA Sky Survey (NVSS) is a radio survey covering the sky north of -40 declination at 1.4GHz. It contains over a million rows so I extracted a subset of sources where the flux density $> 100mJy$ giving appoximately 62,000 sources.

The Two Micron All Sky Survey (2MASS) Redshift Survey (2MRS) was a ten-year project to map the full three-dimensional distribution of galaxies in the nearby universe. It provides a good census of baryonic matter in the nearby universe (to about 300 Mpc). It contains about 400,000 rows so I only extracted sources with a magnitude < 13 in the K band giving about 44,000 rows.

The 2MASS Extended Source Catalog (2MASX) contains over 1.6 millions rows and suveys the entire sky in the J, H and K bands. I restricted the output to sources with a magnitude of < 13 in the J band giving about 77,000 rows.

3

Figure 1 shows a log of number counts per log flux for the NVSS. The slope was calculated:

$$\frac{log(2000/1000)}{log(100-200)} = -1 \tag{11}$$

This figure matches quite well with the figure of -1.5 calculated for a homogeneous universe. The slope is constant apart from very small flux densities (probably due to sampling errors) and large flux densities (the universe is not homogeneous on smaller scales).

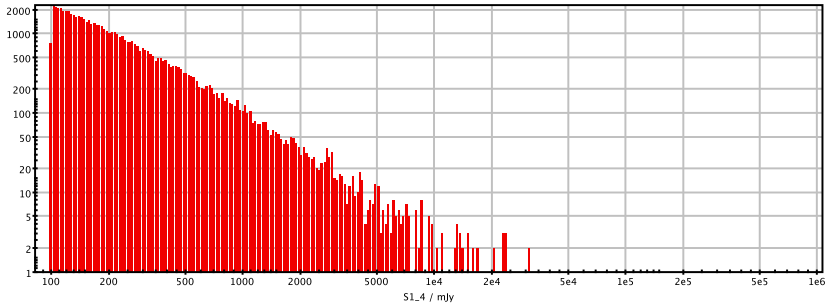

Figure 1: NVSS

Figure 2 shows a log of number counts per magnitude in the K band for the 2MRS survey.

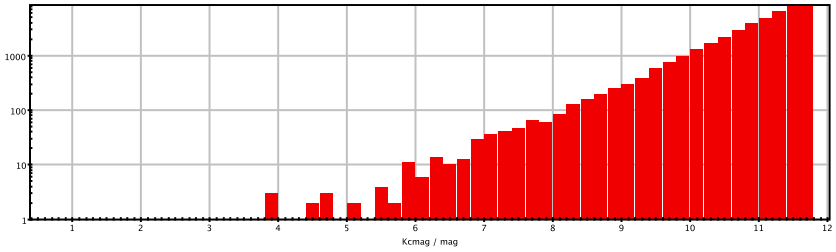

Figure 2: 2MRS

The slope was calculated as:

$$\frac{log(1000/100)}{10/7} = .8 \tag{12}$$

This also reasonably matches the expected slope of .6 for a homogeneous universe. Finally figure 3 shows a log of number counts per magnitude in the J band for the 2MASX survey.

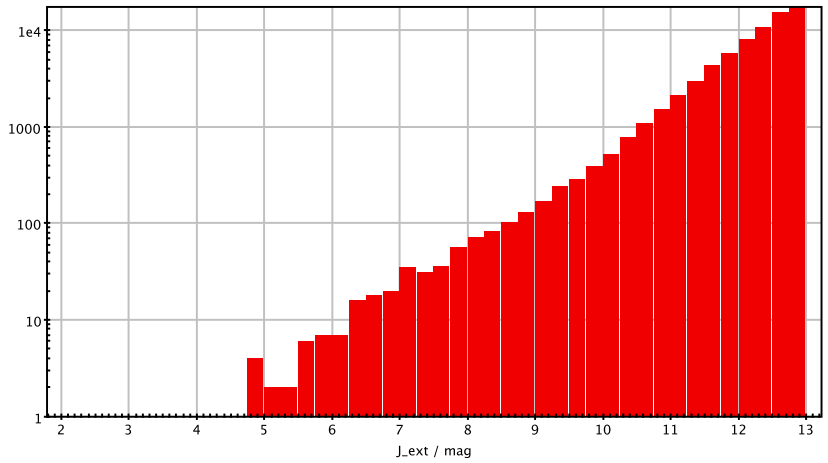

Figure 3: 2MASX

The slope was calculated as:

$$\frac{log(10000/1000)}{12/11} = .9 \tag{13}$$

This is a similar figure to the 2MRS survey.

4

Figure 4 shows the 2MRS data in galactic coordinates restricted to the the closest half of the galaxies i.e. $cz < 8000$ km/s. It clearly shows evidence of structure indicating that the universe is not homogeneous on smaller scales.

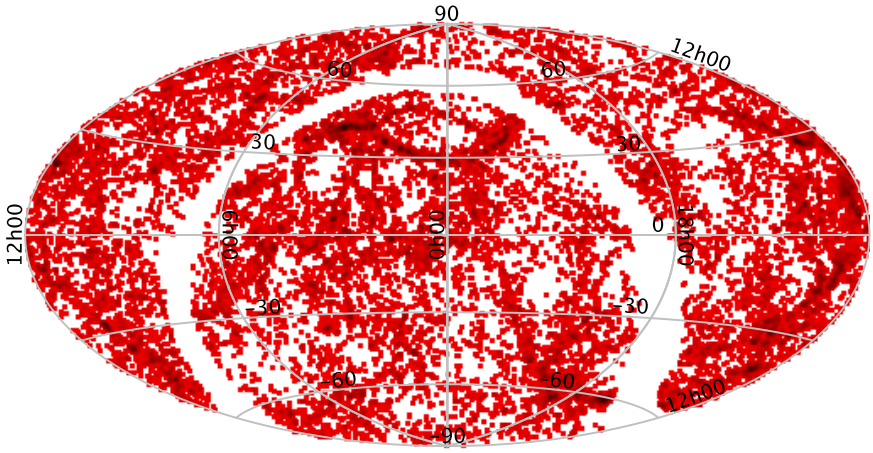

Figure 4: 2MRS