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Galactic Distribution in Nearby Sky

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1 OVERVIEW

During the recent LSC meeting, two groups presented the results of their calculations where they evaluated different LIGO design improvements and their effects on extending the range of detection in the sky. In making the calculations these studies have assumed a uniform and isotropic distribution of sources in the sky. We have looked at this last assumption and tried to make a more quantitative statement about the validity of this assumption and more importantly have compiled a matter distribution metric, from the available data, that can be used in future calculations.

2 OBSERVATIONS

This analysis is based on Brent Tully's Nearby Galaxies Catalog (NBG) (Tully 1988a) . The virtue of this catalog is a reasonably homogenous coverage of the entire unobscured sky, extending out to a distance of almost 50 Mpc. This catalog contains 2367 galaxies. Any object fainter than $M_b = -16$ is not included in this catalog (see Figure 1). Note that counts at $D \sim 17 Mpc$ are high

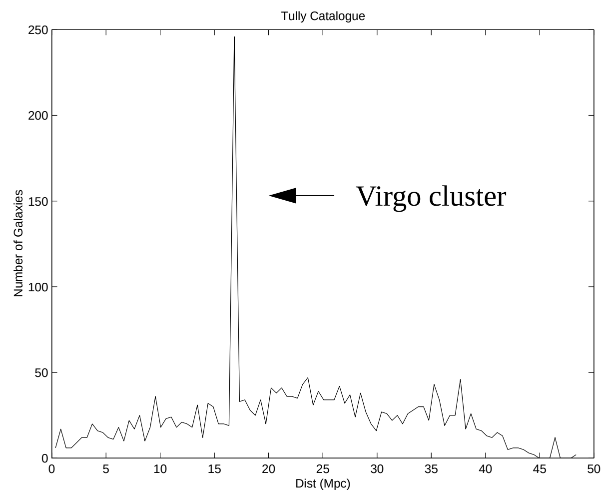

Figure 1: Distribution of Galaxies from Tully's NBG. The spike is the Virgo cluster.

because of the local concentration of galaxies in and around the Virgo cluster.

We also looked at Sandage's Atlas of Galaxies, Zwicky Catalog and UGC Catalog. However,Tully's NBG Catalog seemed to be unique in its coverage of the sky, as others, although extending farther out in sky, were more pencil-like probes or covered wedges in the sky.

3 ANALYSIS

If galaxies were distributed uniformly on average, with a mean number density n, then the mean number of galaxies would just be proportional to the volume of sky and thus to R^3 (strictly speaking this is true only in a Euclidean space, which is a good approximation for the distance scales involved in this note), where R is the radius of the sphere. The distribution of the total number of galaxies as a function of the distance- scale for the NBG catalog does not show this R^3 behavior as illustrated in Figure 2.

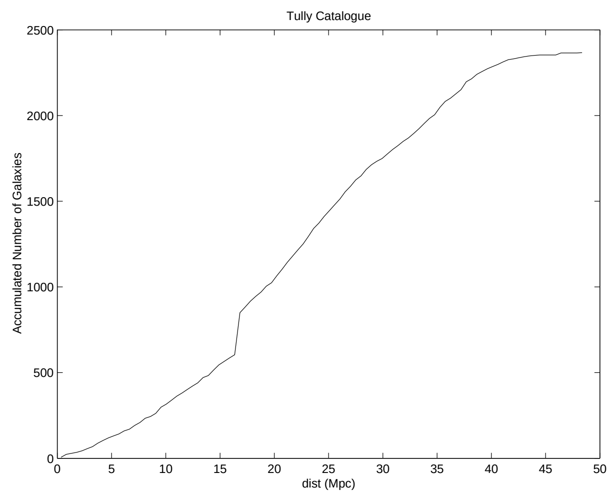

Figure 2: Integrated number of galaxies as a function of distance from NBG catalog.

The incompletion of the NBG catalog within various shells of depth equal to 0.5 mag was evaluated by Tully (Tully 1988b). He compared the observed number of galaxies with the number expected from the normalized suitable Schecther-type (Schechter 1976) galaxy blue luminosity functions, using a cutoff of $M_b = -16$ for the galaxy blue absolute magnitude. The cutoff is chosen since incompletion is extreme and the luminosity function is poorly defined at fainter levels. The parameters used in the Schecter luminosity function are $M^* = -20.18$ and $\alpha = -1.0$, where M^* is related to the parameter L^* of the luminosity function

$$\phi(L)dL = \phi^*\left(\frac{L}{L^*}\right)^{\alpha}\exp\left(-\frac{L}{L^*}\right)d\left(\frac{L}{L^*}\right)$$

by the relation $M^* = 5.48 - 2.5\log L^*$. More than 90% of the NBG galaxies appear to have absolute luminosities greater than that limit. The smooth curve which describes the observed increase in incompletion with distance R (in Mpc) obeys the expression (Tully 1988b)

$$F = \exp[0.041(\mu - 28.5)^{2.78}]$$

where $\mu = 5\log R + 25$ is the distance modulus and $F = 1$ if $\mu < 28.5$. The incompletion factor F expresses the number of galaxies that should have been cataloged for each object that is listed in the NBG catalog at a given distance. The incompletion function as a function of distance R is plotted in Figure 3.

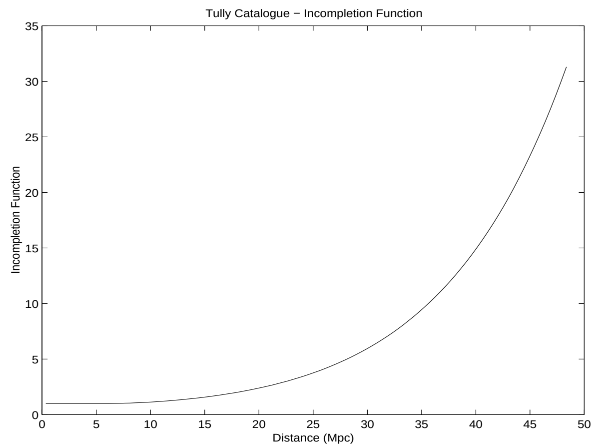

Figure 3: Incompletion as a funtion of distance in (Mpc).

Using the incompletion function, we correct the distribution of the galaxies as function of their distance (see Figure 4a). Once the correction is made the total number of galaxies as a function of their distance is again calculated (Figure 4b).

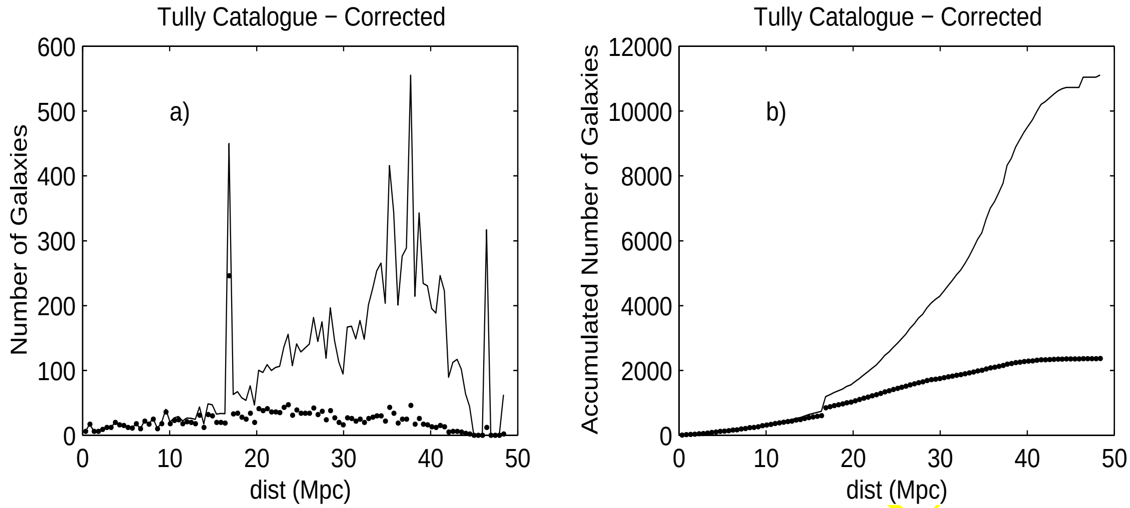

Figure 4: a) Distribution of Galaxies after correction with the incompletion function. b) Integrated number of galaxies as a funtion of distance using the corrected distribution in a). In both figures the distributions before the correction is shown as dotted line.

Plotting this distribution in a log-log plot along with a distribution expected from a simple R^3 model illustrates that the NBG distribution grows less rapidly than an R^3 law would predict. The discrepancy is more pronounced at scales closer than the Virgo cluster, where the slope of the line in this log-log plot is ~1.5. At distances beyond the Virgo cluster the slope of the line is ~2.4. This is shown in Figure 5.

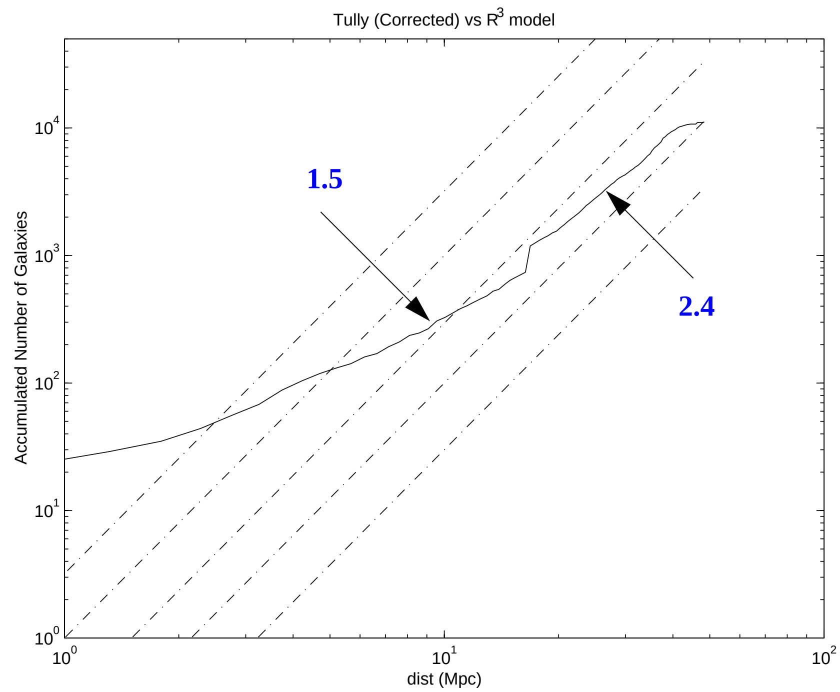

Figure 5: Integrated number of galaxies as a function of distance from NBG catalog plotted in a log-log scale. The dashed lines are contours of what would be expected from a distribution which would scale as R^3. Also shown are the slope of the line segments for the NBG distribution.

4 CONCLUSIONS

We have looked at Tully's NBG catalog of galaxies, which extends to a distance of 50 Mpc. Using an incompletion function we estimated the total number of galaxies as a function of their distance, R. We see that this distribution grows less rapidly than what one would expect from a simple R^3 model, especially at distance scales closer than the Virgo cluster.

We note that this distribution derived from observational data can be used in the future analysis to better ascertain the efficiency of various LIGO enhancement technologie.

5 REFERENCES

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