Physci 120, Spring 2009

Homogeneity of the universe on large scales

Introduction

In the previous lab you have explored clustering of galaxies on scales of about a megaparsec to a few megaparsecs. On these scales galaxies form a variety of different structures: from groups and clusters of galaxies to filaments. However, when we solve equations of general relativity to describe the evolution of the universe as a whole we assume the cosmological principle that states that universe is homogeneous (i.e., distribution of galaxies and matter is uniform) and isotropic (things look the same in different directions. In this short lab, you will try to test how true this is.

Studying galaxy distribution on large scales.

The method we will use is the same statistical approach you used in a previous lab to study distribution of galaxies on smaller scales.

First, you will need the Google Sky script named `SDSS Galaxy Query by R-Magnitude Bins`, which you have used before (turn off all other scripts you have used before in the previous labs). Recall that this script identifies all galaxies within a given range of apparent r-filter magnitudes within your field of you of the SDSS survey. Uncheck all magnitude ranges except for 16-17 (the brightest range, you should see only white circles then). Now zoom-in onto an SDSS field to the point, when the angular scale is close to $1^\circ\,0'$ (one degree). Try to resize the left menu area such that the sky viewing area is as close as possible to a square shape. Wait until the script queries the SDSS database. After it is done, you will see galaxies in the SDSS catalog in the magnitude range $m_r = [16-17]$ in your field marked with white circles. Count them and record the number. Also click on several of them to estimate the typical redshift to these galaxies - a dozen or so redshifts should be fine. Record the *median* redshift (redshift value for which half of galaxies you checked have redshifts smaller than it, and half half value larger than it).

Now without changing the zoom level (so that the angular extent of the viewing area stays the same — this is important!) shift to some other area fairly distant from the first one. Try to choose an area devoid of very bright stars which can block some areas and result in missed galaxies. After the script stops querying and draws circles in your field, count galaxies marked by white circles in the new field again and record the count. Do this for a total of 20 fields (make sure that you do not reach the boundary of the SDSS survey when you do this — there should be no sign of the DSS Consortium imagery near the bottom of the viewing field, only the SDSS survey; the quality of the DSS images is much worse than the SDSS so it should be easy to notice). You can share this work between two of you as there will be more galaxies per field in this case than what you dealt with before, so counting may become quite monotonous. Record the number of galaxies within each field that you examine.

Just like before, once the counts are ready, compute the mean number of galaxies per field, by summing all counts and dividing the sum by the number of fields. This will be the average count number $\bar{N}$. Now perform the same analysis as on smaller angular scales than in previous lab. Sort the counts by the number of galaxies (i.e. first the smallest number, then the next smallest, and so on until the field with the largest number of galaxies). Recall that if the distribution was purely uniform, the distribution of counts among fields would be consistent with the Poisson distribution. Use an applet available at: `http://stattrek.com/Tables/Poisson.aspx` to calculate how likely it is that a given count would be observed according to the Poisson distribution with the mean counts $\bar{N}$ for each of the field.

Lab tasks:

- *Present a table with counts for 20 fields and average count* $\bar{N}$ *you obtain.*
- *Do you find fields with counts which the cumulative Poisson probability either* < 0.05 *or* > 0.95*? (such fields could be considered unlikely for 20 fields, the closer the cumulative probability is to either 0 or 1, the more unlikely the count).*
- *Using the median redshift of galaxies in this magnitude range that you estimated, calculate the physical scale (in Megaparsecs) corresponds to one degree on the sky.*
- *What can you conclude about uniform the galaxy distribution is on this scale?*