City-City Correlations Lab to Introduce Galaxy-Galaxy Correlations

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Abstract

Large Scale Structure (LSS) is commonly characterized by the two-point galaxy-galaxy correlation function. But the meaning of the correlation function is somewhat abstract for typical undergraduates. A lab has been developed that enables students to find the 2-dimensional, two-point city-city correlation function for populous regions of the United States. The favorable correspondence between this function and a student’s intuition enables the student to develop a clearer idea of the meaning of the correlation function in 3-dimensions for galaxies. By analyzing Sloan Digital Sky Survey (SDSS) data, the student will discover that the two correlation function graphs are quite similar.

Uses of Correlation Function

- Characterizes Large Scale Structure
- Peculiar velocity separated from Hubble flow
- Baryon Acoustic Oscillation peak measured
- Dark matter percentage measured

Two-Point Galaxy-Galaxy Correlation Function

Probability of finding a galaxy in each of the randomly placed volume elements $dV_1$ and $dV_2$ in a uniform distribution of galaxies is

$$dP_1dP_2 = \frac{n_1}{N} N_2 dV_1 dV_2$$

where $n$ is number density, $N$ is galaxy number. In the presence of gravity, the probability of finding a galaxy in each of the volume elements $dV_1$ and $dV_2$ separated by a distance $r$ is

$$dP_1dP_2 = \frac{n_1}{N} (1 + \xi(r)) dV_1 dV_2$$

where $\xi(r)$ is the two-point correlation function

$$\xi(r) = \frac{DD(r)}{RR(r)} - 1$$

$<DD(r)>$ = number of galaxy-galaxy pairs at separation $r$  
$<RR(r)>$ = number of pairs at separation $r$ for a random distribution of galaxies

Does City Clustering Resemble Galaxy Clustering?

- Let 1 pixel of city light be equivalent to 1 galaxy
- Choose a group of clustered cities
- Calculate the correlation function for that cluster of cities
- Calculate the redshift space correlation function for a sample of SDSS galaxies: 0.019 < z < 0.13, –22 < $M_r$ < –19

Reference


Acknowledgements

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<table>
<thead>
<tr>
<th>Summary</th>
<th>City Cluster</th>
<th>Galaxy Cluster</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cluster radius</td>
<td>40 mi</td>
<td>10 Mpc</td>
</tr>
<tr>
<td>Corr. Function Cluster to Cluster distance</td>
<td>200 mi</td>
<td>350 Mpc</td>
</tr>
<tr>
<td>Av. Cluster to Cluster distance</td>
<td>230 mi</td>
<td>N/A</td>
</tr>
</tbody>
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