NETWORK ANALYSIS OF GALAXY DISTRIBUTIONS

We have applied simple analysis techniques developed for studying complex networks to the study of the cosmic web, the large-scale galaxy distribution. A galaxy sample with a redshift between 0.91-0.94 is analyzed as a two-dimensional projection for the spatial distributions of galaxies. The aim is to construct and analyze a network of galaxies, utilizing the information on their spatial distributions, types, and other physical characteristics.

INTRODUCTION

The aim is to study the observable Cosmic Web with the aid of complex networks, develop and validate a universal approach for extracting topological environments from the observational data, in order to investigate the relation between properties of a galaxy and its place in large-scale structures, such as clusters, voids, walls, etc.

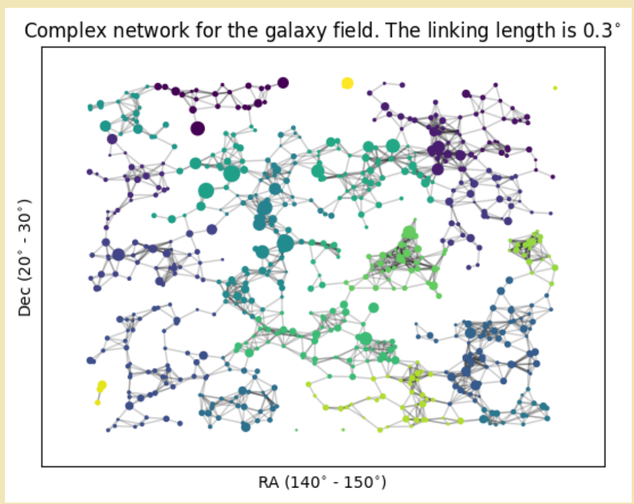
METHODOLOGY

The data set used for the analysis is taken from the Sloan Digital Sky Survey (SDSS). It includes celestial properties such as the coordinates of the galaxy, its redshift, and photometric magnitudes. The galaxy data provided by the SDSS survey covers a 10 deg × 10 deg sky area and contains information for a total of 750 galaxies. The linking length is taken as 0.17 deg.

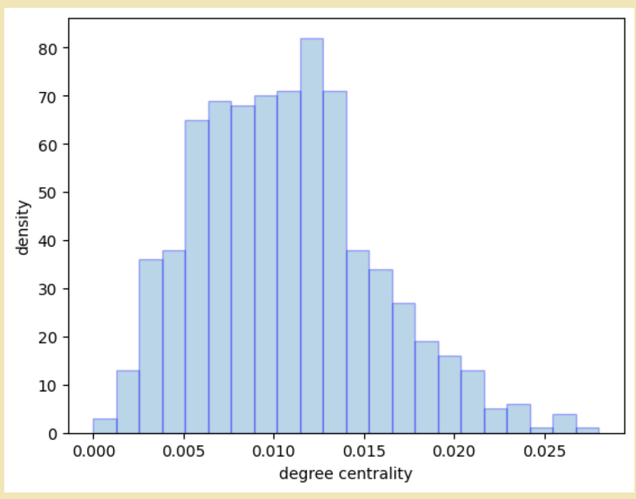
RESULTS

Number of nodes (n) = 750
Number of edges (m) = 2961
Average degree (<k>) = 7.9
Mean shortest path of the GCC (<l>)= 16.05
Number of nodes in the GCC (g)= 742
Diameter of the GCC (D)= 42
Mean clustering coefficient (<C>)= 0.6
Assortativity (r) = 0.69

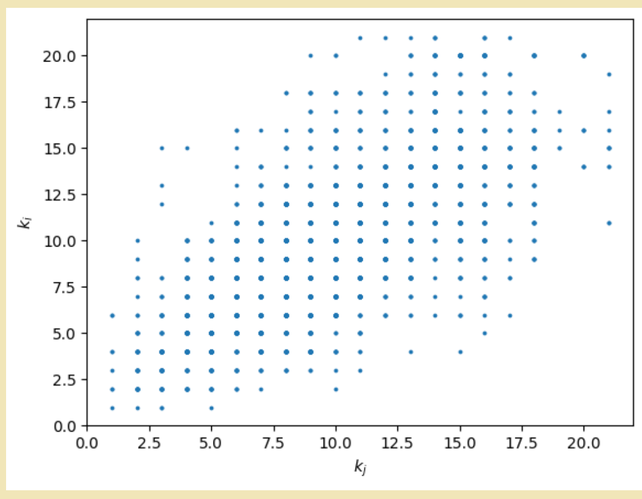
ANALYSIS



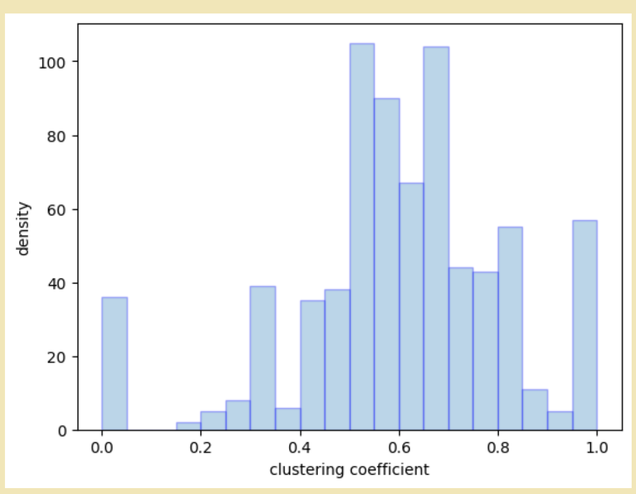
The size of each node is proportional to the mass of the Galaxy. We used the Louvain community detection method to get the partitions



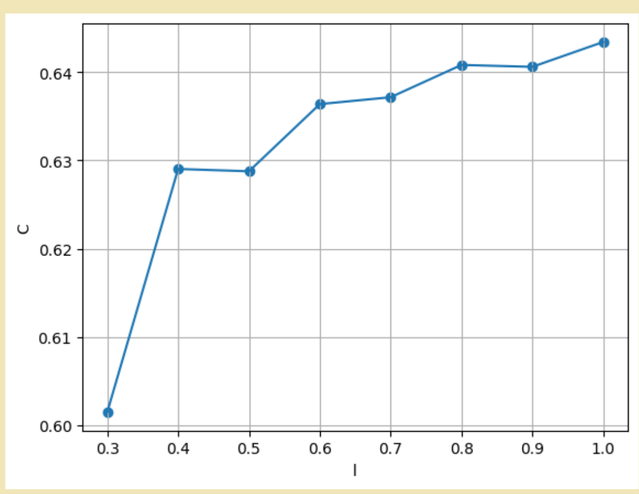
The statistical distributions (histograms with density plots) of degree centrality



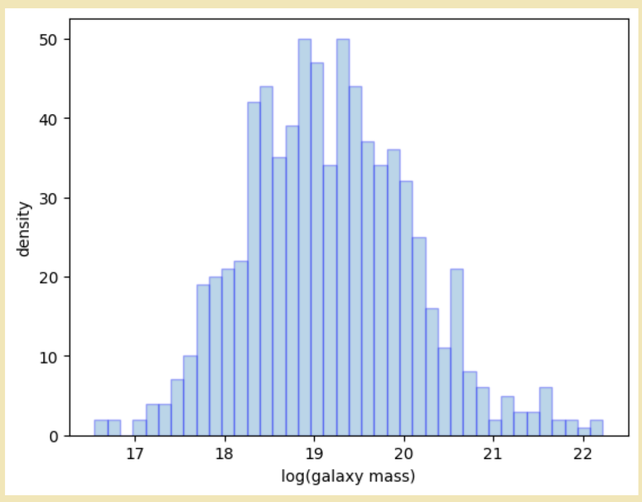
Scatter plot for degrees of connected nodes



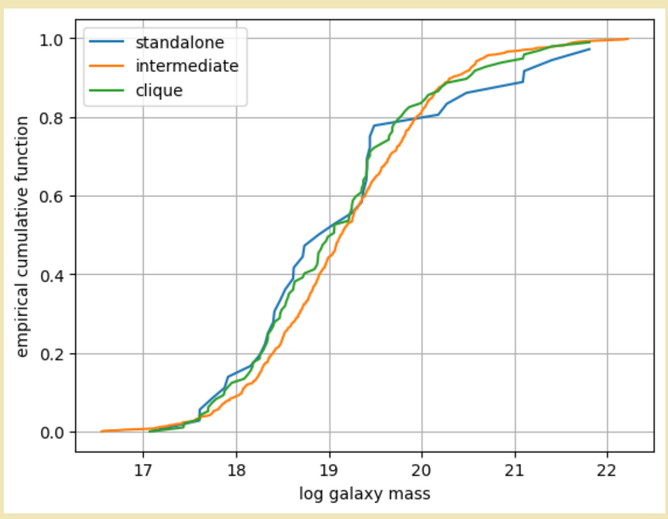
The statistical distributions (histograms with density plots) of the clustering coefficient



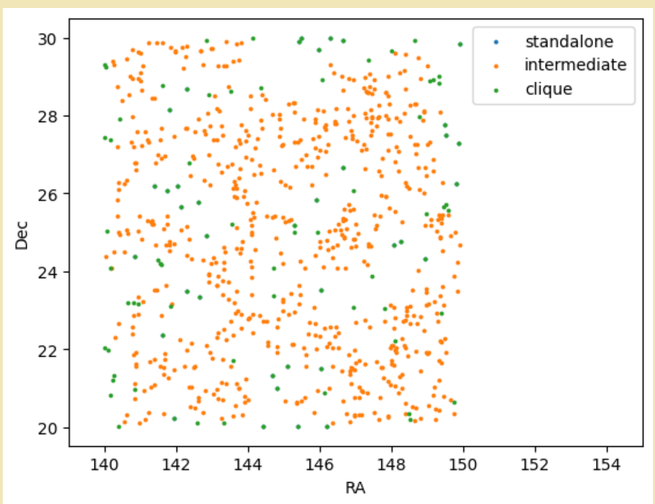
The relation between the clustering coefficient and the linking length of the network



The galaxy mass distribution in our network



The empirical cdf for different selections by the local clustering coefficient



Galaxies from different selections marked according to their clustering coefficient

CONCLUSION

To conclude, we see that as the linking length between the galaxies increases, then so does the clustering coefficient. The clustering coefficient histogram shows 3 main peaks at 0, 0.6, and 1. The galaxies can be divided into 3 subgroups based on their clustering coefficient. So, the network metrics analyzed here allow for discrimination between topologically different structures. Also, The high value of assortativity coefficient means that in the cosmic network galaxies with a similar number of links tend to be connected to one another.

Related literature
[1] The Network Behind the Cosmic Web, B. C. Coutinho et.al., 2016
[2] Network analysis of the COSMOS galaxy field, R. de Regt et.al.,2018
[3] Network analysis of cosmic structures: network centrality and topological environment, Sungryong Hong and Arjun Dey, 2015

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