Cosmic Web Reconstruction and Deciphering (abstract), Marta Minol

Cosmic Web is one of the major discoveries in the field of cosmology. It is a network of matter and galaxies forming a web-like pattern on the largest scale in the Universe, and composes of voids, walls, filaments, and clusters. Plenty of simulation and classification methods have been created to study the large-scale structure and its properties.
This thesis presents a statistical and computational analysis of the appearance and distribution of the Cosmic Web components. The analysis is based on the BORG (Bayesian Origin Reconstruction from Galaxies) simulation. It uses observational data from galaxy surveys as the input (SDSS DR7 in this work), creates a 3D density field and reconstructs initial conditions that are both in agreement with observed data and the baseline model.
To classify the Cosmic Web, the tidal-tensor-based T-Web classifier is applied. The algorithm relies on signs of the eigenvalues of the Hessian of gravitational potential for each voxel of the simulation box. Depending on the number of the positive eigenvalues, the voxel is assigned void, wall, filament or cluster.
The T-Web classifier was applied to the BORG reconstruction to examine how a theory-based classification method performs on simulations constrained by real observations.
An SDSS DR7 galaxy catalog was used to create a mask capturing a valid simulation region and deleting cells containing noise.
The analysis employs statistical 2D histograms to show how probabilities distribute across density values, Volume and Mass Filling Fraction diagrams, and histograms illustrating the distribution of galaxy magnitudes for each structure.
The analysis showed that, in the results of T-Web applied to BORG posteriors, walls dominate the cosmic web in both mass and volume. Masking noisy cells reduces this dominance, but only slightly. The removed cells had the highest wall probabilities, and their exclusion significantly reshaped the wall probability distribution, making it more uniform across density values and increasing the mean probability near the cosmic mean. In contrast, the other three structures were much less affected. The vast majority of galaxies in the catalog were assigned to filaments, while the fewest were assigned to voids. Galaxies in voids showed the lowest mean magnitude, though only by a small margin.