Studying the Effects of Overlapping Objects in Dark Energy

Katarzyna Krzyżańska, SULI Program at Fermilab

Observing the clustering of galaxies allows us to calculate cosmological parameters necessary for understanding dark energy. However, as the density of observed objects increases, the probability of these objects blending likewise increases, causing multiple galaxies to be observed as one. This affects the calculated values of parameters such as the galaxy bias ($b$) and the matter energy density ($\Omega_M$). To see whether the bias from incorrectly inferring the galaxy count is significant, we compare the correlation functions in simulated data for “observed” and “true” data sets with one-to-one and multiple-to-one correspondences.

The data was obtained from the second data challenge (DC2) simulations prepared for the analysis of the Vera C. Rubin Observatory Legacy Survey of Space and Time (LSST) by the LSST Dark Energy Science Collaboration (DESC). After creating images from cosmological catalogs, the simulation was processed by Rubin’s LSST Science Pipelines in order to realistically detect objects. This simulated data covers 400 sq-deg, compared to the 18,000 of the full survey, and accurately portrays an output catalog.

### Methods

The correlation function describes the probability of finding a pair of galaxies a given distance apart compared to if their distribution was random. I calculated the correlation function this way using the TreeCorr python library, dividing the data into 100 patches to make a jackknife estimation for the covariance. This correlation is compared to the model correlation calculated from the power spectrum using the CCL library. An LMFIT analysis is then done to minimize the residual between these two functions and find optimal values for $b$ and $\Omega_M$.

This work was supported in part by the U.S. Department of Energy, Office of Science, Office of Workforce Development for Teachers and Scientists (WDTS) under the Science Undergraduate Laboratory Internships Program (SULI).

### Conclusion

The effect of blending must be quantified for the LSST simulations. If the results were to show that the difference in the correlation function between the true, one-to-one correlation and the many-to-one observations resulting from blending affects the calculated parameters, we’d need to account for this bias. However, the difference is negligible. The galaxy bias fluctuations can be attributed to noise or other error. The $\Omega_M$ values appear distinct when comparing the one-to-one fits to the exclusively many-to-one fits at high $z$, but this is not significant when comparing the one-to-one with all the data (as it will actually be observed). As there may be an issue once the error bars are reduced in higher regimes, these biases should be further investigated.