Understanding the Effects of Overlapping Galaxies in Dark Energy Probes

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FERMILAB-POSTER-20-116-PPD

Introduction

Photometric galaxy surveys show that objects with fainter objects may be "blended" or overlapping. These wide-field surveys cover large areas of the sky which reveal more objects and low-surface-brightness features which reveal "blended" objects. As these surveys get deeper, the expectation is that statistical and systematic errors associated with object blending will increase. Some surveys, such as the Vera C. Rubin Observatory Legacy Survey of Space Time, observe objects from the ground and "blending" of objects raise concerns for analyzing existing and upcoming surveys.

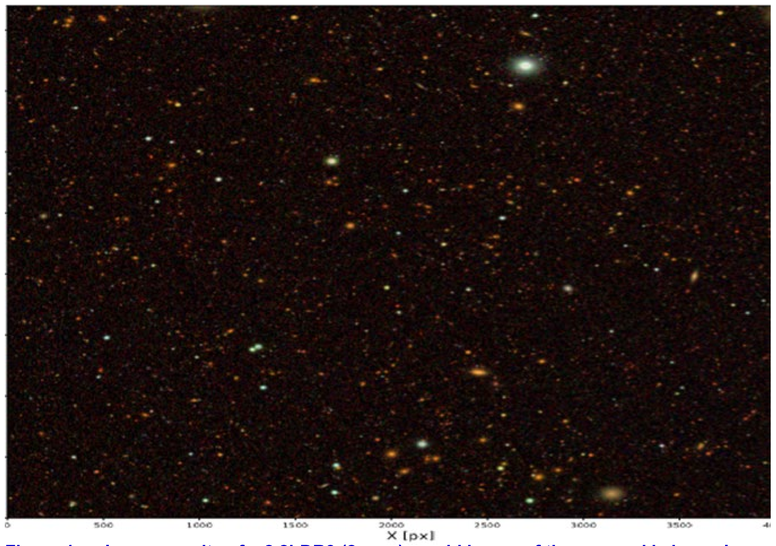

Figure 1. color composite of a 2.2i-DR3 (2 year) coadd image of the g, r, and i channels using g as blue, r as green and i as red.

Dataset

During our study we used data from the LSST DESC Data Challenge 2 (DESC et al., in prep.). This is a simulated galaxy survey where galaxies from a cosmological N-Body simulation were rendered using imSim (DESC et al., in prep.) to generate synthetic images over 400 square degrees similar to those that will be obtained by the Rubin Observatory. In particular, we used data comparable to 2 years of observations. The images were then processed using the LSST Science Pipelines to produce an "output" catalog.

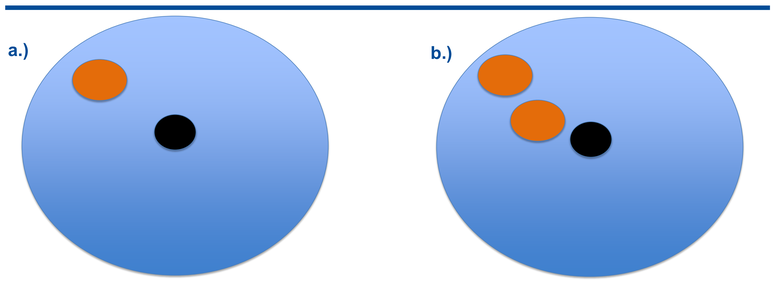

Figure 2. a.) one to one match b.)two to one match

Methods

The main goal of our study is to analyze the impact of blending in the measurements of galaxy clustering and how these translate into potential biases in the estimation of cosmological parameters. In order to do that we use the two-point correlation function. The (angular) two-point correlation function is defined as the excess of probability of finding a pair of objects at a certain angular distance compared to a random distribution.

The Landy and Szalay (Landy & Szalay, 1993) estimator was used to estimate the two-point correlation function.

The dataset was divided in three different samples:

1) The 1-to-1 matches: Each "output" object only has one suitable match in the "input" catalog. These objects are most likely isolated.
2) The multiple to 1 matches: Each "output" object has more than one potential match in the "input" catalog. These objects are potentially blended with other objects, and these other objects are not detected.
3) All matches: Each "output" object has one or more potential matches in the input catalog.

A KDTree was used to find neighbors within one arc second radius, and an schematic view of how the samples 1 and 2 are chosen is show in Figure 2.

Results

The correlation function was estimated for data sets where the truth catalogs and object catalogs were matched one to one, two to one, and multiples to one. By measuring these correlation functions, we were able to appreciate some differences between the one to one and others. However, it still has to be determined that these are not due to statistical fluctuations. Furthermore, we split the sample in 10 different redshift (z) bins, following the fiducial analysis from the DESC Science Requirements Document (DESC Collaboration et al. 2018). The results of such analysis are shown in Figure 3. Where we can see that the three different samples distinguishable from each other. However, the level of statistical uncertainty in our measurements prevents us from identifying a statistically significant bias between the measurements. A larger dataset will be employed in order to overcome this issue in the near future.

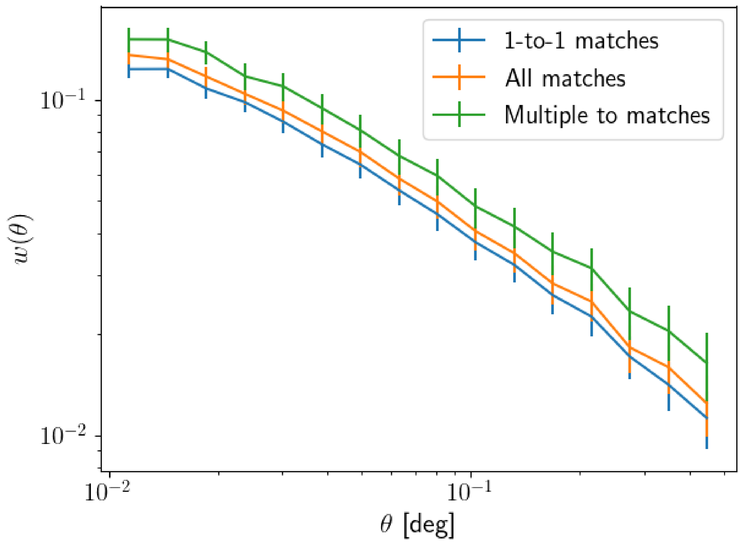

Figure 3. Comparison of the correlation function of the one-to-one matches and the multiple to one and all the detected objects for the slice 0.3 < z < 0.4

Next Steps

For future experiments, we plan to increase the sampling sizes which will increase the statistical power. Those differences will then be translated into cosmological parameters: matter density parameter and dark energy density parameter.

References

Landy, S. D., & Szalay, A. S. (1993). Bias and variance of angular correlation functions. *The Astrophysical Journal, 412*, 64. doi:10.1086/172900

Melchior, P., Moolekamp, F., Jerdee, M., Armstrong, R., Sun, A., Bosch, J., & Lupton, R. (2018). Scarlet: Source separation in multi-band images by Constrained Matrix Factorization. *Astronomy and Computing, 24*, 129-142. doi:10.1016/j.ascom.2018.07.001

Dawson, W. A., Schneider, M. D., Tyson, J. A., & Jee, M. J. (2015). The Ellipticity Distribution Of Ambiguously Blended Objects. *The Astrophysical Journal, 816*(1), 11. doi:10.3847/0004-637x/816/1/11

DESC Collaboration et al. (2018). LSST DESC Science Requirements Document. arXiv: 1809.01669

Acknowledgements

I thank Fermilab for this opportunity. I also thank my mentor for his patience and guidance throughout the summer. This manuscript has been authored by Fermi Research Alliance, LLC under Contract No. DE-AC02-07CH11359 with the U.S. Department of Energy, Office of Science, Office of High Energy Physics.