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Dissertation Summary

Halo Occupation Distribution Using Photometric Information and Its Application in the Anisotropic Halo Model*†

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The present work is framed within the studies of the large-scale structure of the universe, in particular, in the relationship between ordinary (or baryonic) matter and the so-called "dark matter." The current paradigm assumes that galaxies are formed inside the halos of dark matter. However, a great diversity of astrophysical mechanisms are involved in the formation process, which makes it difficult to determine how many galaxies populate a halo of a given mass. To estimate the relationship between galaxies and halos, different statistical estimators emerged that allow to link the mass of the halos with the number of galaxies they possess. One of them, which was established as a simple and at the same time powerful tool, is the halo occupation distribution (HOD), the central concept of the present work. This estimator is defined as the probability that a halo of mass M contains N galaxies with some characteristics, giving the possibility of associating, in a statistical way, galaxies and halos (e.g., Ma & Fry 2000; Zheng et al. 2005; Yang et al. 2008).

At present, large catalogs of galaxies are available that allow us to identify groups of galaxies, determine their masses, and therefore study the HOD. However, for this, only the spectroscopic information provided by the surveys is used, without taking advantage of large amounts of photometric data that are also released by them. This is why we propose a method of discounting background galaxies that allows combining photometric and spectroscopic data to expand the range of luminosities and masses in which HOD can be studied. This procedure was extensively described in Rodriguez et al. (2015). To evaluate this technique, we employed another of the most-used tools in the studies of the large-scale structure of the universe: synthetic catalogs. From simulations of dark matter (Springel et al. 2005) populated with semi-analytical models (Guo et al. 2010), we made synthetic catalogs that allowed us to establish the virtues and shortcomings of our technique before implementing it in the Sloan Digital Sky Survey (SDSS DR 7; Abazajian et al. 2009). As we show in Figure 1, our results are in good agreement with those obtained by Yang et al. (2008) and, given the nature of our method, the samples are deeper and more numerous, allowing us to extend the range of masses beyond the limits explored in previous works, and also to achieve absolute magnitudes as faint as −16.0.

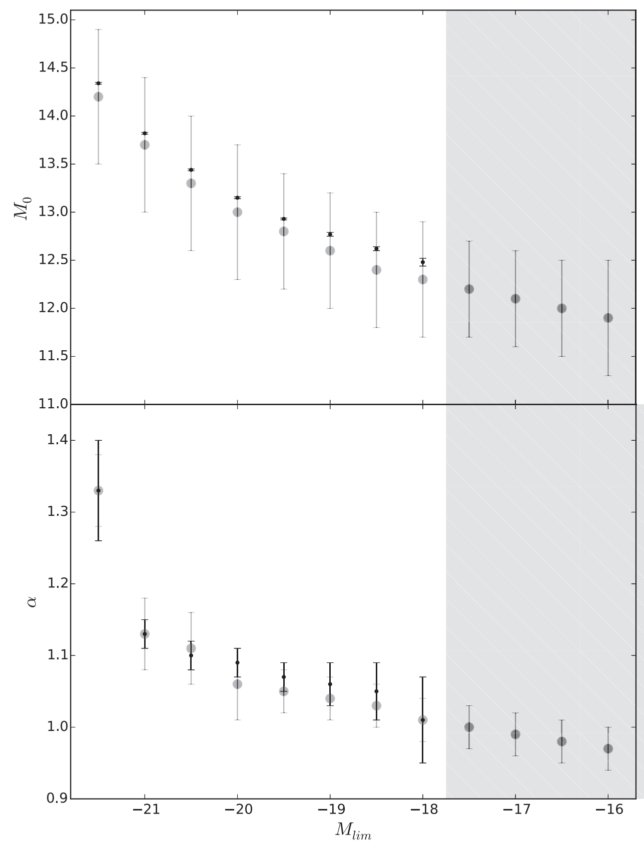

Figure 1. HOD parameters for satellite galaxies: $\langle N_{sat}|M_h\rangle = \left(\frac{M_h}{M_0}\right)^{\alpha}$. Top and bottom panels show M_0 and α parameters, respectively, as a function of the limiting magnitude. Our results are shown in gray circles, while black circles correspond to the results of Yang et al. (2008). There is a good agreement between both results; furthermore, our method allows us to extend the range of absolute magnitude to fainter values up to −16.0 without losing statistical strength (gray shaded area). Figure taken from Rodriguez et al. (2015). Reproduced with permission from Astronomy & Astrophysics, © ESO.

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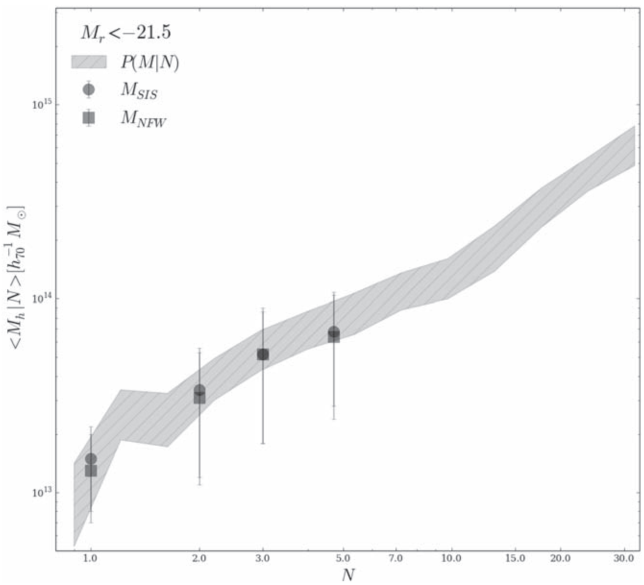

Figure 2. Results obtained implementing background subtraction method for a limiting absolute magnitude of −21.5. Squares and circles represent weak lensing masses determined using NFW and SIS models, respectively, vs. *N*. Figure taken from Gonzalez et al. (2017).

Another of the accomplishments of this thesis was to compare the HOD with other estimators. In particular, we compared it with the mass-richness relation obtained from gravitational lens studies. For this task, we measured the mass and richness of a sample of groups and, using the technique mentioned in the previous paragraph, we determined the HOD. Because both estimators are not directly comparable, we use the same determinations, but modify the calculation of the final estimator to be able to make the comparison; we obtained a great agreement between both estimates, as shown in Figure 2. These results are shown and explained in details in Gonzalez et al. (2017).

The third central subject of our work was to incorporate the HOD to the halo models. These results allow us to describe the dark matter density fields i.e., the correlation function. More precisely, by numerically developed halo models, the correlation function of dark matter can be reproduced. If the HOD is incorporated into these models, the density fields of baryonic matter can be reproduced. In this thesis, we use the HOD estimates and incorporate the anisotropic model of halos by Sgró et al. (2013). We evaluated the feasibility of incorporating HOD into this model through synthetic catalogs, and determined estimates of the shape of dark matter halos for different mass ranges.

References

Abazajian, K. N., Adelman-McCarthy, J. K., Agüeros, M. A., et al. 2009, ApJS, 182, 543
Gonzalez, E. J., Rodriguez, F., García Lambas, D., et al. 2017, MNRAS, 465, 1348
Guo, Q., White, S., Li, C., & Boylan-Kolchin, M. 2010, MNRAS, 404, 1111
Ma, C.-P., & Fry, J. N. 2000, ApJL, 531, L87
Rodriguez, F., Merchán, M., & Sgró, M. A. 2015, A&A, 580, A86
Sgró, M. A., Paz, D. J., & Merchán, M. 2013, MNRAS, 433, 787
Springel, V., White, S. D. M., Jenkins, A., et al. 2005, Natur, 435, 629
Yang, X., Mo, H. J., & van den Bosch, F. C. 2008, ApJ, 676, 248
Zheng, Z., Berlind, A. A., Weinberg, D. H., et al. 2005, ApJ, 633, 791