Measuring the scatter in the mass richness relation for galaxy cluster using the correlation function

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Abstract
Cluster of galaxies are becoming a powerful tool for constraining the cosmological parameters. This has motivated the design of a new wide-area cluster surveys at mm, optical/near infrared, and X-ray wavelengths. These surveys will have the potential to find hundreds of thousands of clusters. The ability to constrain the cosmological parameters from the evolution of galaxy clusters counts is limited by the knowledge of the cluster mass. Accurate constraints require a precise model relating observable, such a richness, to total mass. We present a method to constrain the scatter in the mass richness relation by making use of the bias measured in the cluster correlation function.

We will study the bias in haloes on a part of the lightcone using N-body simulations to study the errors that come from the Halo Model prediction. Finally we assign richness to dark matter haloes with scatter and we compare richness bias measured with the model. By performing a likelihood analysis when the true value is 0.4, we find that \( \text{bias} = 0 \pm 0.4 \text{ (95\% CL)} \). We consult with the literature on X-ray observations. We conclude that we can constrain the scatter although our method is highly dependent on the mass function and bias model. However, the advantage of this method is that it only needs one kind of observations.

The Method

The cluster bias can be measured in a cluster catalog by measuring the spatial correlation function and comparing it to the correlation function of dark matter haloes using the relation:

\[
\xi(r) = W(r) = \frac{\langle NN(r) \rangle}{\langle N \rangle^2}
\]

The average bias expected for a richness value \( N_{200} \) is

\[
\xi_{\text{bias}} = \xi_{\text{bias}}(N_{200}, \text{Halo Model})
\]

We compare the measured bias with the predicted linear bias using the Halo Model and the Mass Richness relation.

\[
\text{bias} = \frac{\sum W(r) \langle NN(r) \rangle}{\sum W(r) \langle N \rangle^2} - 1
\]

\[
\langle NN(r) \rangle = \frac{1}{2\pi^2} \int dk |k| P(k) \langle \delta_m \delta_m \rangle \text{ Hubble Volume Simulation HVS at z=0 compared with the cosmological predictions.}
\]

Figures 7 to 10

Constraining the scatter

The results shows that we can constrain the scatter using the correlation function although still we have to study the effects of the photometric errors and the error covariance for the correlation function. The next steps are combine the likelihood for the bins with the likelihood for the number of clusters as a function of richness and redshift also predicted with the Halo Model. Therefore we could constrain the cosmological parameters and at the same time we calibrate the mass observable relation with the combined likelihood. Finally we want to apply this method to a real galaxy cluster catalog such as the MaxBCG.

References:
- Data: 3 redshift catalogs with 3 scatter values \( m_{\chi,\sigma} = 0.1, 0.2, 0.4 \)
- Two first redshift bin used
- Main systematics: Uncertainty in the mass function and bias model
- Mass resolution: M_{\text{Evolution}} minimum limit
- 4D Likelihood: \( m_{\chi,\sigma} = 0.1 \): Left: Richness bias model integrated in \( M_{\text{min}} = 10^{13} - 10^{15} M_{\odot}/h \). Right: Richness bias model integrated in \( M_{\text{min}} = 10^{15} - 10^{16} M_{\odot}/h \).