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Halo Occupation Distribution of AGNs throught Numerical Simulations

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Abstract. Using a set of simulations in the ΛCDM cosmology, and the mass of intermediate X-Ray Active Galactic Nuclei (AGN) dark matter halos (DMH), we study the Halo Occupation Distribution (HOD) of their host DMH and compare with recent observations. We assume that intermediate X-Ray AGNs have been triggered by a major merger of sub-halos inside larger host halos. We find that the binary major merger HOD slope ($\alpha \approx 0.8$) do not seem to reproduce the observed HOD slope ($\alpha < 0.6$) for these type of AGNs. Other mechanisms may be igniting these AGNs.

Keywords. Numerical, Simulations, AGNs, Cosmology

1. Motivation

According to the recent studies of Allevato *et al.* (2012), the intermediate X-Ray AGNs reside in dark matter halos at z = 0.5 above a virial mass of $M_{vir} \geqslant 10^{12.75} M_\odot\, h^{-1}$ and have a slope in the HOD of $\alpha < 0.6$. This value is consistent with the HOD modeling of the cross-correlation function between ROSAT all-sky Survey AGNs and luminosity red galaxies (e.g. Miyaji T. *et al.* 2011).

We test the hypothesis that the AGNs are triggered by major mergers of sub-halos (representing galaxies) inside larger halos (representing groups/clusters) by comparing resulting HOD of simulated AGNs (sub-halo major mergers) with observation.

2. Method

A set of five similar cosmological simulations within the ΛCDM model from z = 50 to z = 0. Which were carried out using the publicly available parallel Tree-PM code GADGET2 (Springel V. (2005)). The cosmological parameters used were matter density $\Omega_m = 0.222$, dark energy density $\Omega_\Lambda = 0.734$, spectral index $n_s = 0.963$, mass fluctuation $\sigma_8 = 0.816$ and the Hubble parameter $h = 0.70$, consistent with WMAP7 results (Larson *et al.* 2011). The simulation box had a comoving length of $L = 100\,\mathrm{Mpc}\,h^{-1}$ and $N_p = 512^3$ dark matter particles, leading to a mass resolution of $m_p = 6\times 10^8 M_\odot h^{-1}$.

We identified DMH with the Amiga Halo Finder (AHF; Knollmann S. & Knebe A., 2009), selecting all those subhalos that reside in host halos with $M > 10^{12.75} M_\odot h^{-1}$ and that have binary progenitors that meet the following conditions: (a) relative velocity ($V_{12} = |\, V_1 - V_2 \,|$) is less than the average of the rms velocity of the individual haloes, $V_{12} \leqslant V_{rms}$, (b) relative physical separation ($R_{12} = |r_1 - r_2|$) less than the sum of the virial radius of both halos: $R_{12} \leqslant R_{v1} + R_{v2}$, (c) and a mass ratio <1:4 that we call

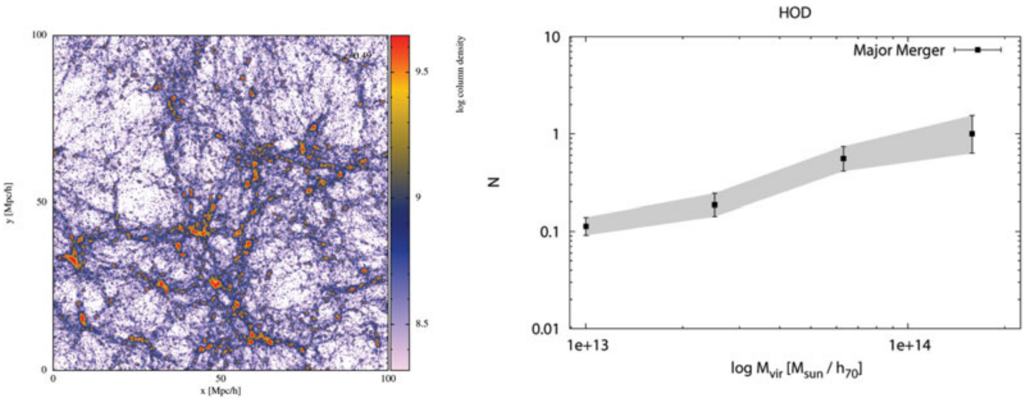

Figure 1. (*Left*) Snapshot of one of our simulations at $z = 0.5$. (*Right*) HOD results for satellites that has been suffered a major merger; the grey color curve represents the 68% of Poisson error band. Observations indicate a slope of $\alpha < 0.6$ while our numerical results $\alpha \approx 0.8$.

for simplicity major mergers; and occuring between $z = 0.5$ and $z = 1$. These subhalos determine the number density of "AGNs" triggered by a major merger. These subhalos that have suffered a major merger ("subhalo-host selected") were used to calculate the HOD for the subhalo-hosts that are satellites (distance to the center of halo host > 200 Kpc);¡TB:break/¿ in practice we calculated the HOD as:

$$N(M_{\rm DMH}) = \frac{n_{\rm agn}}{n_{\rm Host}}, \tag{2.1}$$

Where $n_{\rm Host}$ is the number of halos in siumlation box within the $M_{\rm DMH}$ bin and $n_{\rm agn}$ is the number of simulated AGNs in these host halos.

3. Results and Final Comments

In figure 1, we show the HOD through a cosmological simulation where we obtain a slope ≈ 0.8. This is steeper than that observed by Allevato *et al.* 2012, where the slope of HOD satellites should be <0.6. Our results match with recent studies (e.g. Grogin *et al.* 2005; Bournaud *et al.* 2011 and Cisternas *et al.* 2011) that found that the major merger do not seem to play a role in triggering those AGNs.

A complete report, with further details, on our numerical results is being completed to be submitted for publication consideration.

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