Dark matter deficient galaxies in hydrodynamical simulations

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Dark matter deficient galaxies have lost their dark matter halos due to interactions during their evolution. In particular, during their fusion history. The existence of these galaxies is a debated subject, both from the observational and theoretical points of view. In this work in progress, we study the population of dark matter deficient galaxies in the hydrodynamical simulation IllustrisTNG, which follows the evolution of dark matter and baryonic matter. We analyse the distribution of these galaxies within the host halo, and how this distribution changes with halo mass, and redshift. The aim of this study is to gather information about how these galaxies are formed, and how their population evolves.

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Context and motivation

In the standard ΛCDM framework, cold dark matter is the dominant mass budget of the Universe, but it can be less important at small scales. Nevertheless, low-mass galaxies are expected to be dark-matter-dominated even within their central regions.

However, recent observations suggest that some of these low-mass galaxies may have very low dark matter fractions[1,2]. This type of galaxies, which would be dark matter deficient according to what we have established above, is an unknown and debated subject, and their dark matter deficiency makes them a very interesting object of study.

There are some studies in the literature that address this problem using hydrodynamical simulations (EAGLE, ILLUSTRIS[3]). In this poster, we present the preliminary results of our study using IllustrisTNG simulations, to analyze the population of dark matter deficient galaxies. Our aim is to study this population as a function of the mass of the host, as well as a function of redshift, and try to find out which is the mechanism by which those satellites lose most of their dark matter halo.

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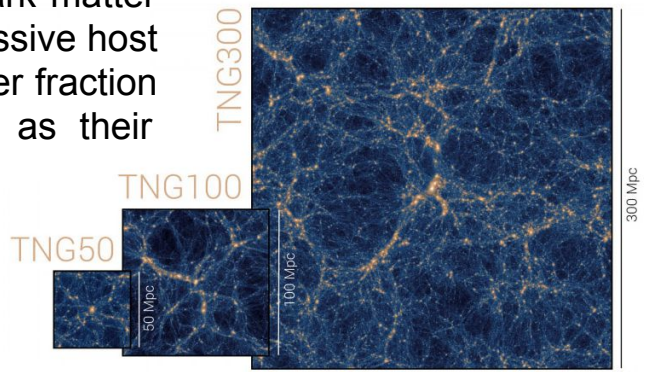
[1] Oh S.H. et al., 2015, AJ, 149, 180.
[2] Guo, Q. et al. 2019, Nature Astronomy, 4, 246.
[3] Jing, Y. 2019, MNRAS 488, 3, 3298.

Project description

The IllustrisTNG project is a suite of state-of-the-art cosmological galaxy formation simulations. It consists of hydrodynamical simulations in which the evolution of different components (dark matter, gas, stellar mass, black holes) is studied. The set of simulations are of high resolution in mass, for all of the particle types.

Three physical simulation box sizes are employed: cubic volumes of roughly 50, 100, and 300Mpc side length. In this project, the TNG100 data at redshifts z= 0, 0.4, 1 and 2 were used to study dark matter deficient galaxies.

The dark matter fraction is measured using the formula $f_{DM} = M_{DM} / M_{tot}$. Dark matter deficient galaxies are defined as those with a dark matter fraction below 50%. We select the satellite galaxies of the most massive host halo's central subhalo at each snapshot and obtain their dark matter fraction within two times of the half-stellar-mass radius ($2R_h$), as well as their halocentric distances.



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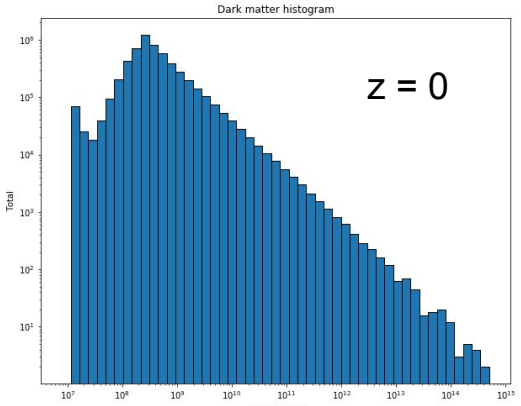
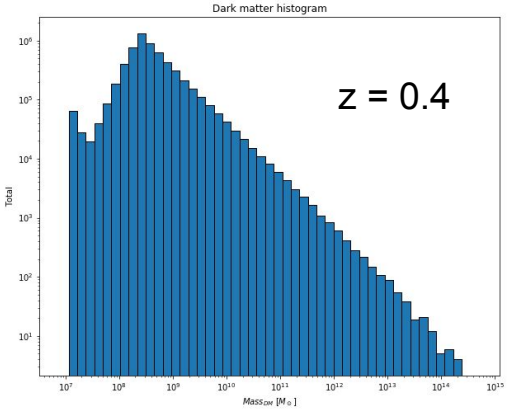
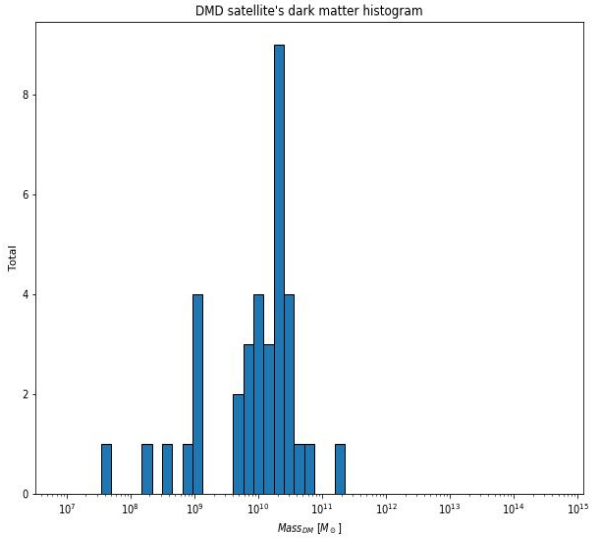
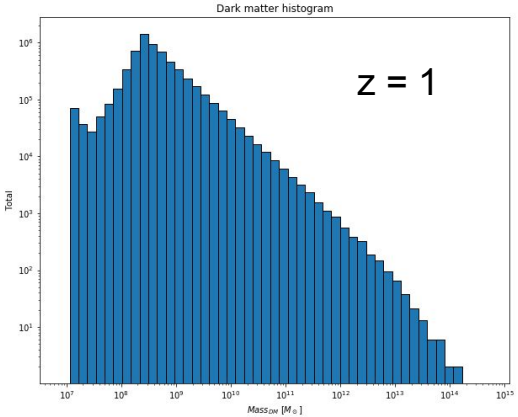
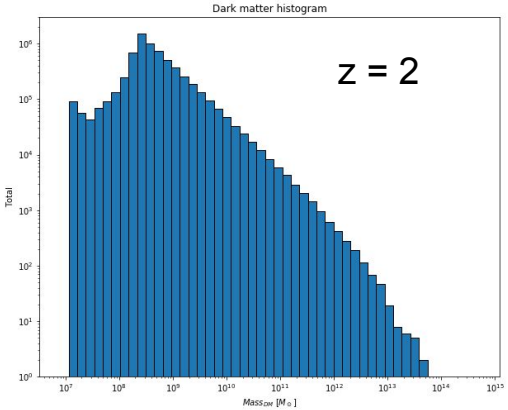
We have computed the mass function at different redshifts, to account for the full population of DM halos. We also investigate which is the mass distribution of DMDGs for the most massive halo at z=0.











Mass distribution of the DMDGs in the most massive halo at z=0.

Results

While dark matter dominates the total mass budget of the majority of the satellite galaxies within $2R_h$, we have found that a few percent of galaxies have a dark matter fraction below 50%.

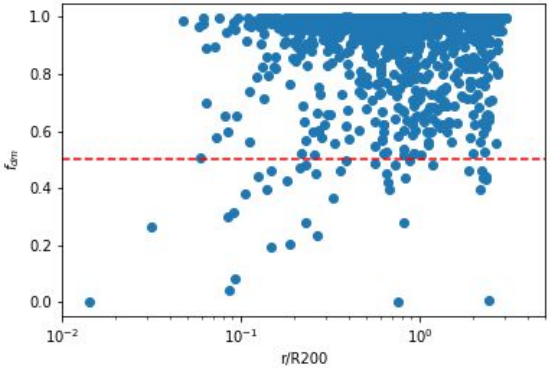
This percentage of dark matter deficient galaxies over the total amount of satellite galaxies is higher at higher redshifts, for the most massive halo: we found that at z=2 there is a percentage of 0.53%, while at z=0 it decreases to 0.23%.

Redshift	Mass of the most massive host halo	Amount of satellite galaxies of the most massive host halo	Amount of dark matter deficient galaxies
z = 0	$38878 \times 10^{10} M_{\odot}$	17184	39
z = 0.4	$18533 \times 10^{10} M_{\odot}$	7718	32
z = 1	$10938.9 \times 10^{10} M_{\odot}$	4948	26
z = 2	$3053.65 \times 10^{10} M_{\odot}$	1501	8

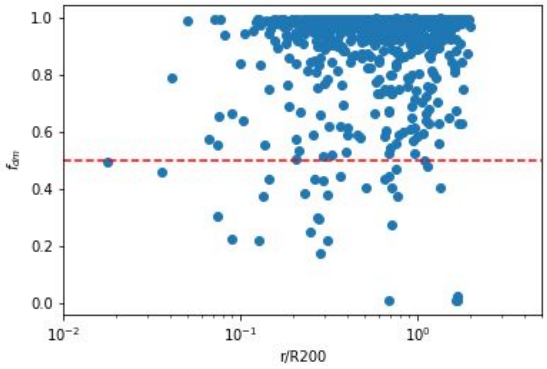
Results

In these figures, we show the dark matter fraction f_{DM} as a function of halo-centric distance, r/R200, at the different redshifts in which the dark matter deficient galaxies were studied.

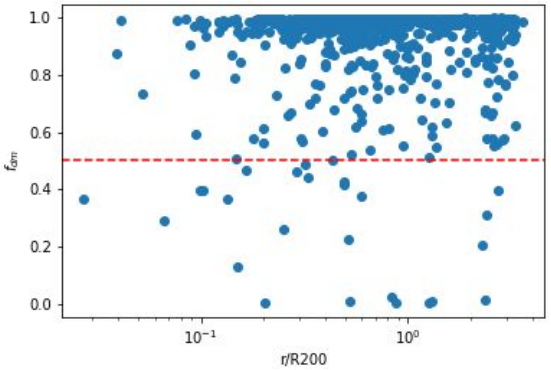
z = 0



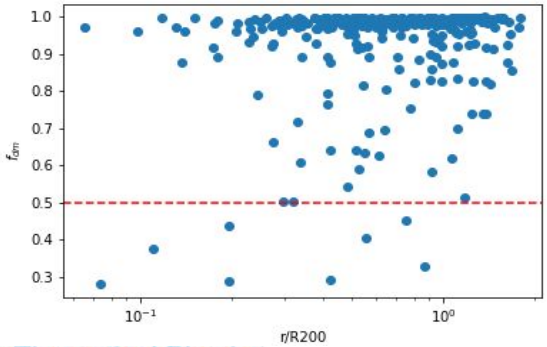
z = 0.4



z = 1



z = 2



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Preliminary conclusions and future goals

- Dark matter deficient galaxies are allowed in current galaxy formation models.
- In the future, we plan to track down the dark matter deficient galaxies found at z=0 in order to study their evolution and history, and also to see if they match the ones found at z=0.4, z=1 and z=2.
- We will also study the environment in which the group is located, and whether there is a dependence of the abundance of deficient dark matter subhalos on the properties of the environment.
- We will repeat this analysis for different mass ranges of the host halo, at different redshifts, to study if there is a dependence of the population of dark matter deficient galaxies with the mass of the host.

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