New Cosmological Data and the Values of the Fundamental Parameters
IAU Symposium, Vol. 201, 2005
Anthony Lasenby and Althea Wilkinson, eds.

The WEB Structures at Small Scale Related to Λ_0 Problem

Marian Doru Suran

Astronomical Institute of the Romanian Academy, str. Cutitul de Argint 5, Bucharest, Romania

Nedelia Antonia Popescu

Astronomical Institute of the Romanian Academy, str. Cutitul de Argint 5, Bucharest, Romania

Abstract. In the present paper, using a variety of N-body and gas codes, we study the large and small scale structures. Furthermore, we identify coherent objects at various threshold levels and calculate their planarity and filamentarity. The WEB theory is used to constrain the cosmological parameters of inflation-based Λ_0 CDM models.

1. Introduction

The paper addresses the question of the structure and evolution of populations of underdense objects in N-body simulations at high redshifts ($12 > z > 5$).

In respect of this, the analysis of the extended lower density region of the Universe, rather than rich filamentary and wall-like structures, will be of great importance and provide complementary information to the analysis of the large scale galaxy distribution. However, at high z the existence of all three kinds of structure elements, namely, high density filaments, clumps and low density regions in the DM spatial distribution, has been demonstrated. The statistical comparison between the main simulated and observed structure can be used in the analysis and interpretation of the absorbers observed at large redshift, such as the Ly-α forest ($z \lesssim 5$), in order to reproduce their characteristics. The validity of this description, when it is applied to structure at high redshifts ($z \gtrsim 5$), is not yet reliably verified with available simulations due to the small density contrast of poor structure elements dominating at higher redshift. The observations of galaxies at large redshifts verifies that strong nonlinear compression of the DM and gaseous components occurs even at $z \sim 3$–5 and earlier (Steidel 1998, Fan et al. 2000). Absorbers can be expected to be predominantly related to the more numerous population of moderate rich pancakes and to the periphery of richer pancakes and filaments. The theory cannot yet describe in a detailed fashion the relaxation of compressed matter, the disruption of structure elements caused by the gravitational instability of compressed DM and the distribution of neutral hydrogen across DM pancakes.

The composition of observed absorbers is complicated and at low redshifts a significant number of stronger Ly-α lines and metal systems are associated with galaxies.

https://doi.org/10.1017/S0074180900216938 Published online by Cambridge University Press

However, a possible population of weaker absorbers which dominates at high redshifts and mainly disappears at $z < 2$ could be related with the structure elements formed by nonluminous baryonic and DM components and situated in extended lower density regions. In this approach, a number of the absorbers can be considered as progenitors of present galaxies.

2. The simulations

In this paper, we present some algorithms and simulations on the intermediate scale ($25h^{-1}$ Mpc), in order to determine the formation and the evolution of such earlier underdense objects.

In order to solve the problem as generally as possible we have made different kinds of N-body simulations:

- PM for DM only (LCDM models, Klypin PM code);
- PM for DM+massive neutrinos (CHDM models) ;
- P3M for DM+SPH (LCDM models, HYDRA code).

The simulations are with 128^3-256^3/256^3-512^3 points on an intermediate scale of 25 Mpc .

The chosen cosmological scenarios were:

- LCDMa models: H_0=60kms^{-1}Mpc^{-1}, Ω_m=0.3 (Ω_b=0.05), Ω_Λ=0.7;
- LCDMb models: H_0=90kms^{-1}Mpc^{-1}, Ω_m=0.3 (Ω_b=0.05), Ω_Λ=0.7;
- CHDM models: H_0=50kms^{-1}Mpc^{-1}, Ω_m=0.8 (Ω_b=0.05), Ω_ν=0.2.

We choose these alternative scenarios because of their very good agreement in respect to the first two peaks location and amplitude in CMB adiabatic spectra.

The N-body simulations were supplied by a series of different proper models and algorithms for the interpretation of these simulations: halo identification; halo history and progenitor identification; pancake evolution; shape of under and dense regions. Using these algorithms we identify coherent objects at various threshold levels and we can follow the formation and the evolution of the different kind of objects in our simulations for all the needed period ($12 > z > 5$).

The simplest approach is to identify clouds as underdense regions with densities above a chosen threshold. There are two major motivations for defining our 'clouds' in such a manner. First of all, this method allows us to associate the clouds found at each density cut with a particular column density, to obtain information about the characteristic sizes of the clouds. Secondly, density perturbations with amplitudes larger than a certain threshold become self-gravitating, bound clouds. Thus, this cloud definition also has a physical motivation in that the structures above some high-density threshold are gravitationally bound distinct objects. However in our simulations at very high redshifts ($12 > z \gtrsim 5$), the lifetime of such clouds is an indicator of their distinct object class. For the determination of the possible underdense objects we used a simple algorithm. This algorithm calculates, for 1 out of 10 particles of the simulation, the inertia tensor using a different filtering radius r (corresponding to different size objects) and diagonalises it. The decomposition of the inertia tensor describes the geometry of the matter ellipsoidal distribution which is essential in the describing of the characteristic sizes and forms of the underdense clouds. For example, normalization using the trace of the tensor, gives the linear (CL), planar (CP) and spherical case (CS). An anisotropy measure describing the deviation from the spherical case, regardless of whether it is linear or planar anisotropy, is achieved by summing the normalized coordinates of the two cases: CA = CL + CP. Also the history of objects in the filtering radius r can be followed. The 3D distribution, the shape and the history of the long-lived objects can define for us the 'secondary' Web structure (possible progenitors of the Ly-α−like structures).

3. Results

The results were obtained using three different filtering radius for clouds (underdense regions with $0.1\,\bar{\rho} < \rho < \rho_{halos}$) as follows:

- $r = 0.05$ Mpc - corresponding to a small class of galactic-like objects;
- $r = 0.5$ Mpc - corresponding to intermediate scale objects;
- $r = 1.5$ Mpc - corresponding to the large scale, filament-like features of the underdense regions.

In order to discriminate between different kind of underdense regions we take into account two types of regions:

- high temperature regions (T> 10^5K - representing heated and shocked gas regions), and,
- low temperature regions (T< 10^5K).

One of the most interesting results obtained during our calculations deals with the different 3D distribution of each type of objects taking into account:

- the objects of filtering radius $r = 0.05$ Mpc are clustering around and could be associated with galactic haloes formation (compressional shocks at the formation of galaxies);
- the objects of filtering radius $r = 1.5$ Mpc are clustering around and could be associated with the density pancakes or filamentary structures (compressional shocks at the boundary of such large scale systems during the accretional or dissolution periods);
- the most curious systems must be the objects of intermediate filtering scale ($r = 0.5$ Mpc), which cannot be associated with high density structures and which are situated in the low density regions. Perhaps these objects represent the population of the weaker absorbers clouds. At the same time, these objects live for a long time (some of them can be followed during the entire period $z =$ 12–5). Moreover, for such absorbers the contribution of second order pancakes and mini-voids can be more significant.

References

Fan, X. 2000, Astron. J., 120, 1167

Steidel, C.C. 1998, in Proceedings of the National Academy of Sciences of the United States of America, 95, 22

https://doi.org/10.1017/S0074180900216938 Published online by Cambridge University Press