A Connection Between Star Formation Rate and Dark Matter Halos at $Z \sim 6$ In 2013 Planck Cosmology.

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ABSTRACT

This work relates baryonic matter and dark matter at redshift $z = 5.9$ using observational data from CFHTLS (Willott 2013), HUDF09 (Bouwens 2006, 2012), UKIDSS and SDXS (McLure 2009), and results of the Multidark Simulation (Riebe 2013) in a cubic box of 1000Mpc h^{-1} length with 2013 Planck Cosmology. The Luminosity Function (LF) is fitted via four parameters with the Markov Chain Monte Carlo method. The relationship between the Dark Matter Halos Mass and Star Formation Rate is obtained using the relationship between the UV continuum (from the fitted LF) and Star Formation Rate (SFR) by Kennicutt (1998).Cosmic variance effects are studied on smaller boxes of 250Mpc h^{-1} length.

Halos.

Subject headings: Dark Matter, LF, SFR, High Redshift Galaxies, Reionization

1. Introduction

Cosmological simulations still playing an important role on astrophysics and cosmology. They have become the bridge between observations and theory, a laboratory where is possible to create universes with different parameters and new physics.

This is an important tool in the study of dark matter. Since its existence was purposed, DM has been not observed directly neither on telescopes or high energy particle colliders, there exists many other theories explaining the observed universe behavior modifying the gravity itself.

The most successful and accepted cosmological model is the Lambda-CDM. Dark matter is a significative component of the universe. (Trimble 1987)

Hierarchy Structure Evolution: Early formation of small structures merging on major structures after.

From simulations, Halo Mass Function as function of redshift (or time).

In this paper is established a relation between dark matter and galaxy luminosity functions at high redshifrt. This relation is a direct connection between the Lambda-CDM model and the farthest galaxy observations made with space and grounded telescopes.

Star formation rate as function of time. Peak at $z \sim 2$.

Main Objetive: Reproduce the observed luminosity function at redshift $z = 5.9$ from a DMH catalog from simulations.

1.1. Halo Mass Function (HMF)

1.2. Cosmic Variance

2. Linking Galaxy Luminosity Function (GLF) and Dark Matter Halo (DMH) mass

2.1. Magnitude to Luminosity

Luminosity Functions (LF) are usually expressed in terms of magnitude instead luminosity. Luminosity is the energy emmited by a source in a given wavelengt range, is a physical quantity. Magnitude is a classification inherited from ancient Greeks, this quantifies the response of the first astrometric device: the human eye, this perception grows loarithmically with the retrieved radiation.

Luminosity of any object can be compared with Sun Luminosity ($L_{\lambda\odot}$) at any wavelengt. With the Sun Magnitude as reference ($M_{\lambda\odot}$), the absolute magnitud of the objet at an specific wavelengt is given by:

$$M_\lambda = M_{\lambda\odot} - 2.5\log_{10}\left(\frac{L_\lambda}{L_{\lambda\odot}}\right)$$

The solar absolute magnitude in the U filter is $M_{U\odot} = 5.61$, and the solar luminosity in the same filter is $L_{U\odot} = 10^{18.48}\text{ergs s}^{-1}\text{Hz}^{-1}$ or $L_{U\odot} = 3.02 \times 10^{18}\text{ergs s}^{-1}\text{Hz}^{-1}$. The solar luminosity can be used as refference unit, in this fashion, the typical luminosity of a galaxy can be expresed in terms of $10^8 - 10^{11}$ times the sun luminosity.

The absolute magnitude of a galaxy equation in the U filter:

$$M_U = 51.82 - 2.5\log_{10}(L_U)$$

2.2. The Luminosity Model

In this model we have made two assumptions:

1. Each halo in the catalog hosts one galaxy. There are not empty halos, also none of halos has two or more galaxies.
2. The UV luminosity of each galaxy is function of one variable: the mass of the DMH in wich is located.

The simplest relation we can have is a powerlaw:

$$L = L_0 M^{\alpha} \tag{1}$$

but has not well agreement with observed luminosity functions.

A better model is a four parameter function. Each galaxy has a luminosity given by:

$$L = L_0 M \left[\left(\frac{M}{M_0} \right)^{-\beta} + \left(\frac{M}{M_0} \right)^{\gamma} \right]^{-1} \tag{2}$$

where M is the hosting DMH mass, L_0 is a normalization constant, M_0 is the critical mass where the luminosity function has a slope change, β and γ are the slopes. This equation has a similar fashion to the mass to light relation (van den Bosch 203) and the mean relation between stellar mas of a galaxy and the mas of its halo used by Moster (2010).

There are more complex models(Lee 2009) that includes a random behavior: galaxies has not synchronization on the beginning of star forming stage, also this stage may be time limited. This is called duty cycle. It is probable to have in the observations some invisible galaxies in the UV continuum due their duty cycle may has not started as well it may ended. Also may be present a normal distribution of the luminosity around the expected values.

2.3. Star Formation Rate

The age of a star can be estimated by analyzing its spectrum. But when far galaxies are studied, individual stars can not be resolved. Is not possible to make a detailed census of the galaxy popullation. Only is possible to get information from the whole stellar population, an integrated spectrum.

Kennicutt pruposed a method in wich a linear relation between SFR and luminosity in specific wavelength ranges can be assumed. This model allows to estimate the young stars fraction and the mean SFR over periods of $10^8 - 10^9$yr. The luminosity in the model, comes from the UV and the FIR broadband, also from speciffic recombination lines.

In a typical galaxy spectrum the visible wavelengths are dominated by the main sequence stars (A to early F) and G-K giants. In few wavelength ranges we have a significative contribution from the young stars rather than the old stars. The infrared and far infrared wavelengths emission is dominated by dust, this dust is heated by the whole stellar popullation, in particular by young, UV-bright stars (Law 2011).The UV broadband emission is dominated by blue stars with temperature near to 40.000K. These hot and massive stars has a lifetime of 10^8Gyr, they spend their nuclear fuel faster than smaller and cooler sunlike stars.

The relation between UV luminosity and Star Formation Rate (Kennicutt 1998) is given by: $\mathrm{SFR}\,(M_\odot \mathrm{yr}^{-1}) = 1.4 \times 10^{28} L_\nu \left(\mathrm{erg\ s^{-1}Hz^{-1}}\right)$ With Initial Mass Function (IMF) between $0.1M_\odot$ and $100M_\odot$, in the range of $1250 - 2500\text{Å}$

The star forming rate will be:

$$SFR = k \times L_0 M \left[\left(\frac{M}{M_0} \right)^{-\beta} + \left(\frac{M}{M_0} \right)^{\gamma} \right]^{-1} \tag{3}$$

The UV dust absorption (Kennicutt 2009) is not taken account in this work.

DUST EXTINTION ALSO STUDIED by 002-TACCHELLA-A Physical Model for —

3. Observations

This paper is based on three main observation sets. The most recent is from the Hubble Space Telescope, this observations where performed by Bouwens (2014). The second set is from the Canada-France Hawaii Telescope, Willott (2013) and the last one by the UK Infrared Telescope and the Subaru Telescope McLure (2009). Those observations where made using the Frop-out technique.

The data from the HST is a compilation of previous works since 2006 (Bouwens 2006), wich includes also observations after the 2009 upgrade mission(Bouwens 2012).

The dataset was retrieved from graphs for Bouwens (2014) and McLure (2009) using GAVO-DEXTER[1].

3.1. The Drop-out Technique - Lyman Break Technique

Steidel (2003)

[1]http://dc.zah.uni-heidelberg.de/dexter/ui/ui/custom

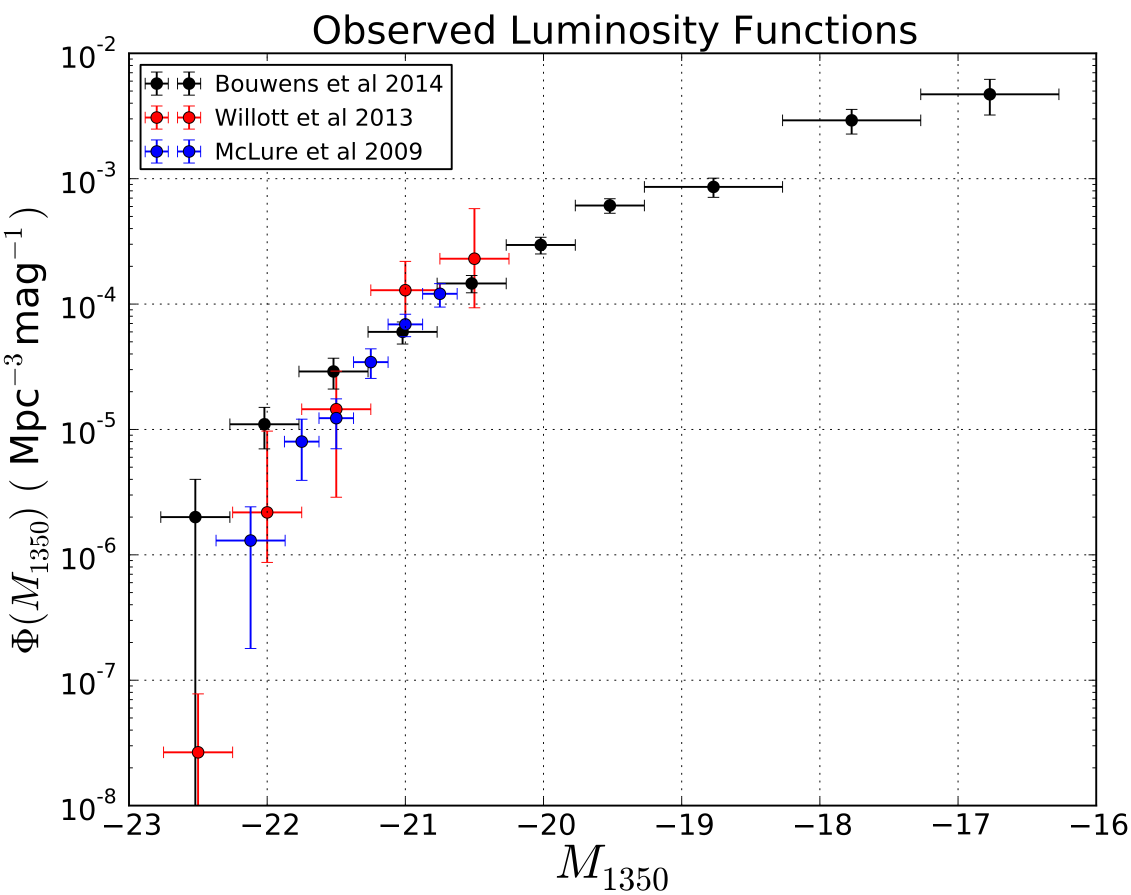

Fig. 1.— Observational data from Bouwens (2014); McLure (2009)and Willott (2013).

4. Discussion

Q: Mpc/h ?

(Lundgren 2014(@) SFR evolution from $z = 1$ to 6

(Bouwens 2014) HST Legacy

(Jiang 2011) Keck pectroscopy

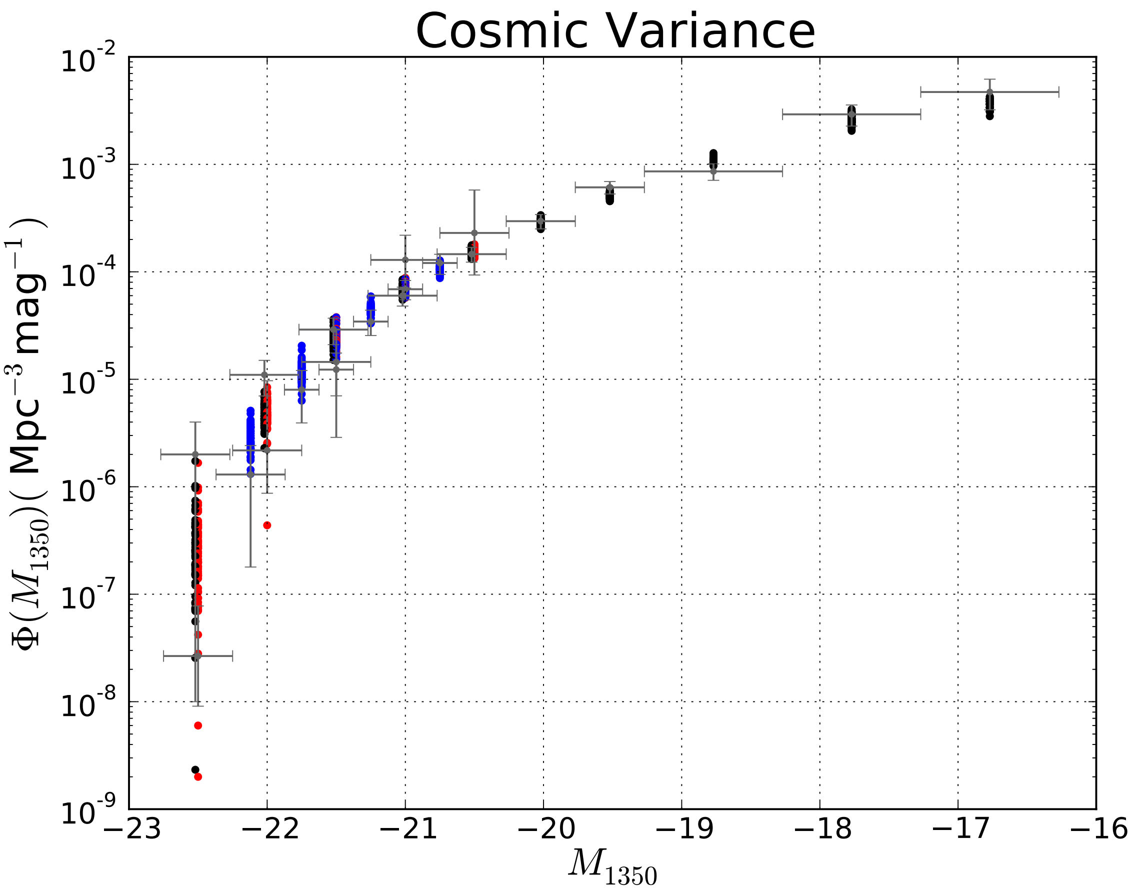

Fig. 2.— Cosmic Variance: The Luminosity Function is made using the DMH catalog from the full box and the set of parameters from the small boxes.

5. Summary

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