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THE COSMIC STAR FORMATION HISTORY

M. A. Muñoz-Gutiérrez[1] and V. Avila-Reese[1]

RESUMEN

Se presenta y compara con observaciones un modelo para calcular la historia de la densidad de la tasa de formación estelar cósmica en un universo ΛCDM jerárquico. Se discuten el rol de diferentes procesos astrofísicos como la función de la masa y época, así como potenciales problemas.

ABSTRACT

A model for calculating the cosmic star formation rate density history in a hierarchical Λ Cold Dark Matter (ΛCDM) universe is presented and compared with observations. The role of different astrophysical processes as a function of mass and epoch, and potential shortcomings are discussed.

Key Words: cosmology: theory — galaxies: formation

1. INTRODUCTION

The star formation rate density (SFRD) measured at different redshifts resumes the complexity of galaxy and star formation. Recent observational efforts allowed to improve the determination of the global SFRD history (up to $z \sim 8$) and decompose it by galaxy mass up to $z \sim 2$. In the context of the popular ΛCDM cosmological scenario, the assembly of galaxies is primarily driven by the hierarchical mass assembly of their dark matter halos, which trap into their centers a fraction of the hot/ionized gas; the cooled gas then form galaxies, where the gas is partially transformed into stars. Stars, mainly through SN explosions, exert feedback to the gas that, specially in low mass halos, is even ejected from the halo (galaxy outflows). In the case of massive galaxies, the powerful AGNs formed in their centers, inject energy to the intrahalo medium, avoiding its further infall to the galaxy.

What is the role that play the ΛCDM *"backbone" and these different astrophysical effects on the global* SFRD *history? What is the contribution of different masses to the* SFRD *at each epoch?* In order to answer to these questions, we have implemented an economical approach for modeling the SFRD history and dissect it by halo masses and peak heights (Muñoz-Gutiérrez 2010).

2. THE MODEL

The global SFRD at a given z is calculated as:

$$\dot{\rho}_*(z) = \int_{M_{\rm min(z)}}^{\infty} N_h(M,z) \times \dot{M}_{\rm SF}(M,z), \quad (1)$$

where $N_h(M,z)$ is the halo mass function at a given z and

$$\dot{M}_{\rm SF}(M,z) = \epsilon_{\rm SF} f_{b,\rm cold} \langle \dot{M} \rangle, \quad (2)$$

is the SFR associated to a halo of mass M at epoch z; $M_{\rm min(z)}$ is the minimum halo mass at z able to host galaxy formation. We assume that the SFR is driven by the (average) halo mass aggregation rate, $<\dot{M}>$; this average rate as a function of M and z has been given as a fit to the results of the dark matter Millenium I and II Simulations in Fakhouri et al. (2010).

By assuming that a universal fraction f_U ($=\Omega_b/\Omega_m$) of M are baryons, the cosmic *baryon aggregation rate density* (BARD) of galaxies is then:

$$\dot{\rho}_b(z) = \int_{M_{\rm min(z)}}^{\infty} N_h(M,z) \times f_U \langle \dot{M} \rangle. \quad (3)$$

In our approach, $f_{b,\rm cold}$ in equation (2), the fraction of cold gas inside the halos, initially is equal to f_U but the inclusion of several astrophysical processes reduce it as a function of M and z. These processes are:

- Capture of gas by halos in the presence of an UV radiation background.
- Radiative cooling of the trapped gas.
- Galaxy outflows of gas driven by SN feedback.
- AGN-driven feedback to the intrahalo medium.

The efficiency of SF in equation (2), $\epsilon_{\rm SF}$, is related to instabilities in the cold gas and we approach it as the ratio of the global dynamical time to a typical SF instability time: $t_{\rm dyn}/t_{\rm SF}$. Halos emerging from high density peaks, i.e. large values of $\nu \equiv \delta_c/\sigma(M)$ at a given z, are highly clustered and are expected to assemble galaxies by major mergers; since these mergers at high z's are plenty of gas,

[1]Instituto de Astronomía, Universidad Nacional Autónoma de México, Apdo. Postal 70-264, 04510 México, D.F., Mexico (mmunoz@astro.unam.mx).