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COMUNICACIÓN DE TRABAJO – CONTRIBUTED PAPER

# Study of the relationship between the gamma ray bursts and their host galaxies

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**Abstract.** Gamma ray bursts (GRBs) belong to the most energetic events in the Universe. Recently, the extragalactic nature of these sources has been confirmed with the discovery of several host galaxies (HGs) and the measurement of their redshifts. To explain the origin of GRBs various models have been proposed, among which the coalescence of compact objects and the *collapsar* scenarios are the most representative, being the collapsar model one of the most accepted to explain the long duration GRBs. A natural consequence of this model is that the GRBs would trace the star formation rate (SFR) of their HGs. In this contributed paper we present preliminary results of the development of a Montecarlo-based code for collapsar event formation which is coupled to chemicalcosmological simulations aiming at studying the properties of HGs in a hierarchical scenario.

**Resumen.** Las explosiones de radiación gamma (ERG) se encuentran entre los eventos más energéticos del Universo. Recientemente, la naturaleza extragaláctica de estas fuentes fue confirmada con el descubrimiento de varias de sus galaxias huésped y la medición de sus corrimientos al rojo. Para explicar su origen, varios modelos han sido propuestos, entre los cuales las colisiones de objetos compactos en sistemas binarios y los llamados *collapsars* son los más representativos, siendo este último modelo uno de los más aceptados para explicar las ERG de larga duración. Una consecuencia natural del mismo es que las ERG trazarían la tasa de formación estelar de sus respectivas galaxias. En esta comunicación se presentan resultados preliminares del desarrollo de un código Montecarlo para la formación de collapsars en simulaciones químico-cosmológicas, con el fin de estudiar las propiedades de sus galaxias huésped en un escenario jerárquico.

## 1. Introduction

The gamma ray bursts (GRBs) are the most energetic electromagnetic events in the Universe (e.g. Piran et al. 2000). One of the preferred models to explain the long duration (i.e., $> 2$ s) GRBs is the star core collapse into a black hole produced in a supernova type SNIb/c explosion (Mac Fayden, Woosley & Heger 2001). This mechanism of GRB formation is also known as the *collapsar* scenario. This model is linked to the evolution of massive stars which normally have a mean lifetime of several million years implying that the typical lifetime of a GRB progenitor system is negligible in cosmological terms. So, it turns to be natural to consider these events as possible tracers of the cosmic star formation history up to high redshifts. In particular, the GRBs would permit to obtain information about star formation regions in galactic systems with different levels of evolution.

Recently, Courty et al. (2004) made use of structure formation simulations in order to identify galactic populations in the simulated sample capable to reproduce the observational features of the observed HGs. These galaxies show a trend to be bluer and sub-luminous (e.g. Le Floc'h et al. 2003). Their analysis seems to confirm the connection with the star formation rate (SFR) if the GRBs events are formed in galaxies with high star formation efficiency. In this work we develop a GRB event generator based on the collapsar model for the progenitors and study the properties of the HGs in cosmological simulations.

## 2. GRB Montecarlo code and discussion

The GRB event algorithm has been designed to work coupled to numerical simulations in a cosmological framework. We used the simulated galaxy catalog constructed by De Rossi et al. (2005) from simulations performed with the chemo-dynamical code of Scannapieco et al. (2005) developed within GADGET-2

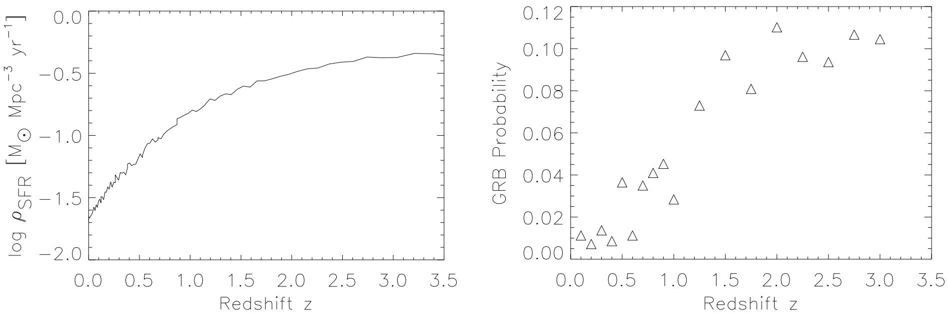


Figure 1. *Left:* Cosmic SFR density for the simulated box of 10 Mpc $h^{-1}$ comoving size as a function of redshift. *Right:* Simulated *probability* for GRBs occurrence as a function of redshift.

(Springel & Hernquist 2002). The gas component is followed using the Smoothed Particle Hydrodynamics technique while the dark matter component is followed using a Tree-Particle Mesh method. This chemo-dynamical code describes the enrichment of the interstellar medium by SNII and SNIa supernova explosions. The cosmological model assumed is defined by the following set of cosmological parameters: $\Omega_{\rm M} = 0.3$, $\Omega_\Lambda = 0.7$, $\Omega_{\rm b} = 0.04$ and $H_0 = 100\,h$ km s$^{-1}$ Mpc$^{-1}$ with $h = 0.7$. The simulations represent a typical region of 10 Mpc $h^{-1}$ comoving size with $2\times80^3$ particles which translates into an initial mass resolution of $2\times10^7$ M$_\odot$ $h^{-1}$ and $2\times10^8$ M$_\odot$ $h^{-1}$ for the gas and dark matter particles, respectively. The catalog of simulated galaxies provides information on the gas, stellar and dark matter components for the redshift range $z = [0, 3]$. A Montecarlo-based code was developed to generate GRBs events in each simulated galaxy of the catalog. We assumed Poissonian statistics to emulate the probability distribution of the GRBs events. The GRB generator selects young stars as possible candidates, where SNIb/c events may occur, and consequently, collapsar events can develope. For that, we adopted a cut-off in stellar ages of $t_{\rm c} = 10^7$ yr. A median rate of collapsar events ($R_{\rm coll}$) consistent with that estimated by Fryer et al. (1999), $R_{\rm coll} \sim 10 - 1000$ Myr$^{-1}$ Galaxy$^{-1}$ where Galaxy represents a typical galaxy, was assumed. In particular, in this work we used $R_{\rm coll} = 100$ Myr$^{-1}$ Galaxy$^{-1}$ and a typical galaxy mass of $10^{11}$ M$_\odot$. A total of 500 Montecarlo realizations was perfomed for every selected stellar particle in each simulated galaxy in the catalog. Our preliminary results can be seen in Figures 1 and 2.

Figure 1 shows the simulated comoving SFR density ($\rho_{\rm SFR}$, left panel) and the simulated *probability* of GRB event occurrence (right panel) as a function of redshift. As it can be seen from Figure 1, assuming the collapsar scenario, where GRBs originate from massive stars, produces the expected behaviour of GRBs being good tracers of the cosmic SFR history. Figure 2 shows the SFR efficiency ($\epsilon_{\rm SFR}$, defined as the SFR normalized to the total stellar mass at each analysed redshift) versus circular velocities ($V_{\rm opt}$) of the HGs from $z = 3$. It can be seen from this figure that the SFR efficiency anticorrelates with $V_{\rm opt}$, so that the higher the efficiency, the smaller the systems (i.e. slower rotating systems). Note that, at all analyzed $z$, more than 50 per cent of the simulated HGs have $V_{\rm opt} < 100$ km s$^{-1}$. According to the Tully-Fisher relation, this result implies that high SFR efficiencies are associated to sub-luminous systems in agreement

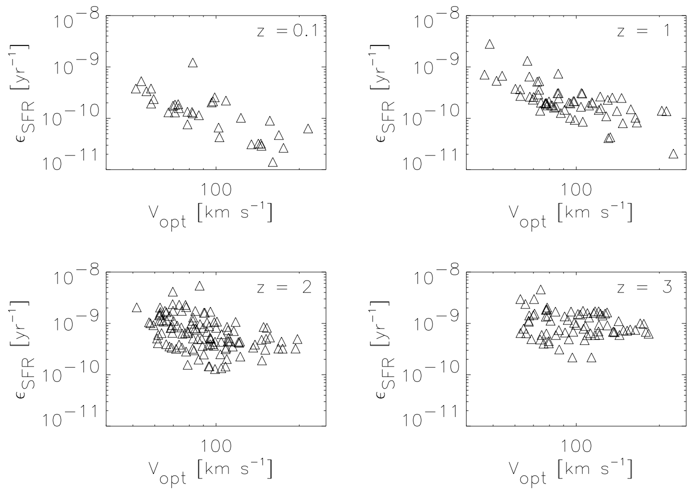


Figure 2. SFR efficiency versus circular velocity for the simulated HGs sample from $z = 3$ to $z = 0.1$.

with observations. Note also that the SFR efficiency increases with increasing redshifts and that for $z > 1$, all HGs seem to have similar values.
Interesting improvements for the future would be to include an analysis based on the simulated colours and metallicities of the simulated HGs. Numerical simulations with higher resolution are also being analysed in order to confirm these trends.

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