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A VARIABLE IMF SLOPE TO FIT THE LCDM PICTURE TO OBSERVED HIGH-Z SUBMILLIMETER SOURCES

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RESUMEN

El uso de una función inicial de masa (FIM) Salpeter permite describir bastante bien una gran variedad de propiedades en galaxias. Sin embargo, algunos estudios han encontrado que es necesario cambiar ésta a una FIM plana en brotes de formación estelar para dar una predicción adecuada en la abundancia de galaxias submilimétricas (SMGs) a altos corrimientos al rojo. Mostramos los resultados preliminares de una implementación de la pendiente de una FIM que depende de la intensidad de formación estelar en un modelo semi-analítico de formación de galaxias, el cual ha sido conectado con un código espectrofotométrico que entrega un tratamiento adecuado de luz estelar reprocesada por polvo. También exploramos efectos sistemáticos en las cuentas de fuentes submm provenientes del tamaño del haz del receptor teniendo en cuenta la correlación espacial de fuentes y objetos en el primer plano. Esto ayuda a aligerar las discrepancias entre modelo y observaciones.

ABSTRACT

Using a Salpeter initial mass function (IMF) allows to describe fairly well a large variety of properties in galaxies. However, some studies have found that it is necessary to change it for a top-heavy IMF in starbursts to give an adequate prediction in the abundance of submillimeter galaxies (SMGs) at high redshifts. We show preliminary results of an implementation of a star formation intensity dependent IMF slope in a semi-analytic model of galaxy formation, which has been connected with a spectrophotometric code that provides an adequate treatment of reprocessed starlight by dust. We also explore systematic effects on the counts of submm sources coming from the beamsize of the receiver taking into account the spatial correlation of sources and foreground objects. This helps alleviate the discrepancies found between the model and the observations.

Key Words: galaxies: evolution — galaxies: high-redshift — methods: numerical — submillimeter: galaxies

1. SUBMILLIMETER GALAXIES

The SMGs (Hughes et al. 1998) are generally interpreted as being dust-enshrouded starbursts, in which the dust is being heated by UV radiation from young stars. In order to address the way these galaxies fit into current theories of galaxy formation, it is necessary to model their stellar populations as well as their dust content.

Baugh et al. (2005, hereafter B05) developed a model which predicts the abundance of SMGs in a ΛCDM cosmology. They adopted a top-heavy IMF for stars formed in bursts, having this the biggest impact on the counts of submm sources, compared with the assumption of a Kennicutt IMF, where the counts were dramatically underpredicted.

2. THE MODEL

We use the semi-analytic model of galaxy formation (SAG) developed by Lagos et al. (2008, hereafter LCP08) within the ΛCDM framework. The cosmological parameter values assumed are $\Omega_m = 0.3$, $\Omega_\Lambda = 0.7$ and $h = 0.7$. SAG considers processes of gas cooling, star formation, feedback from core-collapse supernovae explosions and AGN, galaxy mergers and chemical enrichment of baryons. Evolutionary synthesis models are considered (Bruzual & Charlot 1993) assuming a Salpeter IMF. In addition we also use the GRASIL code (Silva et al. 1998), which computes each integrated spectral energy distribution based on the star formation and metal enrichment histories predicted by SAG. Thus the properties of galaxies are produced consistently, taking into account extinction at short wavelengths and thermal re-emission in the IR.

We follow the history of galaxies inside a periodic box of 67.68 h^{-1} Mpc, and assume that this sample is statistically representative of the overall galaxies

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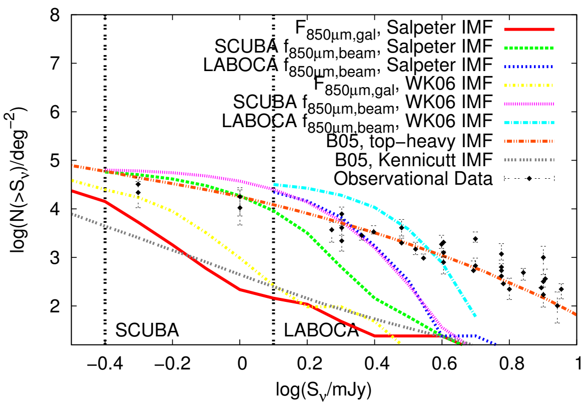

Fig. 1. Cumulative number counts deg^{-2} at 850 μm, predicted by the model simulating SCUBA and LABOCA observations, down to the respective confusion limit (indicated by dashed black vertical lines), assuming Salpeter and WK06 IMFs. For comparison, we include the counts predicted by B05 using a top-heavy IMF in bursts of star formation (orange line) and using a standard Kennicutt IMF (gray line). The symbols show a compilation of observational data obtained by different surveys using SCUBA (see B05, and references therein).

in the universe. So, we build an array with simulated boxes at different consecutive redshifts, and choose a line of sight, which defines our lightcone. The final catalog spans an angular area of ∼0.083 sq deg and comprises ∼105000 model galaxies.

3. RESULTS AND DISCUSSION

We compute the cumulative number counts at 850 μm for the model galaxies, exploring two effects: (a) the beamsize of the receiver, and (b) a variable IMF slope. We simulate square beams, having 14″ and 19″ per side for SCUBA and LABOCA, respectively. Each one of the pixels receives the flux from all the galaxies that fall within it ($f_{850\mu\mathrm{m,beam}} = \sum_{\mathrm{beam}} F_{850\mu\mathrm{m,gal}}$), which is assumed as the flux belonging to one single source. Observations indicate that there is a connection between the SFR and the slope of the integrated galaxial IMF for massive stars (Weidner & Kroupa 2005); we implement the variation in the IMF slope (Weidner & Kroupa 2006, hereafter WK06) in the LCP08 model, consisting of 6 values of α in the range 1.4–2.1.

In Figure 1 we show that the counts predicted by assuming a Salpeter IMF and using the true source positions and flux densities (red solid line) are strongly underestimated when compared to the observational data, being consistent with the B05 model assuming a Kennicutt IMF. In order to investigate the effect of low resolution submm observations, we model the SCUBA (green line) and

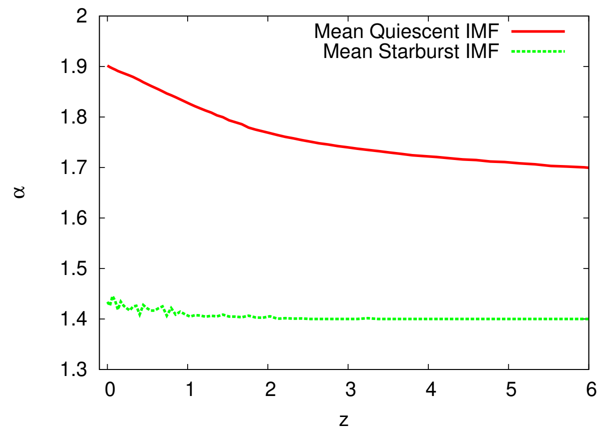

Fig. 2. Mean IMF slope for the cases of quiescent star formation and starbursts (red and green lines respectively).

LABOCA (blue line) beams, and find that the counts are nearly consistent (at low and moderate fluxes) with the observations and the B05 top-heavy IMF model. At higher fluxes the model underestimates the counts as well. However, by assuming a WK06 IMF, the amount of galaxies with higher fluxes increases (yellow, magenta and cyan lines), finding a better agreement with B05 when considering beams.

Additionaly, when adopting a WK06 IMF we compute the mean IMF slope as a function of redshift (see Figure 2). We find that the mean IMF slope for quiescent star formation processes decreases progressively at higher z, while for starbursts it remains roughly constant. This would effectively produce a more top-heavy-like IMF at high z.

Further improvements can be introduced in the model, increasing the periodic volume in the SAG and using realistic noise maps from specific instruments. Our simulated lightcones can be designed as mock catalogs for future research with ALMA, CCAT and LSST.

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