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The spheroidal galaxies-QSO connection: multiwavelength predictions

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Abstract. In view of the problems encountered in standard CDM models in explaining the statistics of sub-mm sources, of K-selected samples, as well as the properties of local large Ellipticals, we have computed a physical model that is able to reproduce all these as well as other constraints (Granato et al 2001, 2003). Keeping into account the mutual feedback between the QSOs and the host galaxy, we show a monolithic-like assembly of baryons is obtained within the hierarchical merging of DM halos. Here we show predictions for the multiwavelength evolution of the sub-mm sources, in particular at the bands of SIRTF and Herschel.

1. Introduction

In the standard CDM scenario for galaxy formation, most of the star formation occurs in relatively small galaxies that later merge to make bigger and bigger objects. These predictions for the behavior of baryons stem from necessarily approximate prescriptions to describe sub-grid physics (SF, SN feedback etc). Among several successes, several discrepancies with observations still persist for these models, mostly related with large Ellipticals (e.g. large E were already in place at $z > 1 - 1.5$; the color-magnitude and the $[\alpha/\mathrm{Fe}]$-M relations for E; the statistics of sub-mm selected high-z galaxies and of K selected samples, see Granato et al 2003 and references therein). These evidences are more consistent with a view in which (stars in) large E are old and almost coeval.

In Granato et al. (2001, 2003) we proposed and demonstrated with a physical model that one of the key ingredients to obtain a monolithic-like evolution of baryons in a hierarchical assembly of DM halos could be a treatment of the mutual feedback between the formation of high-z QSO and their host galaxies, usually ignored by simulations. Several facts hint to a deep link between high-z QSO activity and galaxy formation (e.g. local spheroids contain a central MDO with $M = 10^6 - 3\times10^9$ $M_\odot$; their mass function matches that accreted onto BH during QSO activity; $M_{BH} \propto M_{sph}$ and $M_{BH} \propto \sigma_c^{4-5}$; spheroidal galaxies are the most common hosts of high-z QSOs; QSOs at high z are associated to high metallicity, dusty environments).

In our *Anti-hierarchical baryonic collapse scenario* (ABC, see Granato et al), we explain the statistics of sub-mm selected sources (Fig. 1), as well as several other constraints: the clustering of SCUBA galaxies, the chemistry and the LF of local E, the MF of BHs (Granato et al., Romano et al. 2002, Perrotta et al. 2003)

Here we show our predictions for the contribution of the sub-mm sources to other wavelengths, in particular those where SIRTF and Herschel will observe. The SED of our model galaxies are computed from the UV to the radio with our code GRASIL (Silva et al. 1998; Granato et al 2000; Bressan, Silva, & Granato 2002).

2. Source counts and redshift distributions

In Fig. 2 the 15μm counts and redshift distribution are shown and compared to data. Note that predictions for this spectral region strongly depends on details of dust properties and radiative transfer. Therefore, as far as the contribution from the sub-mm sources is concerned, one could find also a situation in which they are negligible at 15μm, the rest being almost unvaried (Silva et al. 2003). At longer wavelengths these uncertainties are less strong. In Fig. 3, the expected counts at 160μm are shown. This is a band of SIRTF-MIPS, for which we expect a 5σ confusion limit $S_c = 80$ mJy. Therefore the survey SWIRE, with a sensitivity limit of $\sim$ 18 mJy, will reach S_c, and an important number of sub-mm souces could be detected. At 170μm (Fig. 4) ISO data are available at bright fluxes. For Herschel-PACS, that will observe in this band, we expect $S_c = 20$ mJy. In Fig. 5 and 6 we show our predictions for the SIRTF MIPS and IRAC bands respectively at 24 and 8 μm. In both cases, a contribution by passive E is present, particularly important at 8 μm, where we expect them to be detected even at high z. The confusion limits in these bands are computed to be 0.2 mJy and 3μJy. The GOODS survey will reach these limits and will detect important numbers of the sub-mm sources.

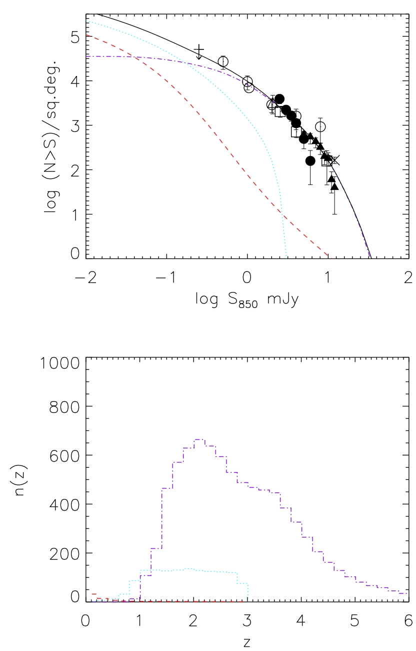

Fig. 1. Up: 850μm counts. The *dot-dashed* line is our model for forming spheroid. The *dotted* and *dashed* lines refer to a population of respectively starburst and spiral galaxies. These are introduced using the usual simple kinematic approach of adopting a local LF, a SED and a $(1+z)^k$ evolution. Their parameters are fixed to reproduce the ISO counts data, and we consider them only for an estimate of the relative importance at other bands of the sub-mm population. Down: Redshift distribution per deg^2 for $S_{850} > 1$ mJy.

3. Conclusions

We have computed a physical model for the joint formation of QSOs and spheroidal galaxies. This coupling is strongly suggested by several lines of evidences. We are able to explain a large number of constraints: sub-mm and K-band selected source statistics; chemistry and LF of E; the MF of BHs; the clustering of SCUBA galaxies etc (Granato et al). With our code GRASIL (Silva et al 1998) we can com-

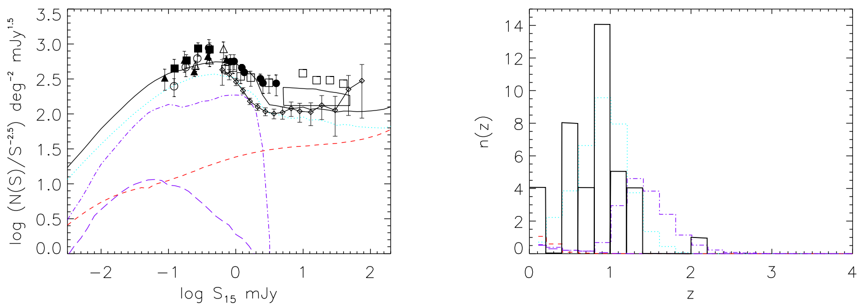

Fig. 2. Left: 15μm counts. Meaning of lines as in Fig. 1. The *long-dashed* line shows the contribution from E in passive evolution. Right: Redshift distribution within $6\,10^{-3}$ deg^2 for $S_{15} > 0.1$ mJy. Continuous line is the observed z distribution by Elbaz et al. (2002).

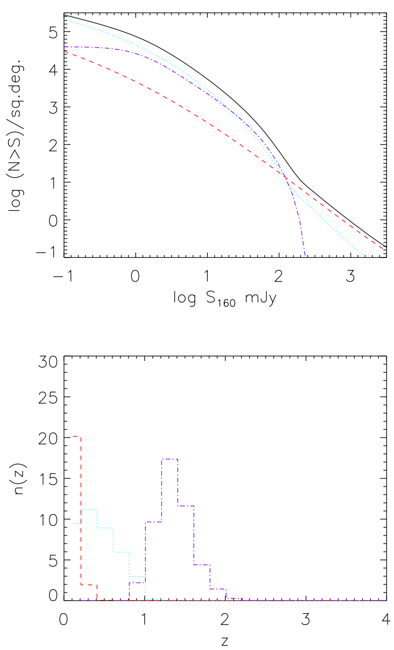

Fig. 3. Up: 160μm counts. Meaning of lines as in Fig. 1. Down: Redshift distribution per deg^2 for $S_{160} > 80$ mJy, the 5σ confusion limit for SIRTF-MIPS.

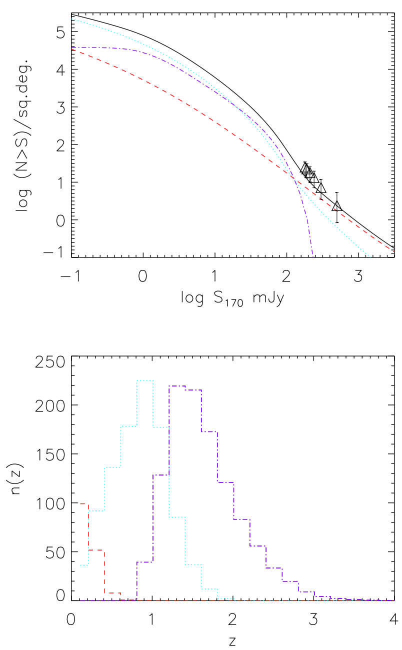

Fig. 4. Up: 170μm counts. Meaning of lines as in Fig. 1. ISO data by Dole et al. (2001). Down: Redshift distribution per deg^2 for $S_{170} > 20$ mJy, the 5σ confusion limit for Herschel-PACS.

pute the SED of galaxies from the UV to the radio. We have therefore applied our model to make predictions for the observability of the sub-mm sources at other bands. We expect large numbers of them to be detected by the surveys that will be conducted with SIRTF and Herschel.

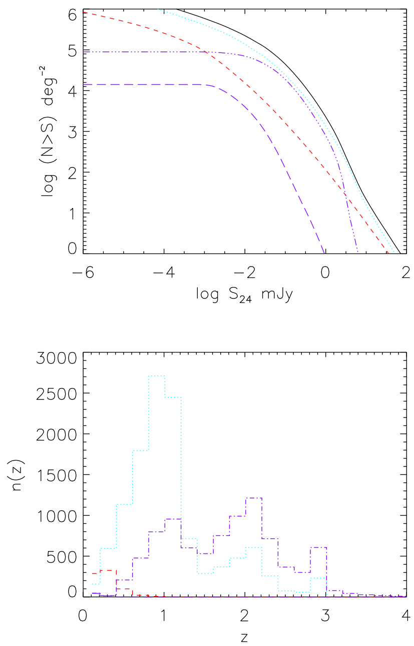

Fig. 5. Up: 24μm counts. Meaning of lines as in Fig. 2. Down: Redshift distribution per deg^2 for $S_{24} > 0.2$ mJy.

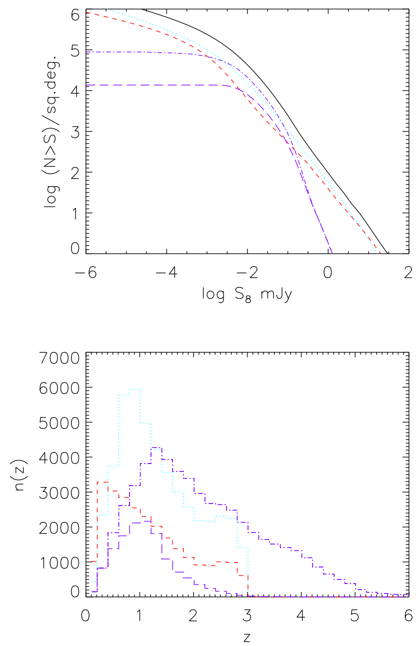

Fig. 6. Up: 8μm counts. Meaning of lines as in Fig. 2. Down: Redshift distribution per deg^2 for $S_8 > 3\mu$Jy.

These observations will provide further fundamental constraints to understand galaxy formation. More details and other bands will be presented in Silva et al (2003).

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