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THE LOCAL UNIVERSE AS SEEN IN FIR AND IN FUV

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Abstract. We have built large samples of nearby galaxies carefully selected in FIR (60 μm from IRAS) and FUV (1530 Å from GALEX) with the aim to have reference samples for comparison with high redshift galaxies selected in the same way. We have also studied the star formation histories of the galaxies we have selected either in FUV or in FIR. In order to check if we sample or not the same galaxy populations in FIR and in FUV, we have performed several statistical analyses: luminosity functions, the specific star formation rate (star formation rate per unit mass) and the ratio of the total IR emission to the FUV one within our galaxy samples. A comparison with high redshift samples selected in the same way is also performed.

1 Introduction

Why to compare FUV and FIR surveys? Numerous measurements of the star formation activity of galaxies as a function of redshift (z) are based on FUV rest-frame data at low z or at higher z (e.g. Lilly et al. 1996, Schiminovich et al. 2005). Infrared surveys have also contributed significantly to the study of the star formation history in the universe (e.g. Flores et al. 1999, Pérez-González et al. 2005). The ultraviolet and the FIR emission are each strongly linked to alternate manifestations of the recent star formation rate: the "transparent" one in FUV and the "hidden" one in FIR (Xu et al. 2006).
The evolution of the luminosity functions and the derived star formation densities were studied in the FUV and at infrared wavelengths: a strong evolution was found at both wavelengths, with a net increase of the luminosity density from $z = 0$ to $z = 1$. Nevertheless the evolution appears to be stronger in the FIR than in the FUV implying a *global* increase of the dust attenuation from $z = 0$ to $z = 1$ by ~ 1 mag (Takeuchi et al. 2005).

Connecting from low- to high-z that which is seen in the rest-frame FIR or in FUV, is a new challenge. Do we see the same galaxy populations in FUV and FIR evolving as a whole and appearing differently in FUV and in FIR, or must we invoke sub-populations of galaxies evolving independently with z and/or being detected only at one wavelength, FUV or FIR?

2 The GALEX/IRAS samples

We have built FIR and FUV selected samples of nearby galaxies over 3000 deg^2 covered by GALEX as part of its All sky Imaging Survey and cross-correlated with the IRAS survey. Each sample contains 800 galaxies with a very high detection rate at both wavelenghts (94% of the IR selected galaxies are detected in FUV and 83% of the FUV selected galaxies are detected at 60 μm). H magnitudes are available from 2MASS for $\sim$ 90% for the targets.

3 Bolometric luminosity functions from young stars

We have combined the FUV and Total Infra-Red (TIR:8-1000 μm) luminosities to estimate the total bolometric luminosity of young stars: $L_{bol} = L_{FUV} + 0.7 L_{TIR}$, the factor 0.7 accounts for the dust heating by stars older

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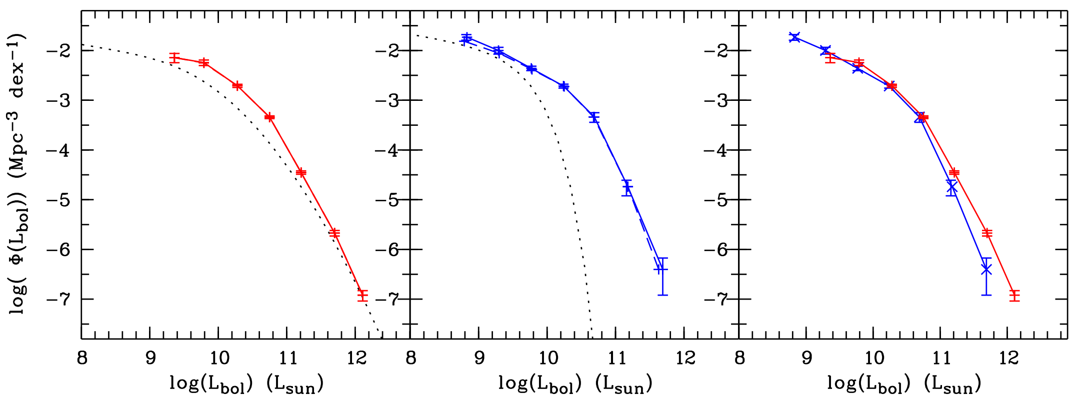

Fig. 1. Bolometric luminosity functions. Left panel: FIR-selected sample, the monochromatic (60 μm) LF is represented as a dotted line; middle panel: FUV-selected sample, the monochromatic (FUV) LF is represented as a dotted line; right panel: comparison of the bolometric LF for the FUV-selected and FIR-selected samples: crosses (X) and blue line are used for the FUV selection and plus symbols (+) and red line for the FIR selection.

than 100 Myrs (Hirashita et al. 2003) and L_{FUV} is calculated as $\nu\ L_\nu$. We have built the bolometric luminosity functions for our FUV and FIR selected samples (Fig. 1) and compared them to the monochromatic ones.

The 60 μm luminosity appears as a robust tracer of the luminosity of young stars. Whereas the FUV flux appears to be a reliable estimator of the bolometric emission from young stars in low luminosity galaxies ($L_{bol} < 2.5\ 10^9 L_\odot$), the difference increases very fast with luminosity: the FUV luminosity is ~ 5 times lower than the bolometric one for $L_{bol} \sim 10^{10} L_\odot$ and the discrepancy reaches a factor ~ 500 for $L_{bol} = 3\ 10^{10} L_\odot$: even within a FUV selection the FUV flux alone (without any correction) misses a large part of the total emission of FUV-selected galaxies. If we compare the bolometric LF for both samples it can be seen that we miss intrinsically bright galaxies in the FUV survey. The shallowness of the IRAS survey does not allow us to compare the distributions at low luminosities.

4 $L_{\rm TIR}/L_{\rm FUV}$ distributions

Analysing the $L_{\rm TIR}/L_{\rm FUV}$ ratio is another way to compare the FIR and FUV selection effects. Indeed, the $L_{\rm TIR}/L_{\rm FUV}$ ratio has a physical significance since it is directly related to the dust attenuation in star-forming galaxies (e.g. Buat et al. 2005).
We calculate the weighted distributions of $L_{\rm TIR}/L_{\rm FUV}$ as a function of $L_{\rm bol}$. The sample is divided into bins of $L_{\rm bol}$ (bin size = 0.5 dex) and for each bin we calculate the averaged ratio $R = \log(L_{\rm TIR}/L_{\rm FUV})$ and its standard deviation as follows:

$$\langle R(L_{\rm bol})\rangle = \frac{\sum_i \omega_i R_i}{\sum_i \omega_i} \qquad (4.1)$$

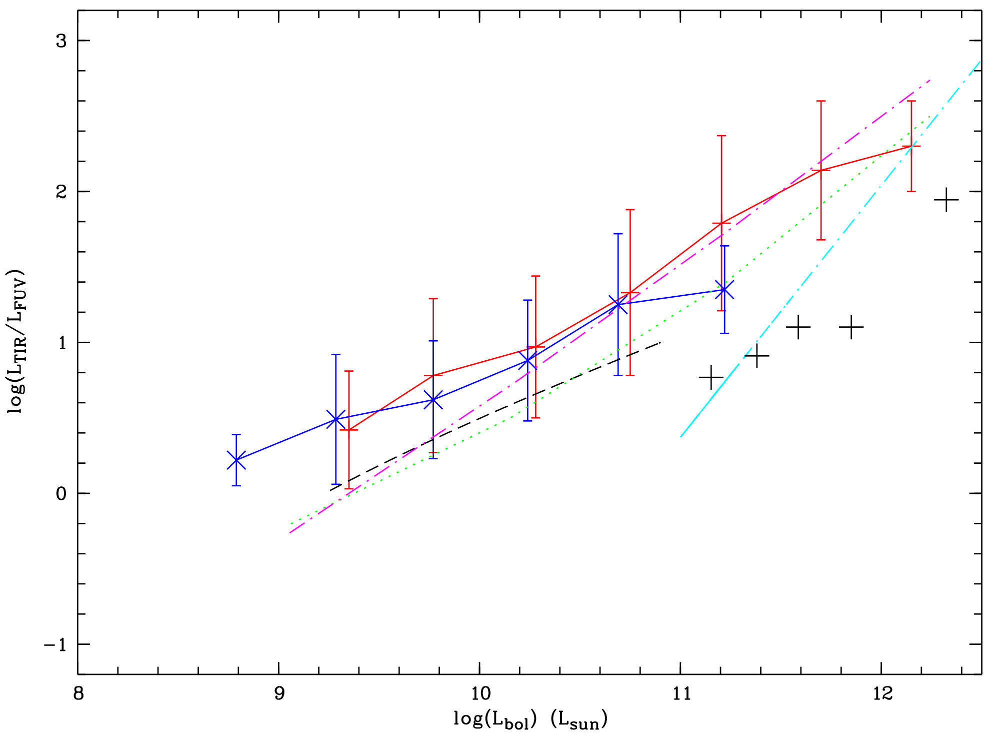

Fig. 2. Mean $L_{\rm TIR}/L_{\rm FUV}$ ratio versus $L_{\rm bol}$ calculated for the FUV-selected sample (blue solid line and crosses) and for the FIR-selected sample (red solid line and plus (+) symbols), the errors (1σ) are overplotted as vertical bars. The green dotted line is from Martin et al. (2005), the dot-dashed magenta line from Xu et al. (2006), the black dashed line from Bell (2003), the dot-dashed cyan line from Reddy et al. (2006) (optically selected galaxies at z∼2 also observed at 24 μm) and the crosses correspond to mean values per bin of luminosity for Lyman Break Galaxies at z∼1 from Burgarella et al. (in preparation)

and

$$\sigma^2(L_{\rm bol}) = \frac{\sum_i \omega_i (R_i - \langle R(L_{\rm bol})\rangle)^2}{\sum_i \omega_i} \tag{4.2}$$

where ω_i is the weight for the i-th galaxy, practically $1/V_{\rm max}$. The results are plotted in Fig. 2. FIR and FUV selected samples give similar trends at low and intermediate luminosities, but the volume corrections cannot completely compensate for the very different distributions seen in Fig. 1 for the high luminosities. Whereas the $L_{\rm TIR}/L_{\rm FUV}$ ratio continues to increase with luminosity for FIR-selected galaxies, it shows a clear flattening for FUV-selected galaxies brighter than 5 10^{10} $L_\odot$. The trends are compared to other studies at low and high z: all confirm the increase of $L_{\rm TIR}/L_{\rm FUV}$ with $L_{\rm bol}$ but at z=1-2 $L_{\rm TIR}/L_{\rm FUV}$ is found ∼ten times lower in luminous galaxies selected in UV-optical (Reddy et al, 1006; Burgarella et al in preparation).

5 Specific Star Formation Rates

The present star formation efficiency of galaxies can be quantified by comparing their whole stellar mass to their present SFR. The specific SFR (SSFR) is defined as the ratio of the present SFR to the stellar mass: $SSFR = SFR/M_\star$. The stellar masses are estimated with the H magnitudes ($M/L_H = 0.57$) and the SFR as $SFR = SFR(FUV_{\rm obs}) + 0.7\ SFR(TIR)$ (Hirashita et al. 2003). As for the $L_{\rm TIR}/L_{\rm FUV}$ distribution, we also perform a volume average. The results are presented in Fig. 3.
For the FUV selection, the SSFR is found to decrease as the galaxy mass increases, with and without applying a volume average confirming previous works. Nevertheless our average values of SSFR for massive FUV-selected galaxies appear larger than previously found from optical surveys at low redshift. Selections effects

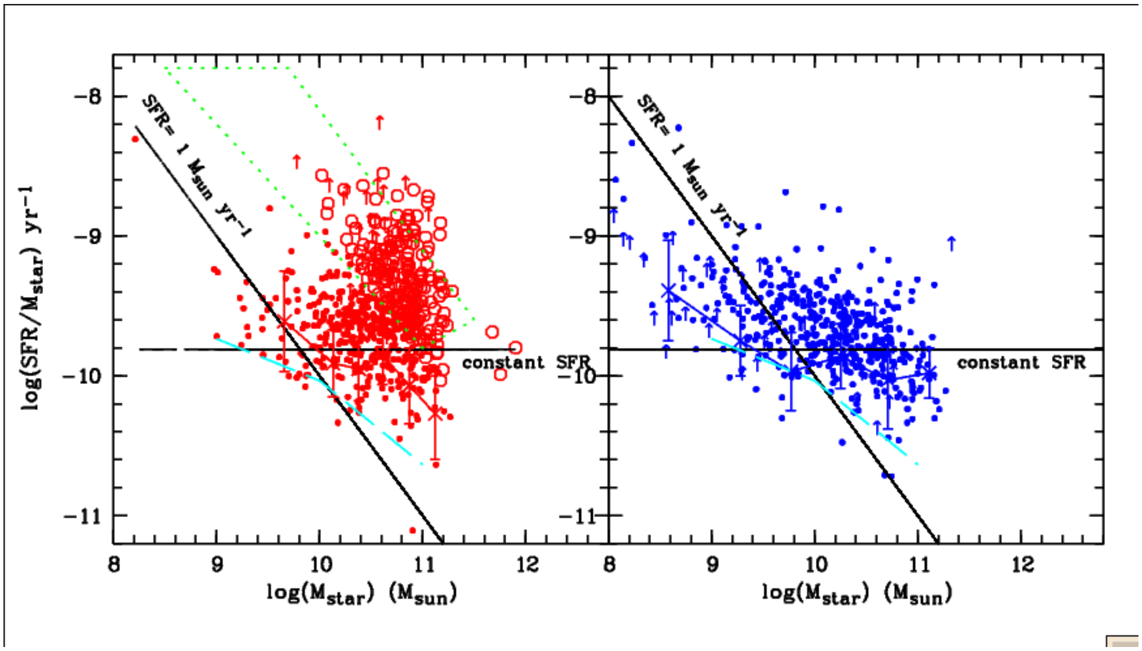

Fig. 3. Specific star formation rate (SSFR). **Left panel**: FIR selection, the empty circles represent the galaxies with $L_{\rm TIR} > 10^{11} L_\odot$. The dashed (green) box is the locus of the galaxies selected by Bell et al. (2005) at $z = 0.7$.Right panel: FUV selection. In both panels the solid lines represent the average specific SFR (SSFR); The horizontal lines a constant SFR over the lifetime of the galaxies and the diagonal lines correspond to a present SFR equal to 1 $M_\odot$/yr. The average SSFR found by Brinchman et al. (2004) is plotted as a cyan long dashed line.

(UV versus optical) are probably at the origin of this discrepancy. The FIR selected sample is shifted toward more massive galaxies as compared to the FUV-selected sample. It also contains a large fraction of bright galaxies ($L_{\rm TIR} > 10^{11} L_\odot$) which do not follow the general trend found in FUV and optical selections: these very bright and massive galaxies exhibit a high SSFR. However these galaxies are rare objects in the nearby universe and as soon as a volume average is performed we also find a global decrease of the mean SSFR when the mass increases for the FIR selection. Similar high SSFR ar found at higher z (z=0.7) by Bell et al. (2005) with a selection at 24 μm.

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