The Cosmic Infrared Background (CIRB) and the Role of the "Local Environment of Galaxies" in the Origin of Present-Day Stars

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Abstract. A combination of evidence is presented suggesting that the majority of the stars in today's galaxies were born during a luminous infrared phase (LIRP) triggered by the local environment of galaxies. The CIRB is a fossil record of these LIRPs and therefore reflects the influence of triggered star formation through galaxy-galaxy interactions, including non merging tidal encounters. This scenario, in which galaxies experienced several LIRPs in their history, is consistent with the measured redshift evolution of the cosmic density of star formation rates and of stellar masses of galaxies.

1 Introduction

Stars represent only 15 % of the cosmic baryonic density, itself only equal to about 4% of the critical density ($\Omega_{\mathrm{b}} \simeq 0.04$), and are unequally distributed into spheroids (10% of Ω_{b}, including spiral bulges) and disks (5% of Ω_{b}, Fukugita, Hogan & Peebles). It is usually assumed that disk stars formed quiescently while bulge stars formed more efficiently and rapidly, as suggested by their redder colors and overabundance in α-element over iron ratio, typical of a SNII origin. However recent studies of the history of the star formation of the disk of the Milky Way indicate that during the last 2 Gyr it has experienced about five major events of star formation, starbursts, whose signatures can be found in the peaked ages of these open clusters (de la Fuente Marcos & de la Fuente Marcos 2004, and references therein). As a result we may wonder whether quiescent star formation did play a major role in the formation of present-day stars at all. There are some evidence that star formation mostly takes place in globular clusters and is rarely isolated. These clusters are thought to evolve into unbound stellar associations, which evolve and dissolve in a time-scale of about 50 Myr. This timescale is longer than the lifetime of massive stars which dominate the luminosity of starbursting galaxies or regions of galaxies. Hence, it is logical to expect that if star formation occurred mainly in starburst episodes within galaxies, then the bulk of galaxies luminosity will be absorbed by dust in the giant molecular clouds, while if star formation is quiescent then only a minor fraction of a galaxy's luminosity will be affected by dust extinction. We will argue in the following that there is presently a solid collection of evidence suggesting that most stars that we see in the local universe formed during starburst episodes.

A major peace of evidence for that comes from the detection of a strong diffuse cosmic infrared background (CIRB, Puget et al. 1996, Hauser & Dwek and

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references therein) which is majoritarily produced by luminous infrared phases (LIRP) within galaxies located around $z \sim 0.7$, for the peak of the CIRB at $\lambda \sim 140\,\mu$m, while the $\lambda \geq 240\ \ \mu$m is due to galaxies at $z \sim 2$ and above (Elbaz et al. 2002, Chary & Elbaz 2001). We have introduced the term LIRP instead of the classical one, luminous and ultra-luminous infrared galaxies, i.e. LIRGs and ULIRGs, because we wish to emphasize the idea that the scenario that is emerging from the study of distant galaxies is that LIRGs do not represent a population of galaxies that would require to be studied independently in order to determine which present-day galaxies are the remnants of these LIRGs, but what is suggested instead is that they illustrate the omnipresence of rapid and efficient star formation as a leading process in shaping the present-day universe, i.e. that any galaxy that we see today must have experienced a phase when it radiated the bulk of its light in the infrared (see also Elbaz & Cesarsky 2003). This phase should not be restricted to LIRGs and ULIRGs, i.e. galaxies with infrared (IR) luminosities larger than 10^{11} $L_\odot$ or star formation rates (SFR) larger than ~ 20 $M_\odot$ yr^{-1}, since the closest starburst M82, for example, presents a spectral energy distribution typical of most LIRGs, with the bulk of its luminosity radiated in the IR although its luminosity is only 4×10^{10} $L_\odot$.

We present evidence suggesting that the bulk of local stars formed during a LIRP. A spectroscopic diagnostic is used to quantify the typical duration of this phase and the amount of stars that formed during it. From the combination of both we will advocate that not only did all galaxies experience a LIRP but that they must have experienced several of them. Finally we will discuss the physical origin of the LIRP and present evidence that a major event in the lifetime of galaxies was probably underestimated: the effect of the "local environment of galaxies" (LEG) and its impact in terms of driving the conversion of gas into stars through passing-by galaxies.

2 Luminous IR Phases and the Origin of Present-Day Stars

The detection of a CIRB came as a surprise since local galaxies only radiate $\sim 30\,\%$ of their bolometric luminosity in the mid to far IR range, i.e. sharing as a common origin stellar photons reprocessed by dust above $\lambda \sim 3\,\mu$m. With about half of the diffuse background light radiated above and below this wavelength cutoff, the extragalactic background light tells us that in the past, major star formation events were strongly affected by dust extinction even when galaxies were less metal rich. Deep surveys in the mid infrared ($\lambda \sim 15\,\mu$m with ISOCAM onboard ISO, Elbaz et al. 1999) brought independent evidence that infrared was more ubiquitous in the past. These surveys detected ten times more objects at faint flux levels than expected from the extrapolation of the local universe (no evolution models). These galaxies turned out to belong to the class of LIRGs and ULIRGs discovered by IRAS in the local universe but located at a median redshift of z$\sim$0.7. They do not exhibit any optical signature of such strong SFRs neither in their optical colors nor in their emission lines, except if careful correc-