Extremely red galaxies: dust attenuation and classification

D. Pierini C. Maraston R. Bender and A. N. Witt

E-mail: dpierini@mpe.mpg.de, C. Maraston1, R. Bender1,2 and A. N. Witt3

abstract We re-address the classification criterion for extremely red galaxies (ERGs) of Pozzetti & Mannucci (2000 – PM00), which aims to separate, in the $I_c - K$ (or $R_c - K$) vs. $J - K$ colour–colour diagram, passively evolving, old ($\geq 1$ Gyr) stellar populations in a dust-free environment, associated with ellipticals (Es), from dusty starburst galaxies (DSGs), both at $1 < z < 2$. We explore a category of objects not considered previously, i.e., galaxies forming in this redshift range on short (0.1 Gyr) timescales and observed also in their early, dusty post-starburst phase. We also investigate the impact of structure of the dusty medium and dust amount on the observed optical/near-IR colours of high-$z$ DSGs/DPSGs, through multiple-scattering radiative transfer calculations for a dust/stars configuration and an extinction function calibrated with nearby dusty starbursts. As a main result, we find that dusty post-starburst galaxies (DPSGs), with ages between 0.2 and 1 Gyr, at $1.3 < z < 2$ mix with Es at $1 < z < 2$ for a large range in dust amount. This “intrusion” is a source of concern for the present two-colour classification of ERGs. On the other hand, we confirm, in agreement with PM00, that DSGs are well separated from Es, both at $1 < z < 2$, in the $I_c - K$ vs. $J - K$ colour–colour diagram, whatever the structure (two-phase clumpy or homogeneous) of their dusty medium and their dust amount are. This result holds under the new hypothesis of high-$z$ Es being as dusty as nearby ones. Thus the interpretation of the optical/near-IR colours of high-$z$ Es may suffer from a multiple degeneracy among age, metallicity, dust and redshift. We also find that DPSGs at $z \sim 1$ mix with DSGs at $1 < z < 2$, as a function of dust amount and structure of the dusty medium. All these results help explaining the complexity of the ERG classification emerged from recent surveys. Model DSGs/DPSGs with $K < 20.5$ and selected as ERGs on the basis of their observed optical/near-IR colours span a large range in absorption efficiency and/or intrinsic UV-to-optical luminosity ratio. As a consequence, the total emission from dust in the rest-frame mid-IR–(sub)mm ranges from $\sim 10^{10}$ to $\sim 5.6 \times 10^{12}$ L for DPSGs through DSGs. This large dynamic range is consistent with estimates made from submm observations of bright ($K < 19.5 – 20$) ERGs. Finally, we show that ERG samples are biased towards a lower fraction either of DSGs/DPSGs at $1.3 < z < 2$ or of DSGs/DPSGs at $z \sim 1$, when selection is made via either the $R_c - K \geq 5.3$ or the $I_c - K \geq 4$ colour criterion.