Testing different stellar mass estimators at 1<z<2

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ABSTRACT

Physical parameters of galaxies (as luminosity, stellar mass, age) are often derived by means of the model templates which best fit their photometric data. We have performed a quantitative test aimed at exploring the ability of this procedure in recovering the physical parameters of early-type galaxies at 1<z<2. A wide range of simulated SEDs, reproducing those of early-type galaxies at 1<z<2 with assigned age and mass, are used to build mock photometric catalogs with wavelength coverage and photometric uncertainties similar to those of two topical surveys (i.e. VVDS and GOODS). The bestfitting analysis of the simuated photometric data allow to study the differences among the recovered parameters and the input ones. Results indicate that the stellar masses measured by means of optical bands are affected by larger uncertainties with respect to those obtained from near-IR bands, and they frequently underestimate the real values. The M/L ratio in the V band results strongly underestimated, even when derived from the recently proposed prescription based on restframe optical colours (e.g. (B-V)).

Tab. 1 – Parameters of the simulated galaxies

Spectrophotometric code	BC03
Metallicity	solar
IMF	Salpeter
SFH	τ=0.6 Gyr
redshift	1.0 - 1.5 - 2.0
A_V	0.0 - 0.2 - 0.5
Masses [10^{11} Msol]	0.3 - 1.0 - 3.0
Secondary burst [%Mtot]	0.05 - 0.2

The possibility of secondary star forming episodes is taken into account by the superimposition of τ=0.1 Gyr models on the principal SF history at different times, depending on the redshift and age of the galaxy.

	Galaxy Ages [Gyr]				
Z=1.0	4.2	3.0	2.7	2.0	1.7
No burst	X	X	X	X	X
At t=0.6 Gyr	X	X	X	X	X
At t=1.7 Gyr	X	X	X	X	
At t=2.7 Gyr	X	X			
At t=3.5 Gyr	X				
Z=1.5	4.2	3.0	2.7	2.0	1.7
No burst		X	X	X	X
At t=0.6 Gyr		X	X	X	X
At t=1.7 Gyr		X	X	X	
At t=2.7 Gyr		X			
At t=3.5 Gyr					
Z=2.0	4.2	3.0	2.7	2.0	1.7
No burst				X	X
At t=0.6 Gyr				X	X
At t=1.7 Gyr				X	
At t=2.7 Gyr					
At t=3.5 Gyr					

1 – Mock photometric catalogs

We first built mock photometric catalogs based on a set of spectral templates reproducing the expected SEDs of early-type galaxies in the range 1<z<2 (see Table 1). The catalogs have wavelength coverage and photometric uncertainties resembling those of the published catalogs of two topical surveys: the VIMOS VLT Deep Survey (VVDS, LeFevre et al. 2005), hereafter referred to as VVDS, and the Great Observatories Origins Deep Survey (GOODS-MUSIC sample, Grazian et al. 2006), hereafter referred to as GOODS and GOODS+Sp in the two cases not including or including the Spitzer IR data.

2 - Analysis

We have analyzed the photometric properties of the simulated galaxies by means of the photometric redshift code *hyperz* by Bolzonella, Miralles \& Pellò (2000). The set of SEDs adopted to find the best fit template for each galaxy is composed by models based on the BC03 code assuming solar metallicity and Salpeter IMF with exponentially declining SFR (τ=0.1, 0.3, 0.6 and 1.0 Gyr). In the best fitting procedure the extinction has been allowed to vary between A_V=0.0 and A_V=0.5, and at each z ages have been forced to be lower than the Hubble time at that z, while z is fixed at the known value. Once a bestfit template has been associated to each simulated galaxy, we derived the following physical parameters:

K and **K(4.5)** = absolute K band magnitude derived from the observed K magnitude and from the observed IR flux at 4.5μm respectively, obtained applying the k-corrections calculated on the bestfit template and the dust correction derived for the best fit value of A_V;

K_{raw} = absolute K band magnitude derived from the observed K magnitude simply applying a constant k-correction depending only from the redshift, without any dust correction;

V(J) = absolute V band magnitude derived from the observed J magnitude, obtained applying the k-correction calculated on the bestfit template and the dust correction derived for the best fit value of A_V;

M/L_K and **M/L_V** = mass to light ratio in the K and V band respectively, as derived from the bestfit template;

M/L_V|B-V = mass to light ratio in the V band as derived by Bell et al. (2005) from the (B-V) restframe colour (derived from the bestfit template);

M(b) = stellar mass content derived from the normalization factor needed to scale the model templates to match on average the observed available fluxes (b parameter in the *hyperz* code);

M(K), **M(V|J)** and **M(V|J|B-V)** = stellar mass content derived from the absolute K and V(J) magnitudes and assuming the mass to light ratios M/L_K, M/L_V and M/L_V|B-V respectively;

V(J)|A_V=0, **M(V|J|B-V|A_V=0)** and **M/L_V|B-V|A_V=0** = parameters obtained on the subsample of the simulated galaxies with no dust extinction imposing A_V=0 in hyperz (i.e., not affected by dust uncertainties).

The derived physical parameters of the simulated galaxies have been then compared with their real known values.

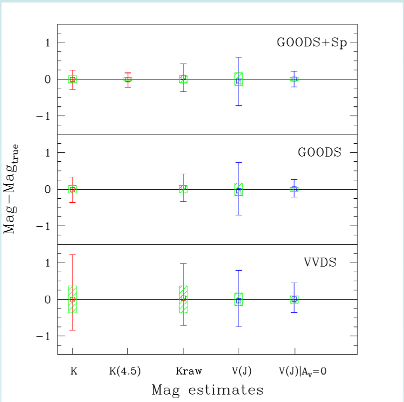

Fig. 1 – Diffrence between the recovered values mag and the true values mag_{true} of the absolute magnitude in the K and V band (see box 2 for details). Green shaded areas display the amplitude of the photomteric errors of the starting magnitude values.

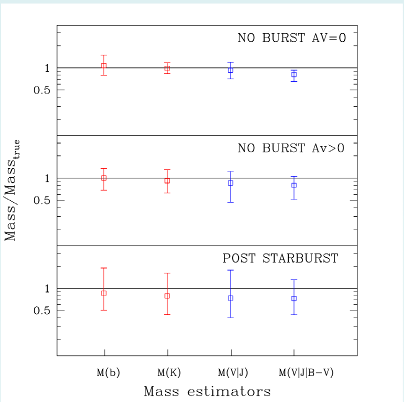

Fig. 2 – In the case of the GOODS mock catalog, the ratio between the recovered values and the true values of the stellar mass content is reported for some mass estimators. Comparison among the three panels show that if dust affects the luminosity of the galaxies, or, more important, if galaxies suffered a recent burst, uncertainties are larger and results tend to underestimate the true values, expecially when optical estimators are adopted.

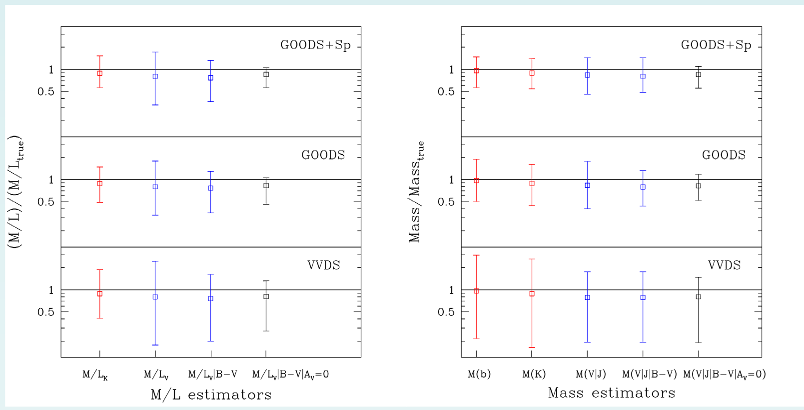

Fig. 3 – Ratio between the recovered values and the true values of the mass to light ratio in K and V band (left) and of the stellar mass content (right) (see box 2 for details).

3 – Conclusions

As far as the luminosities are concerned, Fig. 1 shows that the uncertainties affecting the determination of the V band luminosity are much larger than those relative to the K absolute magnitude. Even the values of K_{raw} are closer to K_{true} with respect to the difference between V(J) and V_{true}. Also the unrealistic case of no dust effects produces V(J)|A_V=0 that is not so much precise than K and Kraw.

The mass to light ratio in the K band is generally recovered within a factor 0.5-1.5 of the true value, and only for the faintest galaxies in the VVDS mock catalog the uncertainties grow up to 0.4-1.9. From Fig. 3 (left panel) it can be noted the tendency to slightly underestimate the real value of M/L_K by a factor of about 0.9. The underestimate of the M/L value in the V band is larger (i.e. around 0.8), and the uncertainties are much larger in this band than in the K band. Also the values of M/L_V|B-V, even if they show a smaller range of uncertainties with respect to M/L_V, strongly underestimate the true values (i.e. factor 0.7). (Actually, Bell et al. do not explicitly state the definition of mass to which they refer, and it could be 0.7-0.8 of that adopted in the present paper).

Finally, Fig. 3 (right panel) shows that the mass estimate is the K band and M(b) are in good agreement and they allow to obtain the most precise estimate of the stellar content of galaxies. Mass estimates obtained by means of the V magnitudes are generally affected by larger uncertainties and, more important, they lead to underestimate the true mass content, expecially when dust or recent burst affect the luminosity of the galaxies (Fig.2).