Photometric redshifts from chemically consistent templates

Ralf Kotulla

Centre for Astrophysics Research, University of Hertfordshire, United Kingdom

r.kotulla@herts.ac.uk

Multi-band imaging allows us to reach the numerous - but faint - population of "normal" galaxies out to high redshifts - far beyond the reach of spectroscopic surveys. This opens the door to a physical understanding of normal galaxies at each redshift, but also bears many potential problems that need to be taken into account.

I here present GAZELLE, a photometric redshift code tailored to include the full chemical and photometric evolution given by our GALEV evolutionary synthesis models. GALEV treats the chemical evolution of galaxies in a chemically consistent way, i.e., fully accounting for the increasing initial abundances of successive stellar generations.

Not accounting for this chemical evolution leads to a significant bias in the derived photometric redshifts and hence galaxy properties. GAZELLE furthermore allows us to derive not only redshifts, but also physical parameters such as stellar and gaseous masses, star formation rates and metallicities in a selfconsistent way.

Impact of subsolar metallicities

Faint galaxies in deep photometric surveys are very different from local galaxies:

- wide range of luminosities out to high redshifts
- many intrinsically faint galaxies
- significantly sub-solar metallicities and
- in significantly younger evolutionary states.

Our aim is to determine the impact of different template sets used to derive photometric redshifts for those galaxies in the distant universe.

To obtain reliable and accurate redshifts all those effects have to be taken into account by

- the template set (⇒ GALEV)
- the photo-z code (⇒ GAZELLE)

So far only GALEV and GAZELLE account for all these effects.

Training based photo-z codes partly include these effects, but can not be extrapolated to fainter magnitudes or higher redshifts.

Our photometric redshift code GAZELLE

Our new photometric redshift code GAZELLE is specifically optimized to work with our GALEV models. It utilizes a dropout-detection scheme with a χ^2 algorithm to compute probabilities for each combination (observed SED, model-SED), and by keeping the full probability density distribution it allows to derive:

- best-match redshift incl. 1σ-uncertainty
- stellar mass incl. 1σ-uncertainty
- intrinsic reddening incl. 1σ-uncertainty
- galaxy type

Since we have the full information from the modeling process at hand, we can furthermore derive:

- Total baryonic (stars + gas) masses incl. 1σ-uncertainties
- Star formation rates, incl. 1σ-uncertainties
- Gaseous metallicities, incl. 1σ-uncertainties
- Stellar metallicities, incl. 1σ-uncertainties

Why care about subsolar metallicities and chemically consistence at all?

Because of the metallicity dependence of:

- **Stellar evolution** (low metallicity (l.m.) → stars become hotter and brighter)
- **Stellar spectra** (l.m. → bluer spectra)
- **Emission line ratios and strengths** (l.m. → stronger Balmer-lines, metal-lines can vary)
- **Stellar lifetimes** (l.m. → high-mass stars live longer, low-mass stars shorter)
- **Chemical yields**

Applying solar metallicity calibrations without accounting for those effects leads to overestimated masses and star formation rates.

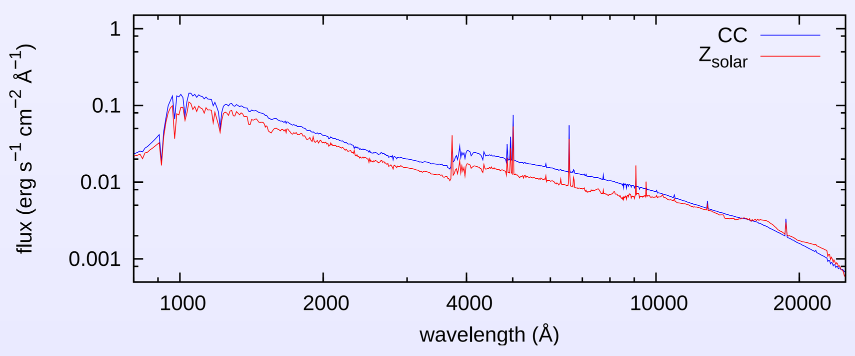


Figure 1: Spectrum of a galaxy with constant star formation rate at an age of 4 Gyr, computed chemically consistent (CC) and with fixed solar metallicity

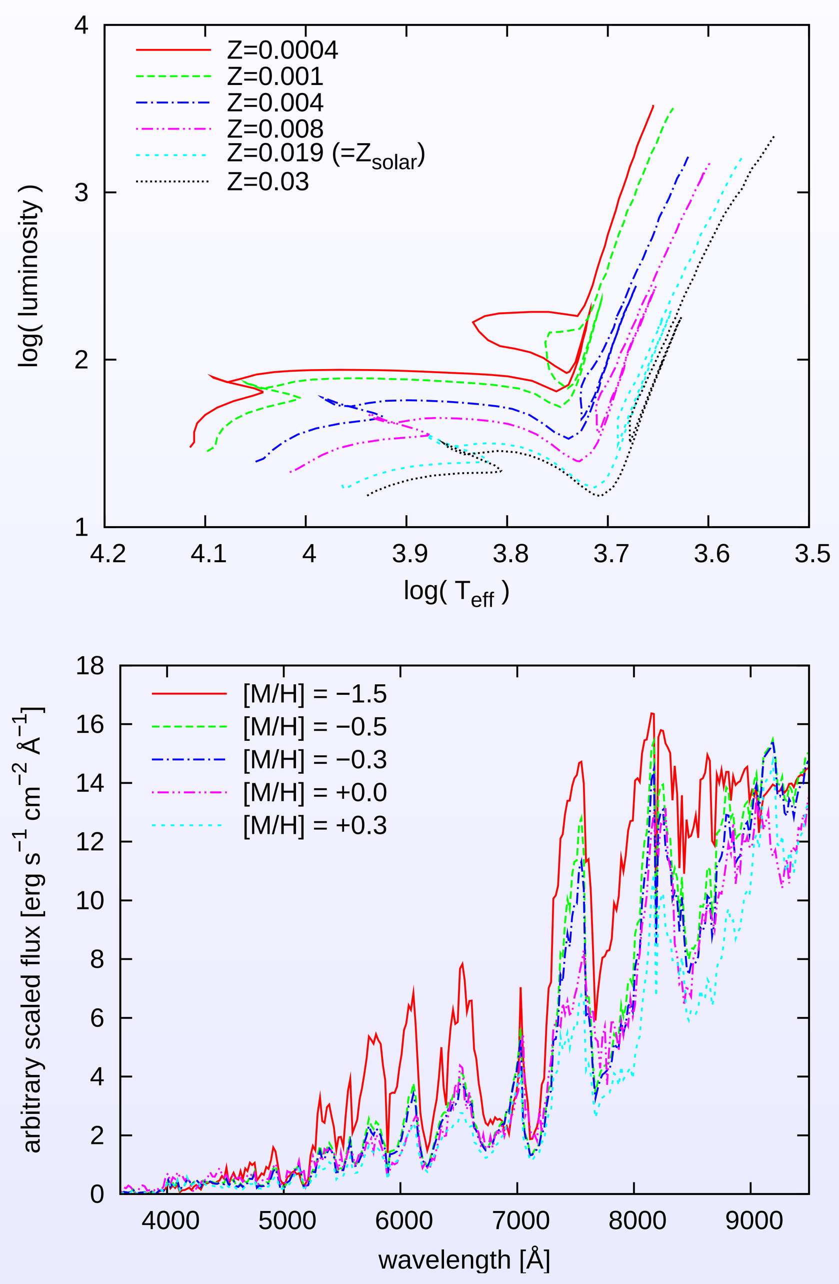


Figure 2: Stellar tracks of a 2 $M_\odot$ star (top panel) and stellar spectra for $T_{eff} = 4000\,K$ and $\log(g) = 4.0$ (bottom panel) for various metallicities.

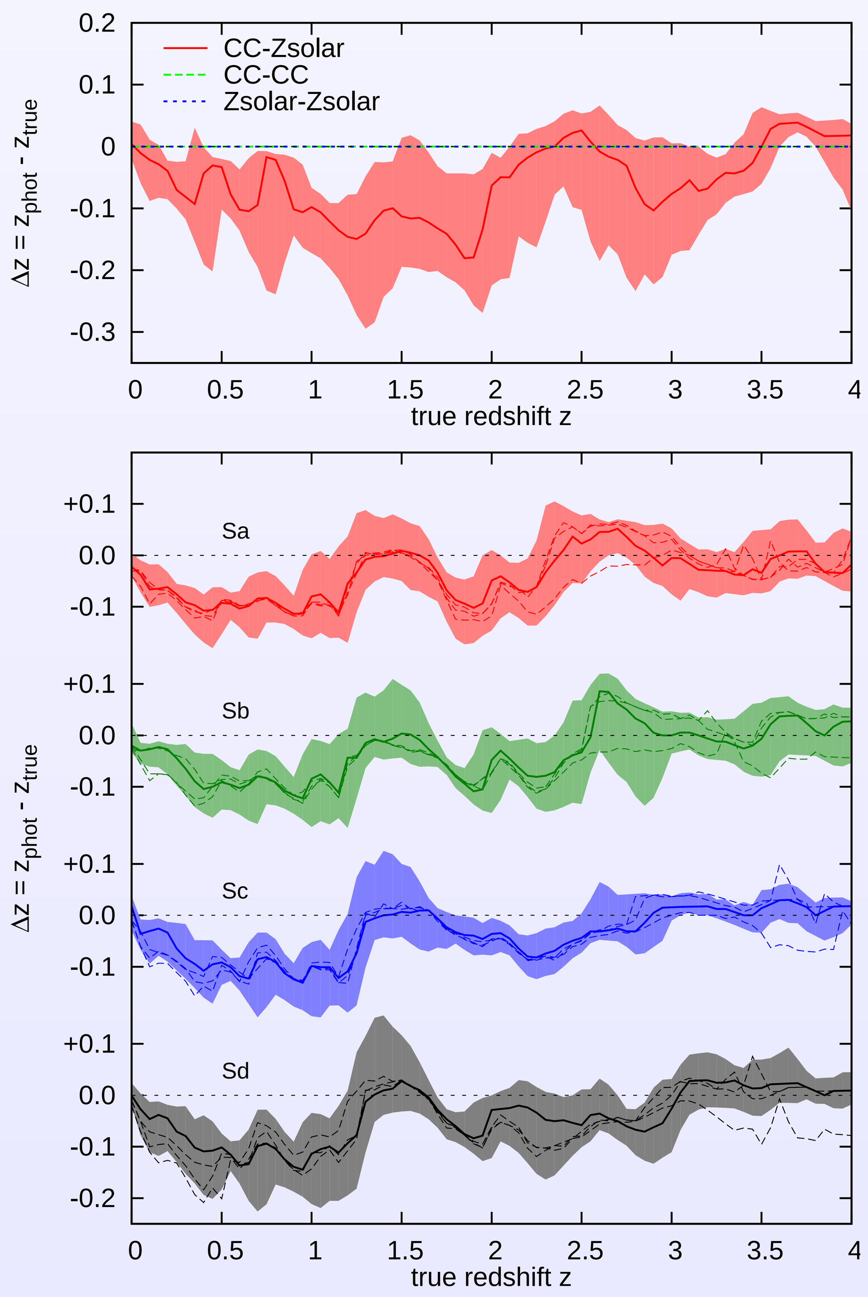
Impact of subsolar metallicities

We use our chemically consistent galaxy evolutionary synthesis code GALEV to generate 2 grids of Spectral Energy Distributions (**SEDs**)

1. one accounting in a chemically consistent way for the increasing initial metallicities of successive stellar generations (matching local observations)
2. one using exclusively solar metallicities

Our input catalog featured realistic photometric noise depending on filter and magnitude as well as a range of intrinsic extinctions.

We then used GAZELLE to analyse sub-solar metallicity galaxies with solar metallicity templates and assess the biases arising from this mismatch.



We found that redshifts are significantly underestimated by $\Delta z \approx 0.1 - 0.2$ until $z = 1.2$ arising from this mismatch between observations and comparison templates, that have to be taken into account if one wants to derive *accurate* and *unbiased* photometric redshifts.

Further information

Kotulla & Fritze, MNRAS Letters, 393, 55 (2009)

Kotulla, Fritze, Weilbacher & Anders, MNRAS, in press, ArXiv 0903.0378 (2009)

Kotulla 2009 a,b,c (MNRAS submitted)