Beyond the Lick Indices: the High-resolution Spectral Synthesis of Stellar Populations

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Abstract. Up-to-date theoretical SED of stellar populations at 2 Å FWHM resolution is obtained by coupling a new library of synthetic spectra from the ATLAS and NextGen atmosphere database with the Buzzoni population synthesis code. We briefly outline the current status of the project, aimed at settling a new theoretical framework of narrow-band spectrophotometric indices to study stellar populations of galaxies.

1   A high-resolution approach to population synthesis

An exceptional effort has been carried out in the recent years in the computation of high-resolution stellar spectra from model atmospheres (e.g. [1], [2]) allowing us to tackle the fundamental properties of stars at unprecedented spectral detail ($\sim$ 0.1 Å resolution or even better). As far as the analysis of the integrated spectral energy distribution (SED) of stellar aggregates is concerned, this new generation of models has found a natural application in the domain of stellar population synthesis by matching synthetic spectra of stars and stellar isochrones. (e.g. [3] and [4]).

Such a remarkable advance calls however for a sensibly different strategy in the study of the integrated SED of galaxies and other stellar systems, as age and chemical properties now intimately "merge" at high spectral resolution with the dynamical piece of information of the system as a whole. In this sense, therefore, also important interpretative tools, like the Lick spectrophotometric indices [5], so extensively used in the population synthesis literature to assess the overall evolutionary properties of stellar populations in external galaxies ([6], [7]) need to be reconsidered on a new basis.

Here, we would like to briefly sketch our project aimed at settling new high-resolution spectrophotometric indices selectively sensitive to age, [Fe/H] and IMF in Simple Stellar Populations (SSPs). Our work relies on the match of a 2 Å FWHM theoretical grid of stellar spectra with the original code for evolutionary population synthesis by Buzzoni ([8], [9]). Our high-resolution spectra ([10], [11]), generated with the Kurucz SYNTHE code [1] and then broadened to 2 Å FWHM, are complemented, at low temperatures, with those based on the NextGen [2] model atmospheres.

As an illustrative example, in Fig. 1 we present our high-resolution synthesis of SSPs in the ultraviolet region around 2800 Å, where two outstanding absorption features of MgII and MgI are present.
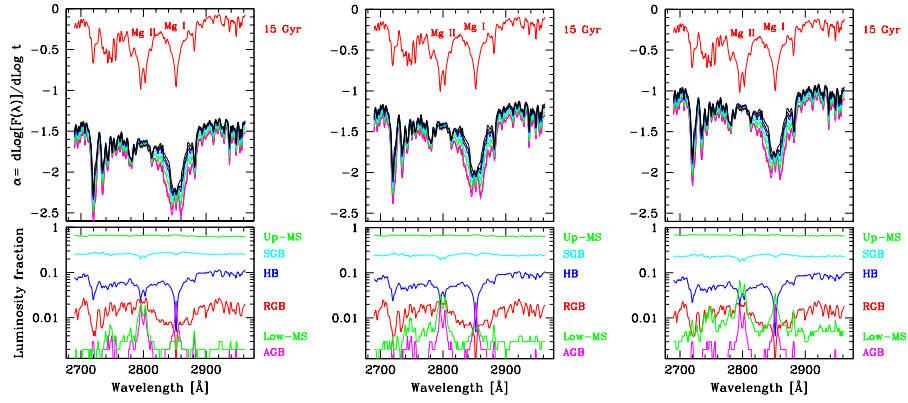
Fig. 1. SSP synthesis models in the MgII-MgI ultraviolet region around 2800 Å. Models assume solar metallicity, red Horizontal Branch (HB) morphology and IMF power-law index $s = 1.35$ (*left panel*), 2.35 (the Salpeter value; *middle panel*), and 3.35 (*right panel*). On the y axis of upper panels we report the rate of SSP luminosity evolution, $\alpha(\lambda) = d \log \mathrm{flux}(\lambda)/d \log t$, evaluated numerically at different ages back to 1 Gyr and taking the 15 Gyr SSP model as a reference (see, as a guideline, its corresponding SED overplotted at the top in each panel, in arbitrary units). A "tuned" trend for α is evident in the MgII region about 2790-2810 Å, whith a steady "plateau" in all plots. A much "steeper" time evolution appears on the contrary for the MgI feature about 2850 Å ($\alpha \sim -2.1$ in this region for the Salpeter SSP) thus making the MgII/MgI line ratio a selective tracer of SSP age not depending on the IMF slope. The contribution of the stars in the different evolutionary phases for the 15 Gyr SSPs is displayed in the lower panels. One sees that most of the Mg features originate from the subgiant (SGB) and HB stars (see their "depressed" relative contribution, compared for example to the "emission" of low Main Sequence, MS, and asymptotic giant stars, AGB, given the lack of both MgII and MgI absorption lines in their spectra).

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