Synthetic Mid-UV Indices of Stars and Simple Stellar Populations

M. Chavez [1], E. Bertone [1], L. Rodriguez-Merino [2], A. Buzzoni [3], A. Bressan [4]

(1) INAOE, Mexico; (2) Johns Hopkins University, USA; (3) INAF – Osservatorio Astronomico di Bologna, Italy; (4) INAF – Osservatorio Astronomico di Padova, Italy

Using the UVBLUE library we have computed all mid-UV spectroscopic indices defined by Fanelli et al. (1990). We explore their behavior in terms of the leading stellar parameters (T_{eff}, log g, [Fe/H]) and quantify the effects of instrumental resolution on the indices. We briefly discuss the extent to which synthetic indices are compatible with indices measured in observed spectra. We also explore the incorporation of UVBLUE in two population synthesis code (Buzzoni 1989; Bressan et al. 1994). We have produced a grid of integrated mid-UV spectra of Single Stellar Populations (SSPs) that spans in age from 10 Myr to 20 Gyr and from Z=0.0001 to 0.1 in metal content. We show the effects of these two parameters on the integrated indices of the synthetic SSPs.

introduction

Over the past decade the use of stellar spectral features in the form of spectroscopic indices have received considerable attention. They have been implemented for both the study of stellar spectra (e.g. Franchini et al. 2004) and the integrated properties of stellar systems (Buzzoni 1992; Bressan, Chiosi & Fagotto 1994; Worthey et al. 1994). The use of spectral indices has a number of advantages; among others, they can easily be measured from spectral energy distributions, they barely depend on interstellar extinction as they are commonly defined in narrow spectral bands, different atomic or molecular species can be studied separately, and allow the construction of mathematical tools such as the fitting functions to account for all stellar types when studying a stellar aggregate.

mid-ultraviolet indices

In the UV range an important effort has been done by Fanelli et al. (1992 and reference therein) who defined 25 narrow-band indices in the ultraviolet covering two spectral segments: 1230-1930 Å and 1950-3200 Å, corresponding to the wavelength limits of the cameras on board the International Ultraviolet Explorer (IUE). Briefly described, the indices are constructed by comparing the flux in a central wavelength band to that of the neighbouring pseudo-continuum. Spectroscopic indices defined in the mid-UV were defined with the aim of analyzing the properties of prominent spectral features in old populations. In general, these indices focus on wavelength regions that are more sensitive to stellar atmospheric parameters and less affected by instrument artifacts and by the effects of features (emission and/or absorption) of interstellar origin. The spectral bands for the full set of mid-UV indices are displayed in Fig. 1. Solid and dotted boxes indicate, respectively, the limits of central and side bands. The background spectra are, in grey, the high resolution entry from the UVBLUE grid (see Table 1 and Rodriguez-Merino et al. 2005 for full details) for the parameters (Teff/log g/[Fe/H])=9000/4.0/0.0. In red we plot the same spectrum after degradation to match the IUE resolution (6 Å)

Table 1

The main properties of the theoretical stellar library

UVBLUE	
Wavelength range	850 → 4750 Å
R = λ/Δλ	50000
Teff	3000 → 50000 K
log g	0.0 → 5.0
[M/H]	−2.0 → +0.5

The UVBLUE grid is public and can be downloaded at:
http://www.inaoep.mx/~modelos/uvblue/uvblue.html
http://www.bo.astro.it/~eps/uvblue/uvblue.html

Following the definitions of Fanelli et al (1990) we have computed all indices for every single entry in UVBLUE. The results of the calculation for some indices (FeII2609, FeII2720, BL2740, MgII2800, MgI2852, FeI3000 and BL3096) are displayed in Figure 2 where we plot the index vs. effective temperature for spectra of solar metallicity. The reference labels inscribed on the right of each panel stand for different gravities. In general, the behavior of the synthetic indices follows the trends discussed in Fanelli et al. (1990) in the sense that index values peak at the same spectral types. It is important to note that with synthetic spectra we can also explore the effects of chemical composition. In Figure 3 we plot the effects of instrumental resolution on the indices depicted in Fig. 2. While in many cases the variation of the value is just a few percent, for some cases (e.g. BL3096) the index decreases of up to 50% when degrading the FWHM from 6 to 10 Å. It is therefore crucial that when comparing theory vs observations, a suitable theoretical library should be used. In this respect, it is worth to mention that the use of the low resolution Kurucz library (Kurucz 1979, 1993) to study the original Fanelli's et al. indices is inadequate.

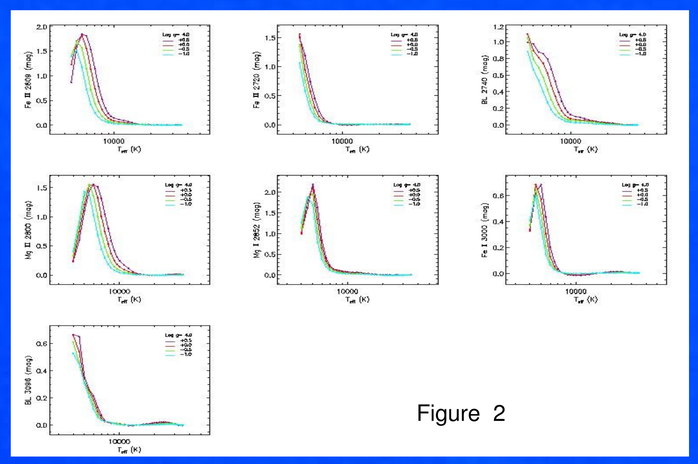

Figure 2

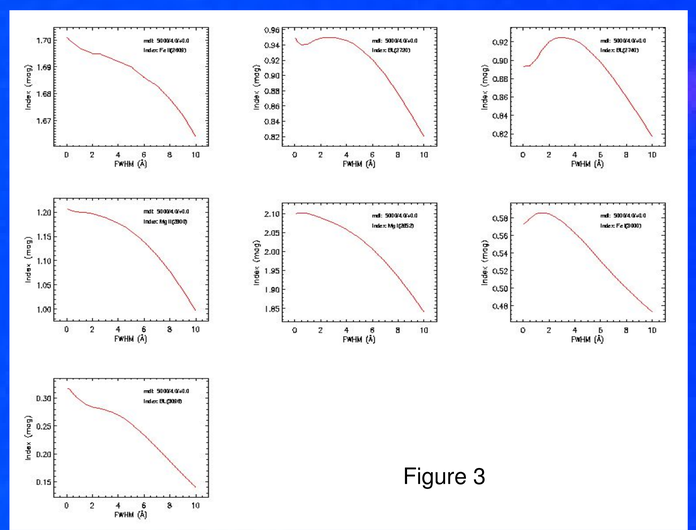

Figure 3

integrated indices of SSPs

We have implemented UVBLUE in the population synthesis codes developed by Buzzoni (1989, 2002) and Bressan et al. (1994). We have calculated the spectroscopic indices for a wide variety of SSP models whose chemical compositions range from Z=0.0001 to 0.1 and ages span from 10 Myr to 20 Gyr. As an example, the effects of age and chemical composition for four indices calculated from Bressan's SSPs are illustrated in Figure 4. Colors code different metallicities with blue being the most metal-poor and red the metal-rich. It is interesting to note that, while the SiII2070 index peaks at about 2 Gyr for the super solar metal content, the index FeI3000 reaches its maximum at ages older than 10 Gyr. Their distinctive sensitivity to age makes ultraviolet spectroscopic indices a promising tool for mapping different stellar populations.

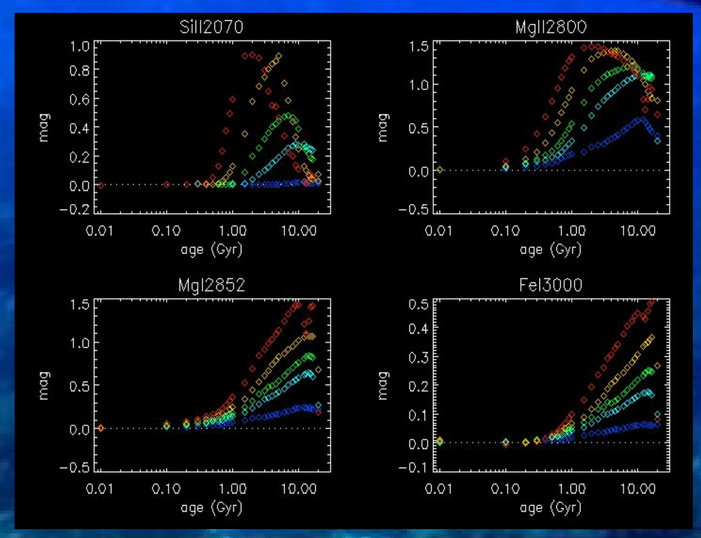

Figure 4

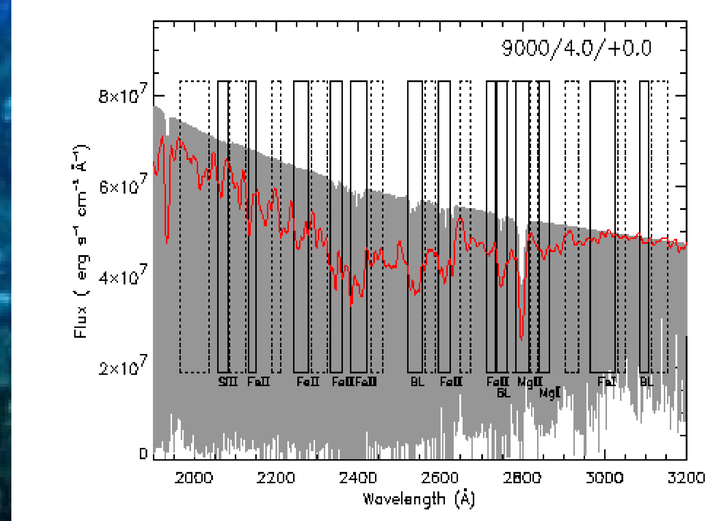

Figure 1

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