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STUDYING STELLAR POPULATIONS AT HIGH SPECTRAL RESOLUTION

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RESUMEN

Describo brevemente las nuevas bibliotecas empíricas de espectros estelares que han sido recopiladas en años recientes y que cubren amplios rangos de valores de los parámetros atmosféricos, T_{eff}, log g, [Fe/H], así como tipo espectral. Entre ellas destacan las bibliotecas HNGSL, MILES, UVES-POP, ELODIE, e IndoUS. Estas bibliotecas son complementarias en resolución espectral y cobertura de longitud de onda y resultan muy útiles para describir rasgos espectrales esperados en espectros de galaxias desde el NUV hasta el NIR. Discuto el uso de estos modelos en el estudio de espectros observados de galaxias.

ABSTRACT

I describe very briefly the new libraries of empirical spectra of stars covering wide ranges of values of the atmospheric parameters T_{eff}, log g, [Fe/H], as well as spectral type, that have become available in the recent past, among them the HNGSL, MILES, UVES-POP, ELODIE, and the IndoUS libraries. These libraries are complementary in spectral resolution and wavelength coverage, and will prove extremely useful to describe spectral features expected in galaxy spectra from the NUV to the NIR. The fits to observed galaxy spectra using stellar population models are discussed.

Key Words: **GALAXIES: EVOLUTION — GALAXIES: STELLAR CONTENT**

1. INTRODUCTION

The use of high signal-to-noise ratio stellar spectral libraries of intermediate and high spectral resolution in population synthesis models is now possible. Several libraries of empirical spectra of stars covering wide ranges of values of the atmospheric parameters T_{eff}, log g, [Fe/H], as well as spectral type, have become available in the last few years. The Hubble's New Generation Spectral Library (HNGSL, Heap & Lanz 2003) contains spectra for over 200 stars covering the wavelength range from 1700 Å to 10,200 Å, providing excellent coverage of the near-UV and the range from 9000 Å to 10,200 Å, which is generally noisy or absent in other data sets. The Medium resolution INT Library of Empirical Spectra (MILES, Sánchez-Blázquez et al. 2006) contains carefully calibrated and homogeneous quality spectra for 1003 stars in the wavelength range 3500 Å to 7500 Å with 2 Å spectral resolution and dispersion 0.9 Å pixel^{-1}. The stars included in this library were chosen aiming at sampling stellar atmospheric parameters as completely as possible. The UVES Paranal Observatory Project (UVES POP Library, Bagnulo et al. 2004) has produced a library of high resolution ($\lambda/\Delta\lambda \approx 80,000$) and high signal-to-noise ratio spectra for over 400 stars distributed throughout the HRD. For most of the spectra, the typical final SNR obtained in the V band is between 300 and 500. The UVES POP library is the richest available database of observed optical spectral lines. The Indo-US library (Valdes et al. 2004) contains complete spectra over the entire 3460 Å to 9464 Å wavelength region for 885 stars obtained with the 0.9m Coudé Feed telescope at KPNO. The spectral resolution is ≈ 1 Å and the dispersion 0.44 Å pixel^{-1}. The library includes data for an additional 388 stars, but only with partial spectral coverage. These libraries are complementary in spectral resolution and wavelength coverage, and will prove extremely useful to describe spectral features expected in galaxy spectra from the NUV to the NIR. See Bruzual (2005) for more details on these libraries and on their use in population synthesis models. Applications of these models to study galaxy spectra will be briefly discussed in the rest of this very short summary.

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2. SSP VS. NON-PARAMETRIC CSP FITS

By means of a standard least-squares technique it is possible to select the age and stellar velocity dispersion at which a given simple stellar population model (SSP) reproduces most closely a given observed galaxy spectrum. Figures 16 to 18 of Bruzual (2005) show remarkably good fits to the continuum spectrum of three galaxies with different ages and velocity dispersions, and in different wavelength intervals. An alternative approach for

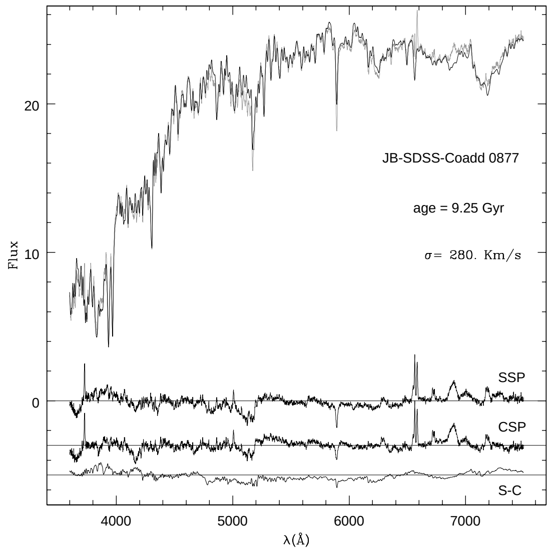

Fig. 1. Best model fit to the spectrum of an early type galaxy resulting from co-adding the spectra of several galaxies from the SDSS until reaching a signal-to-noise ratio of 250. This spectrum, kindly provided by Jarle Brinchmann, is shown as a light line in the wavelength range from 3600 to 7500 Å. The Bruzual & Charlot (2003) standard SSP model computed with the IndoUS stellar library for solar metallicity at an age of 9.25 Gyr is shown as a heavy line. The stellar velocity dispersion $\sigma = 280$ km s^{-1} applied to the model spectrum is also derived by the fitting algorithm. At the bottom of the figure the line marked SSP represents the residuals (observed -model) for the SSP model shown in the figure. The line marked CSP represents the residuals obtained when the fit is performed by the GASPEX non-parametric CSP fitting algorithm described by Mateu, Magris, & Bruzual (2006). The line marked S-C shows the difference between the SSP and CSP solutions. The last two lines have been shifted down for clarity.

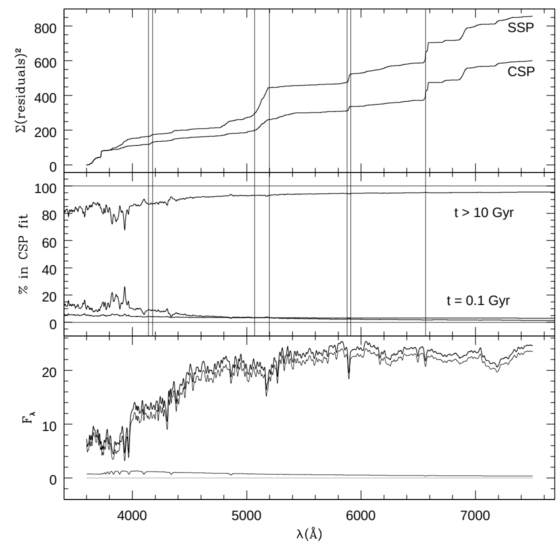

Fig. 2. *Top frame.* Cumulative squared residuals for the SSP and CSP fits shown in Figure 1. The vertical lines show the position of the central bands defining the CN_1-CN_2, Mg_1-Mg_2-Mgb, and NaD Lick indices, and the Hα line. *Middle frame.* Percentage contribution of the old and a very young population (100 Myr) to the total spectrum of this galaxy in the CSP solution as a function of wavelength. The contribution of populations of other ages included in the GASPEX solution, added all together, is below the 5% level at $\lambda < 4500$ Å, and is even less at longer wavelengths. *Bottom frame.* Spectra corresponding to the old, young, and the rest of the stellar populations in the GASPEX solution. The latter contribute essentially zero flux to the total sed, represented by the heavy line.

studying the stellar populations present in a galaxy, based on the fact that galaxies are thought to be more closely described by a composite stellar population (CSP) rather than by an SSP, consists in deriving the galaxy star formation history (SFH) by means of a non-parametric CSP fit to the galaxy sed. In a non-parametric fit the SFH is not assumed to be described by an analytic function, e.g., an exponentially decaying star formation rate with characteristic $e-$folding time τ. Instead, all the spectra defining the evolution of an SSP of one or more metallicity values are allowed to be selected individually by a spectral fitting algorithm. The SFH for the galaxy is rebuilt from the known age and metallicity of each of the selected spectra (Mateu et al. 2006). See Figs 1 and 2 and their respective captions.

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