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MODELLING THE MG_B SPECTROSCOPIC INDEX WITH THE TUNABLE FILTERS OF OSIRIS

J. L. Cervantes-Rodríguez,[1,2] A. Vazdekis,[1] and J. Cepa[1,2]

We present our first attempt to model a new metallicity indicator for old and intermediate aged stellar populations on the basis of the Mg_b absorption index at $\lambda \sim 5175$ Å. Model spectra of stellar populations are convolved with the responses of the Tunable Filters of OSIRIS-GTC to provide a photometric index matching the spectroscopic Mg_b. The new index allows us to obtain galaxy images of this feature on the basis of a photometric approach, without the very high signal-to-noise requirements of the spectroscopic methods.

Introduction

Understanding galaxy ages and metallicities provide strong constraints on how galaxies form and evolve. The study of the integrated light of stellar populations by means of colours lead to the degeneracy between age and metallicity. Spectroscopic absorption line-strengths provide us with greater abilities to break this degeneracy. However obtaining high quality galaxy spectra for measuring these indices is expensive in terms of telescope time and does not allow us to reach galaxy effective radii and further. We follow here an alternative approach by modelling the spectroscopic absorption index Mg_b on the basis of the OSIRIS Tunable Filters (OTF).

A new Mg_b index based on OTF

Tunable Filters of OSIRIS-GTC

OTF are Fabry-Perot etalons working at low spectral resolution (5 - 45 Å $FWHM$) capable of varying its plate separation, d, between $2\mu m$ and $12\mu m$. They transmit a narrow spectral band at a series of wavelengths given by $m\lambda = 2d$, where m is an integer known as the order of interference. Each passband has a transmission given by $FWHM = \frac{\lambda(1-r)}{m\pi\sqrt{r}}$. To use OTF as a single passband, the transmission from all the other detectable bands is supressed by conventional filters, called sorter-orders.

[1]Instituto de Astrofísica de Canarias, IAC, Spain.
[2]Universidad de La Laguna, ULL, Spain.

Definition of the photometric index

A photometric Mg index, suitable for an accurate *mapping* of metallicity in galaxies, should satisfy the following requirements: **i)** great stability against the semaring of the feature due to variations of galaxy velocity dispersion; **ii)** maximum possible stability versus galaxy internal rotation curve; **iii)** insensitivity to the recession velocity; **iv**) large index value coverage. The photometric Mg indicator must be calibrated with the spectroscopic Mg_b index as defined in the Lick/IDS system (Worthey et al. 1994).

OTF provide us several possibilities for defining a Mg photometric index (hereafter Mg_{OTF}), designed taking into account the above requirements:

- **OPTION A:** An OTF, as a narrow-band filter, encloses the feature and the sorter-order of wide band measures the continuum. The Mg_{OTF} index can be defined as a colour index as follows:

$$Mg_{OTF} = W_1 - W_2 + c \qquad (1)$$

$$W_1 = -2.5\log\left(\int_{\lambda_1}^{\lambda_4} F_\lambda R_\lambda d\lambda\right) \qquad (2)$$

$$W_2 = -2.5\log\left(\int_{\lambda_1}^{\lambda_4} F_\lambda d\lambda\right) \qquad (3)$$

$$c = -2.5\log\left(\frac{\lambda_4 - \lambda_1}{\Delta\lambda}\right) \qquad (4)$$

being $\Delta\lambda$, the filter equivalent width and λ_1, λ_4 the limits stated by the sorter-order passband.

- **OPTION B:** An OTF is positioned on the feature to obtain the total flux:

$$\mathcal{F} = \int_{\lambda_1}^{\lambda_4} F_\lambda R_\lambda d\lambda \qquad (5)$$

and the flux per unit of wavelength $\mathcal{L} = \frac{\mathcal{F}}{\Delta\lambda}$; on the pseudo-continua at either side of the feature:

$$\mathcal{C}_{red} = \frac{\mathcal{F}_{red}}{\Delta\lambda_{red}} \qquad \mathcal{C}_{blue} = \frac{\mathcal{F}_{blue}}{\Delta\lambda_{blue}} \qquad (6)$$

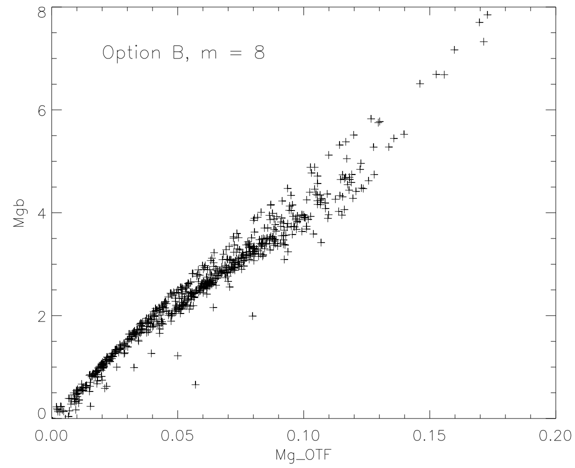

Fig. 1. Mg_b vs. Mg_{OTF} for stars.

to obtain the continuum in the feature via linear interpolation:

$$\mathcal{C} = \frac{\mathcal{C}_{blue} - \mathcal{C}_{red}}{\lambda_{blue} - \lambda_{red}}\lambda + \frac{1 - \lambda_{blue}}{\lambda_{blue} - \lambda_{red}}\mathcal{C}_{blue} \qquad (7)$$

allowing us to define de colour index as:

$$Mg_{OTF} = -2.5 \log\left(\frac{\mathcal{L}}{\mathcal{C}}\right) \qquad (8)$$

Varying the order m introduces more index definitions within each of these options.

Although all these Mg index photometric definitions provide linear relations with respect to the spectroscopic Mg_b index counterpart, OPTION B is particularly favoured. Furthermore, this option also provides a larger index value coverage and, unlike OPTION A, is insensitive to the recession velocity. Taking into account these results, we have optimized the index definition corresponding to OPTION B to minimize the effects of the radial velocities and velocity dispersion, using the widest order $m = 8$, since wide orders have higher stability within a larger range of radial velocity and are less sensitive to velocity dispersion than narrow ones.

In Fig. 1, we measure Mg_{OTF} in stars (Jones 1999), showing how the newly photometric index matches the spectroscopic measurements. In Fig. 2 we show a similar plot making use of single burst galaxy model spectra (Vazdekis 1999) for different metallicities ($[M/H] = -0.68, -0.38, 0, +0.2$) and ages ($1 - 18Gyr$) and real spectra corresponding to six Virgo early-type galaxies (Vazdekis et. al. 2001). This figure shows that the inferred metallicities on the basis of the photometric and spectroscopic indices are in well agreement.

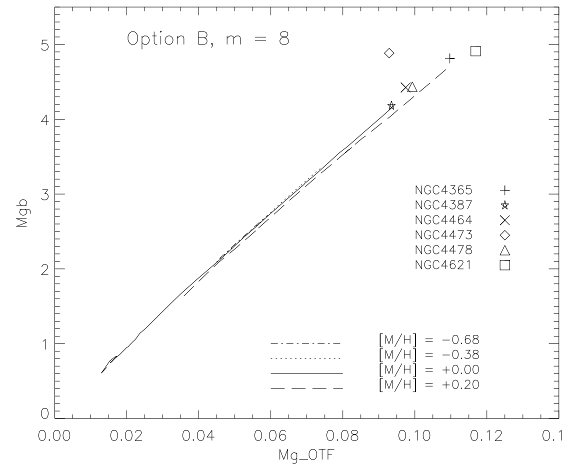

Fig. 2. Mg_b vs. $Mg_{\rm OTF}$ for models at $\sigma \sim 250km/s$ with different $[M/H]$ and for six galaxies in Virgo Cluster.

Our goal is to build up a new system of photometric indicators providing us greater abilities to disentangle most relevant stellar population parameters. This system should include age indicators based on the Balmer lines and appropriate index definitions to provide the abundance of the different species. Furthermore, the information provided by these photometric indicators does not necessarily need to match that from their spectroscopic counterparts, but should be able to improve it.

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