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Line indices as age, metallicity and abundance ratio indicators

R. Tantalo and C. Chiosi

Dipartimento di Astronomia, Università di Padova, Padova, Italy

Abstract. We investigate the ability of the line strength indices to assess the metallicity, age and abundance ratios [α/Fe] of elliptical galaxies. The analysis is made adopting new sets of isochrones with solar-scaled and α-enhanced mixtures.

Key words. galaxies: abundances – galaxies: elliptical, lenticulars and cD

1. Introduction to our analysis

The integrated line strength indices of single stellar populations (SSP) and/or large assemblies of stars, are known to depend on the metallicity, age, and the degree of enhancement in α-elements of their stellar content. Worthey et al. (1994) analyzed the sensivity of each index to the age and metallicity of SSPs, and found that some indices are more sensitive to the age than respect to the others which are more sensitive to the metallicity. Therefore the indices seem to have the potential of partially resolving the *Age-Metallicity Degeneracy*. Over the years, an extensive use of the two indices diagnostics has been made to infer the age and the metallicity of galaxies neglecting the dependence on the enhancement in α-elements. In presence of enhancement in α-elements one has to modify the relationship between the total metallicity Z and the iron content [Fe/H] by suitably defining the so-called 'enhancement degree' Γ (Tantalo & Chiosi, in preparation), which is equivalent to [E/Fe] of (Trager et al. 2000, hereafter T+00), in the following way: [Fe/H]=[Z/H]$-\Gamma$. Assumed a certain degree of enhancement Γ and a total metallicity Z, the abundances of all elements but [Fe/H] can be arbitrarily varied provided their sum is equal to Γ. Assumed a partition of enhanced abundances, the indices of the SSPs are first obtained using the Worthey 'fitting functions' at zero enhancement and then re-scaled to the particular set of abundances. To this aim we adopt the method developed by T+00 which stems from the study of Tripicco & Bell (1995, hereafter TB95) who first introduced the concept of *responce function*. These are obtained by changing one at time the abundance of chemical elements in synthetic spectra and calculating the corresponding variations in the indices. The correction for any specific index is expressed by Eq. 6 in T+00.

Send offprint requests to: R. Tantalo
Correspondence to: Dipartimento di Astronomia, Università di Padova, Vicolo dell'Osservatorio 2, I-35122 Padova, Italy

2. Description of different cases

Case A: C^0O^+ model by T+00. To compare our results with those of T+00 we have derived the indices for solar-scaled stellar models by Bertelli et al. (1994, hereafter B+94) and the pattern of enahnced abundances as in the model C^0O^+ by T+00 i.e. Γ: –0.30, 0.00, 0.32 and 0.75 dex. This allow us to test the effect of a simple enhancement scheme on standard stellar models/isochrones

Case B: S+00 mixture. The new stellar models by Salasnich et al. (2000, hereafter S+00) are used to calculate three sets of SSPs indices adopting the TB95 calibration for three different degree of enhancement Γ: 0.00, 0.3557, and 0.50 dex. This allow us to combine the effect of enhancement both on the stellar models/isochrones and the indices in a self consistent way.

Case C: B+94 and S+00-mixture. Finally, we calculate the SSPs indices using the old isochrones by B+94, and the mixture of chemical abundances as in S+00. This allow us to test the effect of a complex enhancement scheme on standard stellar models/isochrones.

3. Results

We apply the above SSPs indices to the 'Pristine IDS' sample by Trager PhD thesis using the minimum-distance method described in T+00. We consider six different indices and all possible combinations in group of three. A triplet of indices provide good results if theoretical and observational ones coincide within 10%. In the case B there are four combinations of indices which meet the this requirement. We derive age, metallicity and Γ but the results shown that there is a large spread among the determination of the same parameter provided by different index-tiplet. To understand the reason for this, we isolate the good index-triplet in common to all cases (A, B, C) and use this to derive age, metallicity and Γ. The ages obtained for each galaxy according to each case are compared in Fig. 1. It can be see that the major source of disagreement resides in the enhancement factor (top-right and bottom-left).

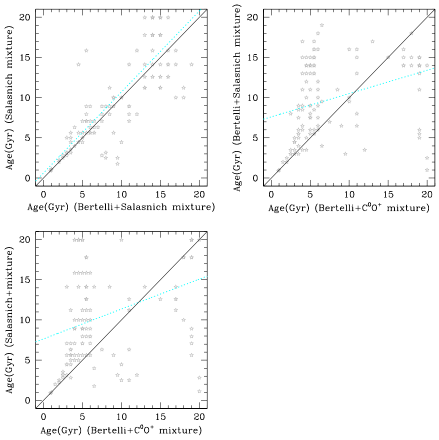

Fig. 1. Comparison between the ages obtained from different cases adopting the same index-triplet. From top-left to bottom-left panels the relation between case A vs. C; case C vs. B; and case A vs. B are given. The one to one relation and the linear best fit are indicated by solid and dotted lines respectively.

Due to the many uncertainties still affecting index calibration, real pattern of abundances, and the sensitivity of different indices to age, metallicity and Γ, we can not safely use the index diagnostics to infer these important parameters for a stellar population.

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