Stellar Populations as Building Blocks of Galaxies
Proceedings IAU Symposium No. 241, 2006
A. Vazdekis & R. F. Peletier, eds.

doi:10.1017/S1743921307007867

Hδ in the integrated light of galaxies: What are we actually measuring?

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Abstract. We present a cautionary study characterizing the influence of non-solar abundance ratios on Hδ derived ages in the integrated light of early-type galaxies. We measure Hδ using a variety of index measurements designed to assess contamination from CN molecular lines in and around the Hδ feature. We propose that neighboring CN lines have a strong effect on continuum levels and the Hδ feature itself, thereby leading to a difficulty in designing an accurate Hδ index definition in populations with C andor N non-solar abundance ratios with population synthesis models that do not account for such variations.

Keywords. galaxies: abundances — galaxies: evolution — galaxies: stellar content

1. Background

(i) Hδ is necessary to measure luminosity weighted mean ages in high redshift studies where Hβ is inaccessible. Hδ is also important for breaking degeneracy between age and Hβ morphology effects and to distinguish multipopulation scenarios from single age populations (Leonardi & Rose (2003), Schiavon (2006)).

(ii) Massive early-type galaxies have different abundance patterns than solar neighborhood stars on which the models are based (Worthey *et al.* (1992)). The left side of Figure 1 shows a dip in the continuum of an early-type galaxy and spectrum in the CN region redward of Hδ which is not replicated in the corresponding model.

2. Index Definitions

We define variations of Worthey & Ottaviani (1997) (WO97) Hδ_A and Hδ_F index definitions that both avoid and include the region of CN redward of Hδ. The new versions of indices use only one band-pass to define the continuum.

Figure 2 shows the synthetic spectrum of a CN strong red giant with WO97 Hδ wide and narrow index band-passes overlaid. CN molecular lines are shown to fall into the red continuum sideband of Hδ and the feature itself.

3. Results

In the right side of Figure 1 we show our primary result. Hδ, a primarily age sensitive index is plot against Fe4383, a primarily metallicity sensitive index, measured on data and Vazdekis (1999) models. The following results can be obtained from Figure 1 and a similar figure of Hβ versus Fe4383.

(i) We derive younger ages from Hδ indices using blue-continuum-only indices and older ages when using the red-continuum-only indices.

(ii) Due to the degree of CN contamination in each bandpass, the original WO97 Hδ indices give the closest match between data and models.

(iii) Ages derived from the Hβ feature are robust, regardless of chosen continuum bandpasses.

(iv) CN lines fall into the red continuum and the Hδ feature itself, an obstacle for creating an accurate Hδ index definition. Unaccounted for CN molecular lines will cause uncertainty in Hδ derived ages when Hδ is measured in old, metal-rich stellar populations with non-solar abundance ratios.

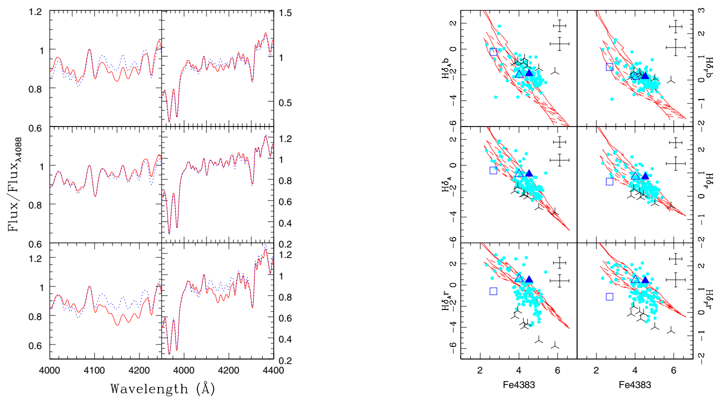

Figure 1. Left: The top panel shows an early-type galaxy spectrum plot with [Fe/H]=0.0, 10 Gyr model spectrum. The middle panel shows M67 plot with [Fe/H]=0.0, 3.98 Gyr model spectrum. The bottom panel is an M31 globular cluster plot with a [Fe/H]=0.2, 11.22 Gyr model spectrum. Right: Hδ indices versus Fe4383 for early-type galaxies (blue circles), M67 (unfilled triangle), M31 globular clusters (skeletal triangles) and M32 (filled triangle). Model grid lines of constant age (dashed lines from top to bottom: 1.00,2.51,3.98,5.62,8.91,11.22,14.12,15.85) and metallicity (solid lines from left to right: [Fe/H]=−0.68,-0.38,0.0,+0.2) are overlaid. All models are from Vazdekis (1999).

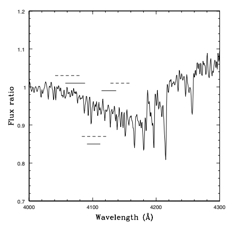

Figure 2. The ratio spectrum is plotted for a CN-strong synthetic spectrum ([C/Fe =0.2 and [N/Fe] $\bar{0}$.8) divided by a CN normal synthetic spectrum (scaled to [Fe/H] =0.5 dex). The WO97 Hδ wide (narrow) index bandpasses are noted with dashed (solid) lines. The same bandpasses are used in our index definition variations.

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