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Age derivation from UV absorption indices and the effect of the UV upturn.

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Abstract. We exploit stellar population models of absorption features in the ultraviolet to assess their power in determining the age of the stellar population in galaxies. We focus in particular on features that can differentiate between an old UV-bright population, contributing to the UV upturn, and a young population due to recent star formation. We use a system of 8 indices between 2200 - 3200Å, tracing several chemical elements including Mg and Fe. We apply these models to a large sample of $z \sim 0.6$ massive galaxies from the Sloan Digital Sky Survey (SDSS) - III / Baryon Oscillation Spectroscopic Survey (BOSS) to derive the ages of the UV-bright populations. We find a subset of indices to be non-degenerate between old and young UV ages allowing us to find evidence for old stars contributing to the UV, rather than new star formation. We find up to 84% of our working sample (274,661 galaxies) to contain a contribution from old UV-bright stars. Those found to have higher contributing mass fractions being on average more massive and redder then those with lower mass fractions.

Keywords. galaxies: evolution - galaxies: stellar content - ultraviolet: galaxies

1. Introduction

The UV traces the hot component of stellar populations. In young galaxies this is composed of luminous O and B-type stars. In older populations, stars may become UV-bright after sufficient mass loss, as shown in phenomena such as the UV upturn in local elliptical galaxies (Burstein *et al.* (1988)) and the extreme horizontal branch in globular clusters.

The UV upturn is seen as an increase in the UV flux of galaxy spectra shortward of 2500Å. The leading hypothesis on its origin suggests that this increase in flux is due to old, hot, low-mass stars (Greggio & Renzini (1990)) which may be evolving towards high T_{eff}. Other possible sources include binary star systems and post asymptotic giant branch stars in the planetary nebula stage.

We explore the effect of such populations on UV spectral indices to determine their usefulness in identifying old UV-bright populations, such as those that might contribute to the UV upturn, and their contribution by mass. We also investigate the redshift evolution of these populations in an effort to constrain the onset of the UV upturn.

We present results from the application of these models to galaxies. By applying models of UV stellar absorption features to a sample of high - z ($z \sim 0.6$) galaxies from the Sloan Digital Sky Survey (SDSS) - III / Baryon Oscillation Spectroscopic Survey (BOSS).

2. Models and Data

We use high-resolution theoretical spectral energy distributions (SEDs) of stellar population models by Maraston *et al.* (2009). Integrated line indices were calculated via direct

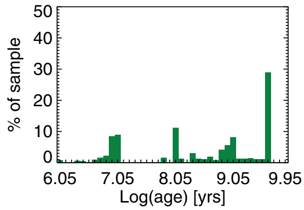

Figure 1. Range of galaxy UV ages calculated from the fitting of 3 non-degenerate indices; Mg I, Fe I, and BL3096.

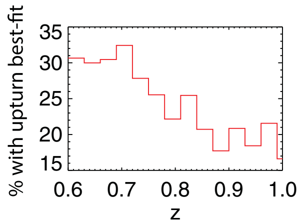

Figure 2. Fraction of galaxies within each redshift bin that select an old UV-bright population as the best fit solution.

integration on the synthetic SEDs computed using the high resolution theoretical library UVBLUE (Rodríguez-Merino *et al.* (2005)) as input to the Maraston (2005) evolutionary population synthesis code. Theoretical spectra were produced for several metallicities ($2Z_{\odot}, Z_{\odot}, \frac{1}{2}Z_{\odot}$ and $\frac{1}{10}Z_{\odot}$), with ages 1 Myr $\leqslant t \leqslant$ 5 Gyr. For ages $>$ 1Gyr the model includes an old hot component with a fuel calibrated UV upturn as in Maraston & Thomas (2000) and Maraston (in preparation).

The observed galaxy spectra come from Data Release 12 of SDSS - III / BOSS which has mapped $\sim$ 1.5 million massive, luminous, galaxies out to $z \sim 0.7$, with an average of $z \sim 0.57$ (Dawson *et al.*(2013)). Due to a combination of the wavelength coverage of the spectra (3600 - 10,400Å) and the redshift distribution of the BOSS sample we have access to the spectral features situated in mid-UV region (2200 - 3200Å) above $z = 0.6$.

3. Analysis and Results

Three of the mid-UV indices; Mg I, Fe I, and BL3096, have been found to be non-degenerate between star forming populations and old UV-bright populations contributing to the UV upturn. All three have index strengths that continue to increase with age making them potentially powerful tools to differentiate between the two populations.

The ages of the UV-bright population in BOSS galaxies were derived by simultaneously minimising the quadratic distance between the EWs calculated from the data and those of the models using the same software and code as in Maraston *et al.* (2009).

By focusing on fitting these 3 indices we obtain the distribution of UV ages shown in Figure 1. Approximately 30% of our working sample are best fitted by a model with an old UV-bright population. By fitting composite populations it is found that up to 84% of our sample has a contribution from old UV-bright populations. Galaxies found to have higher contributing mass fractions are found to be redder and more massive on average.

Figure 2 shows how the percentage of galaxies preferentially selecting an upturn population in Figure 1 evolves with redshift. The percentage of galaxies within each redshift bin determined to have an old UV age from an old UV-bright component decreases towards higher redshifts, hinting towards the onset of the UV upturn occurring at $z \approx 1$.

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