The dust attenuation law of star-forming galaxies at z > 1.5

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Overview

The dust attenuation law is an important ingredient in the analysis of star-forming galaxies. A well-constrained law allows us to derive robust star formation rates and stellar ages from photometric indicators. Moreover, it reflects the physical properties of the dust particles in the interstellar medium and its distribution within galaxies. A relevant feature in the attenuation law is the NUV bump at 2175 Å, explored in galaxies both at high- (e.g. Buat et al. 2012, Kriek & Conroy 2013) and low-redshift (e.g. Conroy et al. 2010; Hutton et al. 2014; 2015). Radiative transfer studies suggest a complex mixture of dust composition and geometry will cause variations in the dust attenuation law (e.g. Witt & Gordon 2000; Seon & Draine 2016).

Sample selection: SHARDS

We make use of SHARDS (Pérez-González et al. 2013), an ultr-deep (<26.5AB) galaxy survey that provides photo-spectra at resolution R=50 via medium band filters (FWHM=150 Å) in the optical. Such dataset allows us to analyse in detail the dust attenuation law of the rest-frame NUV region in star-forming galaxies at redshift z>1.5. This figure shows that our targets lie mostly above the main sequence, thus consisting of strong star-forming galaxies (the green triangles represent upper limits).

Constraining the attenuation law

We focus on the NUV bump strength and the total-to-selective extinction ratio (R_V), targeting a sample of 263 star-forming galaxies (no X-ray detection) over the redshift range z=1.5-3. A comparison of the data with a set of population synthesis models coupled to a parametric dust attenuation law allows us to constrain R_V, the strength, of the NUV bump (B), and the colour excess.

We follow the parameterisation of Conroy et al. (2010, Hereafter CSB10). Our methodology is robust against the presence of populations with a complex star formation history.

Correlations between dust parameters

We find a correlation between R_V and B, which can be interpreted either as a trend of the grain size distribution, or as variations in the distribution of the dust within the populations. The former would suggest that galaxies with overall smaller dust grains are associated with a stronger NUV bump. The interpretation for the latter suggests a trend towards a shell-like distribution of the dust at low R_V (Witt & Gordon 2000). We show in blue the results by Kriek & Conroy (2013), which quantitatively agree with our results. Nevertheless, our study covers a wider range of the dust parameters. We also observe that a strong NUV bump is preferentially found with a milder reddening. The green dashed lines describe the linear fit of our results R_V=4.20 – 1.59B (RMS=0.9), E(B-V)=0.29 – 0.19B (RMS=0.1).

The effect of bump variations on the UV slope (β)

Our data show a wide range in the strength of the NUV bump. The UV slope β, commonly used to express the presence of dust in star-forming galaxies (Calzetti et al. 1994), is derived in a region that includes the bump (although the fitting region tries to avoid it). Do these variations in B affect β? This plot shows the difference in the NUV slope (Δβ) derived from two populations with the same age (150Myr), metallicity and overall reddening, but assuming two different attenuation laws: the Calzetti (2000) law, that lacks the NUV feature, and CBS10, for which the total-to-selective ratio, bump strength and colour excess are free parameters. The shaded areas extend over the observed values of E(B-V), at three different choices of R_V as labelled. Δβ can be very significant (we show the observed distribution of the NUV bump in the bottom panel).

The histograms on the right show for potential differences in these parameters with stellar age. The most notable cases are R_V (older galaxies have greyer attenuation), and B (a slightly stronger NUV bump in younger populations).

Take-home message

• SHARDS provides a unique dataset to constrain the dust-attenuation law of star-forming galaxies at high redshift (z>1.5).
• A wide range of attenuation parameters is found, with significant correlations: galaxies with a strong NUV bump feature lower R_V and milder reddening.
• Variations in the dust attenuation law can introduce systematic changes in UV slope (β) for a fixed choice of stellar population parameters.
• Significant trend between UV slope (β) and both R_V and age: likely driver could be dust geometry rather than dust composition.

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REFERENCES