EQUIVALENT WIDTH OF AN ABSORPTION LINE

Equivalent width is a way to quantify the strength of a spectral line, and also compare the relative strength between lines. The general definition of equivalent width is

$$W = \int_{-\infty}^{\infty} \left(\frac{f_{c,\lambda i} - f_{\lambda i}}{f_{c,\lambda i}} \right) d\lambda \tag{1}$$

where $f_{\lambda i}$ is the flux in the i-th wavelength pixel λ, and f_c is the continuum flux level corresponding to that wavelength. Thus, to calculate the equivalent width of a line, the continuum should be known; in other words, the spectrum should be continuum fitted). Thus, the equivalent width is a measure of the area of the absorption or emission line. Since we are normalizing the numerator in the above expression with the continuum level, the area will have units of wavelength.

In practice, the integration is done only from the beginning of the absorption feature to the end of the absorption feature and not over an infinitely long wavelength range.

For extragalactic absorption lines, we have to take into account the fact that the equivalent width will be enhanced by the expansion of the universe. Hence the quantity that is usually quoted is the equivalent width of a line in the rest-frame of whatever source is causing that absorption feature. The relationship between rest-frame equivalent width and observed equivalent width is :

$$W_r = \frac{W_{obs}}{1+z} \tag{2}$$

where z is the redshift of the astrophysical object that is responsible for the absorption feature.

Lab Tasks :

1. Download the ASCII file, which is the HST acquired spectrum of the quasar PG $1424+240$. The ASCII file has information in four columns. The first column is observed wavelength (in units of Angstrom), the second column is corresponding observed flux (in units of ergs/s/cm^2/A), the third column is the 1σ uncertainty in the flux (in the same units as flux), and the fourth column is a model continuum fitted to the spectrum (in the same units as flux).

2. Write a code that will display the continuum normalized spectrum over a 40 Å interval at a time. Using the code one should be able to move forwards and backwards in wavelength in 40 Å segments. Plot the spectrum in histogram mode; aesthetically this is a visualization of a spectrum than joining the flux points with slopped lines.

3. Using the code, the user should be able to define a starting and ending wavelength (through mouse clicks or a similar intuitive feature) to be used as the lower and upper limits for the equivalent width integration.

4. The code should print out on-screen the equivalent width and the 1σ uncertainty in equivalent width (use propagation of errors), along with the dimensions of the equivalent width. The code should be able to do this for any absorption line in the spectrum.

5. The code should also have an option to ask the user if the line is redshifted, and if so, the redshift of the line feature.

6. Estimate using the code, the equivalent width of the three absorption lines at $\lambda = 1430.8, 1432.6, 1438.8$ Å respectively, and show to the instructor.

7. For a user specified redshift, also display the equivalent width corrected for the rest-frame of the astrophysical object producing the absorption line.