Data analysis Exercises — 4

Read: P. Schneider—Extragalactic Astronomy Section 3.6, 3.7, 3.8, 3.10 & chapter 5

Identifying star-forming and AGN galaxies in SDSS galaxy catalogues using observed emission line fluxes.

Note that logarithmic scaling is the usual way of visualisation.

1. Find the Halpha luminosities based on the given fluxes and redshifts. Then estimate the SFR's using the Kennicutt+1998 relation and plot the location of galaxies in the SFR-galaxy stellar mass plane (e.g., a scatter plot with contours and/or a 2D histogram). Add the Elbaz+07 (z~0 SDSS) relation for comparison. Which well-known scaling relation is shown?

2. To what extent would this relation be biased if only galaxies with an Ha flux above 10^{-13} erg/s/cm^2 were detected?

3. Plot location of observed galaxies more massive than 1e9 M_{sun} in the classical BPT diagnostic diagram, [OIII]/Hb vs [NII]/Ha (scatter plot). Explain the dependence of the location of a galaxy in this diagram on different gas and radiation properties. In general, what is the significance of the BPT diagram for observational spectroscopic data?

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4. Use the classical BPT diagnostic diagram ([OIII]/Hb vs [NII]/Ha) to identify the dominant ionising sources using the selection criteria of Kewley et al. 2001 and Kauffmann et al. 2003 (SF, composite and AGN-dominated galaxies). Which complications/caveats can arise using these selection criteria?

5. Investigate how the SFR-galaxy stellar mass plane changes for different galaxy types, and interpret your findings.

6. Use the scaling of Lamastra+09 to estimate the bolometric AGN luminosity and thus, the BH accretion rate, from the [OIII] line luminosity. You can assume an efficiency η of 0.1. Plot the location of galaxies in the BHAC — SFR plane; interpret your result in the light of the observed BH scaling relations (black hole-stellar mass relation).

Information for Exercises — 4

The SDSS catalogues contains emission line measurements from the Sloan Digital Sky Survey. Fluxes are given in units of 10^{-16} erg/s/cm^2. Astro-III_Ex4_EmissionLines-Snippets.ipynb contains a python routine for reading the relevant line fluxes, as well as the redshift and the stellar masses (given in log10).

The file further contains useful snippets to calculate the luminosity distance and luminosity, as well as the empirical relations which you can plot alongside your data.

Empirical relations — 4

Kennicutt+98

$$\mathrm{SFR}\ (M_\odot\ yr^{-1}) = 7.9 \times 10^{-42}\ L(H\alpha)\ (\mathrm{ergs\ s^{-1}})$$

Elbaz+07

$$SFR_{\mathrm{SDSS}}^{z\sim0}\ \left[M_\odot\ \mathrm{yr}^{-1}\right] = 8.7\ [-3.7, +7.4] \times \left[M_\star/10^{11}\ M_\odot\right]^{0.77}$$

Kewley+01

$$\log\left(\frac{[\mathrm{O\ III}]\ \lambda5007}{\mathrm{H}\beta}\right) = \frac{0.61}{\log([\mathrm{N\ II}]/\mathrm{H}\alpha) - 0.47} + 1.19$$

Kauffmann+03

$$\log([\mathrm{O\ III}]/\mathrm{H}\beta) > 0.61/\{\log([\mathrm{N\ II}]/\mathrm{H}\alpha) - 0.05\} + 1.3$$

Lamastra+09

[OIII] bolometric correction factor, C_{OIII} in different L_{OIII} ranges to estimate the bolometric luminosity

C_{OIII} = 87, 142, and 454
$\log L_{\mathrm{OIII}}$ = 38–40, 40–42, and 42–44