

How to Find a Quasar?

Tutorial #4

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The goal of this tutorial was to ...

1. Part I

1.1. Getting the Data

First of all, I downloaded the data from SDSS DR18 [1] using the following SQL query:

Code 1: SQL Query

```
1 SELECT s.specobjid, s.plate, s.mjd, s.fiberID, s.subclass, s.z,  
2 g.oiii_5007_flux, g.oiii_5007_flux_err,  
3 g.h_alpha_flux, g.h_alpha_flux_err,  
4 g.h_beta_flux, g.h_beta_flux_err,  
5 g.nii_6584_flux, g.nii_6584_flux_err,  
6 W.w1mpro as w1, W.w2mpro as w2, W.w3mpro as w3  
7  
8 FROM GalSpecLine AS g  
9 JOIN SpecObj AS s ON g.specobjid = s.specobjid  
10 JOIN wise_xmatch AS x ON s.bestobjid = x.sdss_objid  
11 JOIN wise_allsky AS w ON w.cntr = x.wise_cntr  
12  
13 WHERE  
14 (s.class = 'QSO' or s.class = 'GALAXY')  
15 AND 2.355 * g.sigma_balmer < 500  
16 AND 2.355 * g.sigma_forbidden < 500  
17 AND s.snmedian_g > 40  
18 AND g.oiii_5007_flux > 5  
19 AND (g.oiii_5007_flux / g.oiii_5007_flux_err) > 5  
20 AND g.h_alpha_flux > 5  
21 AND (g.h_alpha_flux / g.h_alpha_flux_err) > 5  
22 AND g.h_beta_flux > 5  
23 AND (g.h_beta_flux / g.h_beta_flux_err) > 5  
24 AND g.nii_6584_flux > 5  
25 AND (g.nii_6584_flux / g.nii_6584_flux_err) > 5
```

This query defines the sample, gets the spectroscopic information on the needed lines and gets the colours from the WISE catalogue [2]. This query resulted in 960 objects. I checked their spectroscopic

subclasses and saw that 163 objects are classified as starburst galaxies, 319 as broadline, 71 as AGN broadline, 214 as starforming, 29 as starforming broadline, 84 as AGN, one as starburst broadline, and the rest had no sub-classification. I plotted a BPT diagram (see Section 1.2) with the spectroscopic subclasses from SDSS as the style of the data points in Figure 1. The trends of the different classes are already visible. This plot includes 866 sources out of the full sample. The excluded ones have no spectroscopic classification from SDSS.

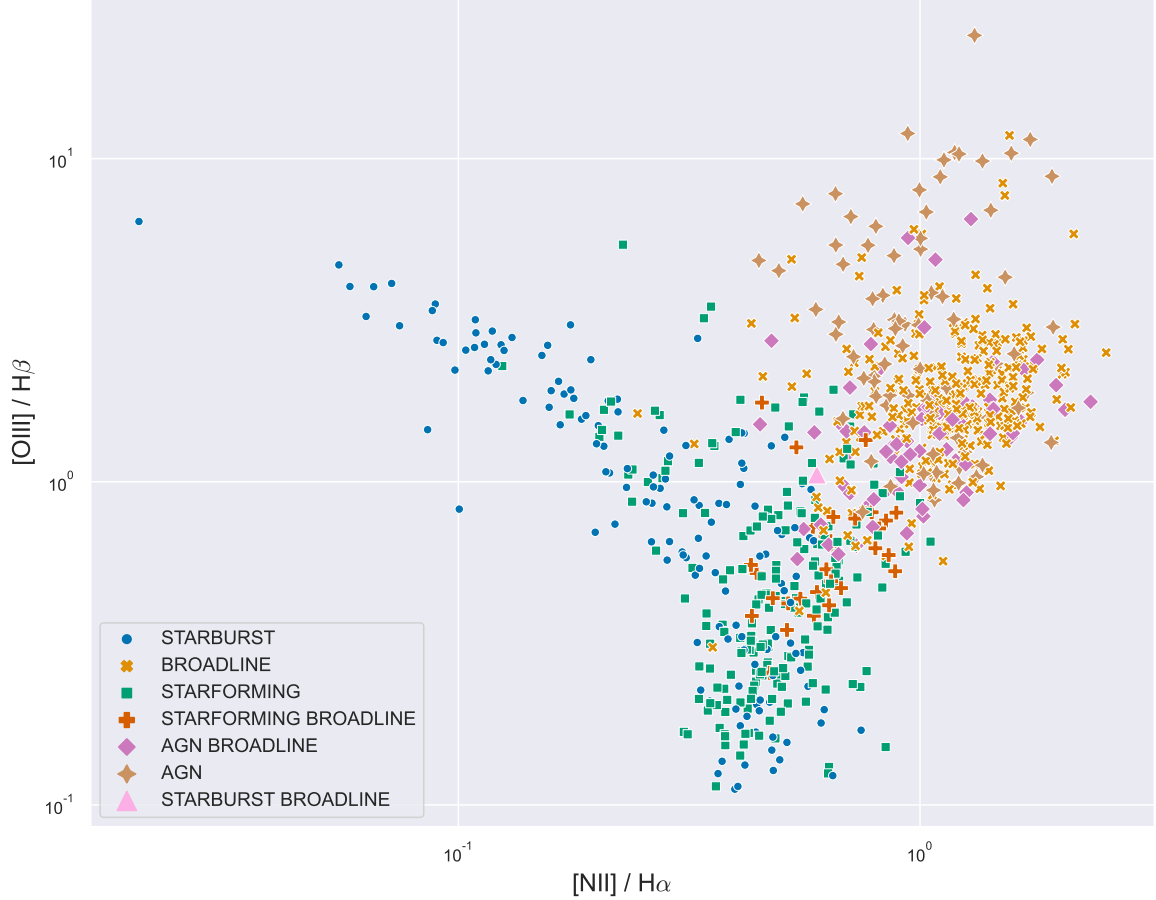


Figure 1: BPT Diagram with SDSS subclasses.

I also plotted the distributions of the relevant spectral line fluxes (see Figure 2).

1.2. BPT Diagram

Next, I plotted the BPT diagram using theoretical lines in Figure 3. This diagram allows to distinguish between star-forming or star-burst galaxies and AGN. I used three different theoretical lines to distinguish between star-forming galaxies, Seyfert galaxies and LINERs (low ionization nuclear emission line regions).

The papers [3] and [4] propose a theoretical line to separate star-forming galaxies from AGN. The one from the former is stricter and poses a lower limit on the amount of AGN.

$$\log [\text{OIII}]/\text{H}\beta = \frac{0.61}{\log [\text{NII}]/\text{H}\alpha - 0.47} + 1.19 \quad (1)$$

$$\log [\text{OIII}]/\text{H}\beta = \frac{0.61}{\log [\text{NII}]/\text{H}\alpha - 0.05} + 1.30 \quad (2)$$

The objects labeled as “Composite” in Figure 3 have a different classification by [3] and [4]. Then, [5] further separates AGN into Seyfert galaxies and LINERs:

$$\log [\text{OIII}]/\text{H}\beta = 1.05 \log [\text{NII}]/\text{H}\alpha + 0.45 \quad (3)$$

2. Part II

I downloaded the WISE colours [6] using the same SQL as the first part 1.

2.1. WISE Colour-Colour Diagram

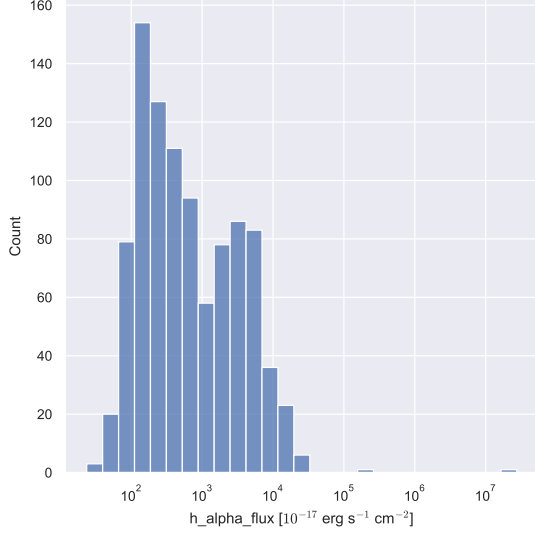
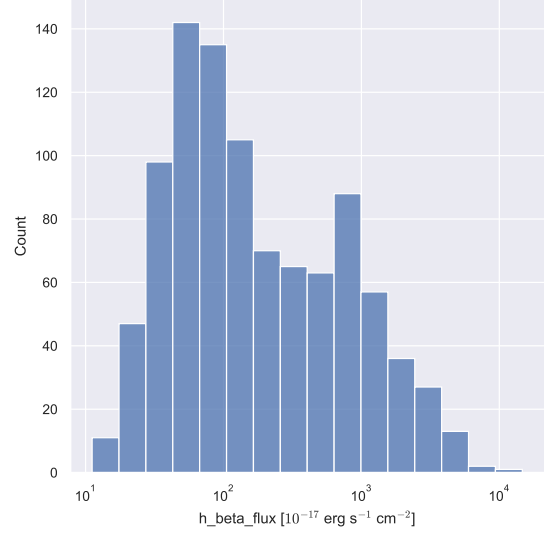
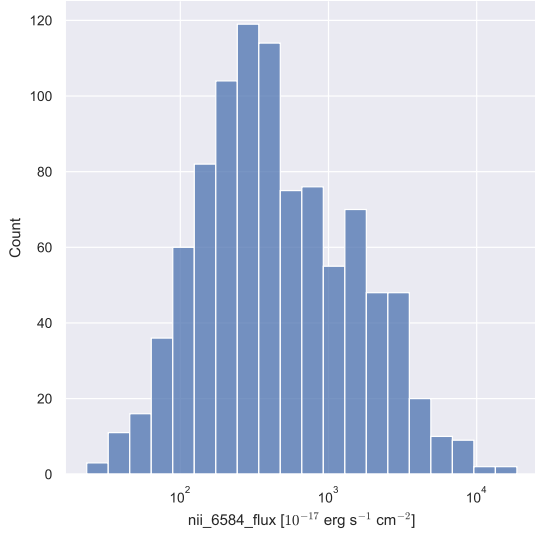
[7]

2.2. Analysing a Particular Object

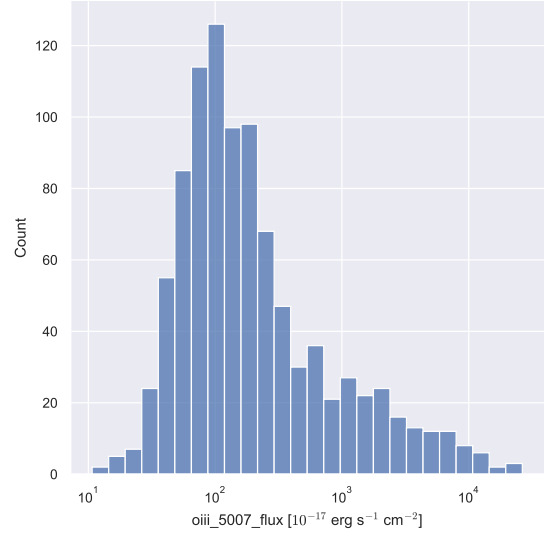
References

- [1] “Sdss sky server.” <https://skyserver.sdss.org/dr18>, Date of access: April 2023.
- [2] “Wise all sky catalogue.” <https://wise2.ipac.caltech.edu/docs/release/allsky/>, Date of access: April 2023.
- [3] L. J. Kewley, M. A. Dopita, R. S. Sutherland, C. A. Heisler, and J. Trevena, “Theoretical Modeling of Starburst Galaxies,” , vol. 556, pp. 121–140, July 2001.
- [4] G. Kauffmann, T. M. Heckman, C. Tremonti, J. Brinchmann, S. Charlot, S. D. M. White, S. E. Ridgway, J. Brinkmann, M. Fukugita, P. B. Hall, Ž. Ivezić, G. T. Richards, and D. P. Schneider, “The host galaxies of active galactic nuclei,” , vol. 346, pp. 1055–1077, Dec. 2003.
- [5] K. Schawinski, D. Thomas, M. Sarzi, C. Maraston, S. Kaviraj, S.-J. Joo, S. K. Yi, and J. Silk, “Observational evidence for AGN feedback in early-type galaxies,” , vol. 382, pp. 1415–1431, Dec. 2007.
- [6] E. L. Wright, P. R. M. Eisenhardt, A. K. Mainzer, M. E. Ressler, R. M. Cutri, T. Jarrett, J. D. Kirkpatrick, D. Padgett, R. S. McMillan, M. Skrutskie, S. A. Stanford, M. Cohen, R. G. Walker, J. C. Mather, D. Leisawitz, I. Gautier, Thomas N., I. McLean, D. Benford, C. J. Lonsdale, A. Blain, B. Mendez, W. R. Irace, V. Duval, F. Liu, D. Royer, I. Heinrichsen, J. Howard, M. Shannon, M. Kendall, A. L. Walsh, M. Larsen, J. G. Cardon, S. Schick, M. Schwalm, M. Abid, B. Fabinsky, L. Naes, and C.-W. Tsai, “The Wide-field Infrared Survey Explorer (WISE): Mission Description and Initial On-orbit Performance,” , vol. 140, pp. 1868–1881, Dec. 2010.
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J. A. Peacock, C. C. Popescu, E. M. Sadler, E. N. Taylor, R. J. Tuffs, and L. Wang, “Galaxy and mass assembly (gama): Exploring the wise web in g12,” *The Astrophysical Journal*, vol. 836, p. 182, feb 2017.

(a) Distribution of H α fluxes.(b) Distribution of H β fluxes.

(c) Distribution of [NII] fluxes.



(d) Distribution of [OIII] fluxes.

Figure 2: Distribution of the fluxes of the relevant spectral lines.

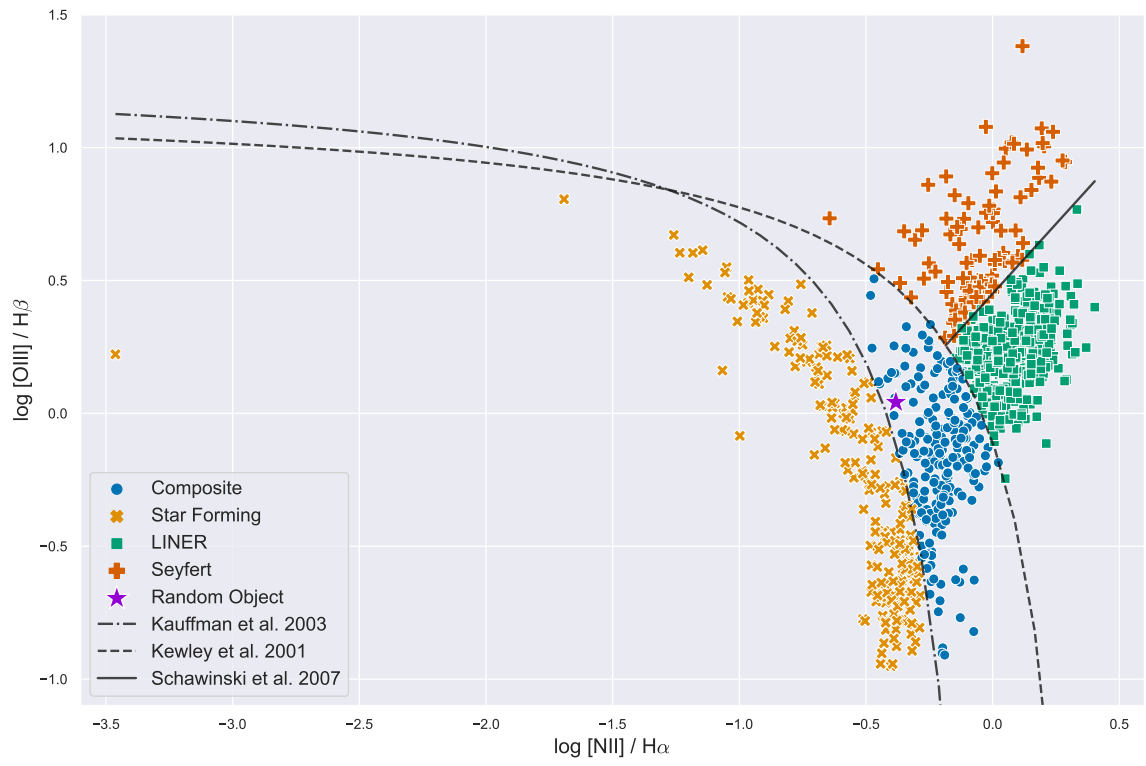


Figure 3: BPT Diagram with theoretical lines.

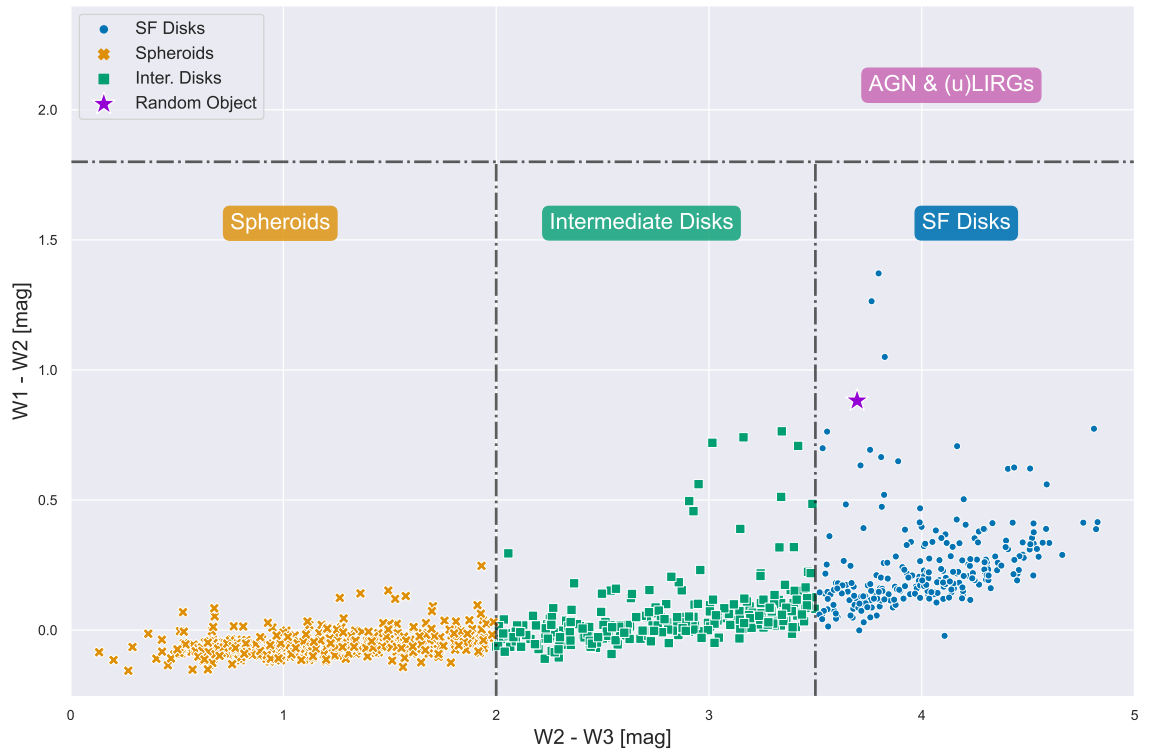


Figure 4: WISE colour-colour diagram.