

Compute Redshifts of Quasars Using SPLAT-VO

M. Castro Neves,
based on the VOSpec Tutorial by
Phil Furneaux and Deborah Baines

November 16, 2015

Abstract

In this tutorial you will use SPLAT-VO to search for spectra of galaxies and quasars in the VO, and compute their redshifts and velocity, using the Hydrogen Lyman Alpha line.

Software: [SPLAT](#)

Before you start

SPLAT has to be installed on the system. If you don't have it already, please download it. You can either download the jar package or install it via Webstart. You'll also need a calculator or another application for computing the final redshift. If you use the jar package: After downloading it, start the installer with:


```
java -jar splat-vo.jar
```

After installation, SPLAT can be started (from the directory where SPLAT has been installed) with

```
bin/splat/splat
```

Search for and retrieve a spectrum

We will now get a spectrum of an object to compute its redshift.

- ▷ **1** On the main SPLAT window, click on the SSAP button to open the VO browser window. 
- ▷ **2** *Choosing a SSAP Service* – On the left part of the VO browser window, you see a server selection frame. It contains a list of SSAP services and some checkboxes.

There you can see the available SSAP services and what type of information they have. If you click on a service with the right mouse button, (or, in older versions, click on the icon left of it) information about the service will appear. Check the **Observed Data** button on the left upper side of the frame. Only services containing observational spectra will be queried.

- ▷ **3** *Setting waveband range* – In this tutorial we are looking for spectra on the ultra-violet waveband range, so see that only the **UV** box is checked. Only the services offering spectra in this range will be queried. Notice that the services list has changed. Below the list of services in the lower left, click on **Select all** to select the services. In older versions of SPLAT this is not necessary.
- ▷ **4** On the *search parameters* frame, add *3C 273* as **Object**. It is a quasar, actually one of the closest, and (optically) brightest. Click on **Lookup**, to get its coordinates. Click the **SEND QUERY** button. In the *Query results* frame you will get a card box with answers from some services. Each tab contains the list of query results for the service.
- ▷ **5** For this example, choose the *IUE* (International Ultraviolet Explorer) tab. Scroll the table of spectra to the right until you see the **min_wavelength** and **max_wavelength** columns. We will use the Lyman alpha line, which has a rest wavelength of 1215.67 Angstroms, so chose a spectrum containing this wavelength within its range. Double-click on the chosen line where to display the spectrum.

You can zoom in using the middle mouse button, and zoom out using the right button. You can also zoom only the X, or the Y scale. When moving the mouse over the plot, the current position's values will be displayed (**Wavelength** and **DataCount**).

Compute Redshifts of Quasars Using SPLAT-VO

Flux calibration: None Select all De

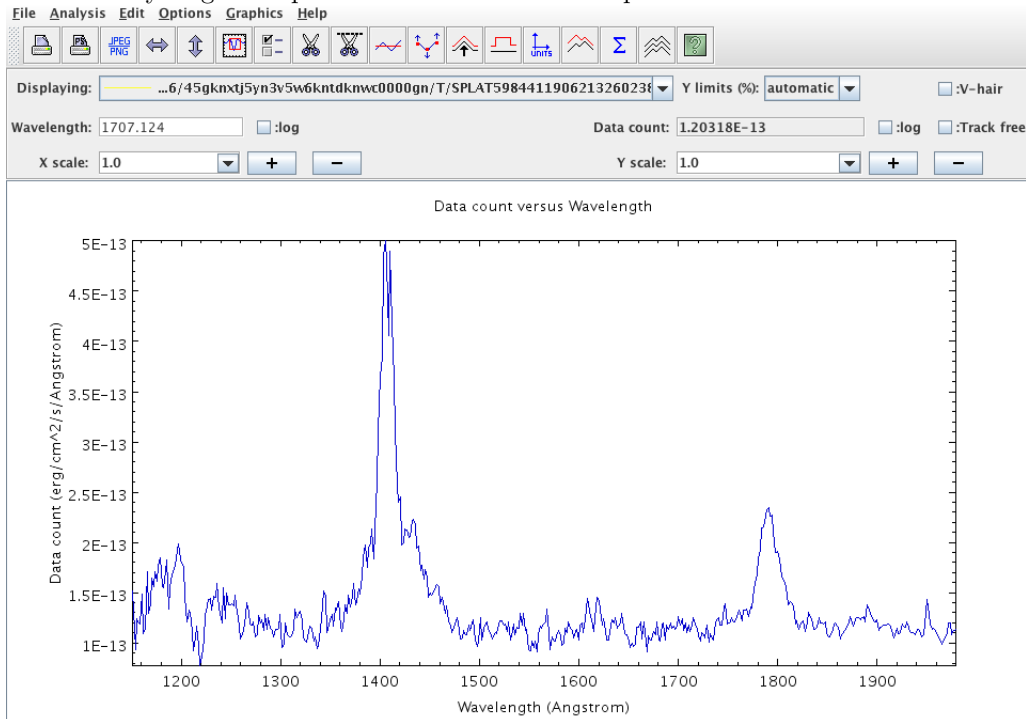
Query: <SERVER>?REQUEST=queryData&POS=187.27789583333333,2.0524055555555556&SIZE=0.166666666

Query results:

HUT	WUPPE	HST STIS Spectra	EUVE	BEFS	HST-FOS Spectra	HST.GHRS Spectra	HST Spectra	
xlxlo	lwr01027mxlo	2008-02-29 00:00:00	1.0	LWR	POINTED	Far-UV,Near-UV	9.83	
mxlo	swp19731mxlo	2008-02-29 00:00:00	1.0	SWP	POINTED	Far-UV	14.49	
op...	lwr15579mxlo	2008-02-29 00:00:00	1.0	LWR	POINTED	Far-UV,Near-UV	5.92	
op...	xlxlo	lwr01321mxlo	2008-02-29 00:00:00	1.0	LWR	POINTED	Far-UV,Near-UV	7.5
ctra	mxlo	swp01655mxlo	2008-02-29 00:00:00	1.0	SWP	POINTED	Far-UV	18.1
op...	xlxlo	swp01365mxlo	2008-02-29 00:00:00	1.0	SWP	POINTED	Far-UV	4.04
el...	mxlo	swp01366mxlo	2008-02-29 00:00:00	1.0	SWP	POINTED	Far-UV	11.57
lrrer	xlxlo	lwr13042mxlo	2008-02-29 00:00:00	1.0	LWR	POINTED	Far-UV,Near-UV	9.85
op...	mxlo	swp33907mxlo	2008-02-29 00:00:00	1.0	SWP	POINTED	Far-UV	16.9
ph...	xlxlo	lwp06501mxlo	2008-02-29 00:00:00	1.0	LWP	POINTED	Far-UV,Near-UV	11.29
d...	mxlo	swp16790mxlo	2008-02-29 00:00:00	1.0	SWP	POINTED	Far-UV	26.82
st...	xlxlo	swp16801mxlo	2008-02-29 00:00:00	1.0	SWP	POINTED	Far-UV	18.87
	mxlo	swp16802mxlo	2008-02-29 00:00:00	1.0	SWP	POINTED	Far-UV	17.53
	xlxlo	swp16803mxlo	2008-02-29 00:00:00	1.0	SWP	POINTED	Far-UV	19.88
	xlxlo	lwp10060mxlo	2008-02-29 00:00:00	1.0	LWP	POINTED	Far-UV,Near-UV	13.16
	xlxlo	lwp10061mxlo	2008-02-29 00:00:00	1.0	LWP	POINTED	Far-UV,Near-UV	12.89
	mxlo	swp44608mxlo	2008-02-29 00:00:00	1.0	SWP	POINTED	Far-UV	24.36
	xlxlo	lwp09997mxlo	2008-02-29 00:00:00	1.0	LWP	POINTED	Far-UV,Near-UV	12.67
	xlxlo	lwp09998mxlo	2008-02-29 00:00:00	1.0	LWP	POINTED	Far-UV,Near-UV	10.87
	xlxlo	lwp09913mxlo	2008-02-29 00:00:00	1.0	LWP	POINTED	Far-UV,Near-UV	13.66
	xlxlo	lwp09914mxlo	2008-02-29 00:00:00	1.0	LWP	POINTED	Far-UV,Near-UV	13.14
	xlxlo	swp40619mxlo	2008-02-29 00:00:00	1.0	SWP	POINTED	Far-UV	19.24

Display selected | Display all | Download selected | Download all | Desc tabl


- ▷ 6 The strongest peak in the plot corresponds to the Hydrogen Lyman alpha line. The Lyman alpha line's rest wavelength at 1215.67 Angstroms. Notice that the observed Ly-alpha line lies to the left of the peak. For calculating the redshift, it's necessary to get the position of the center of the peak.

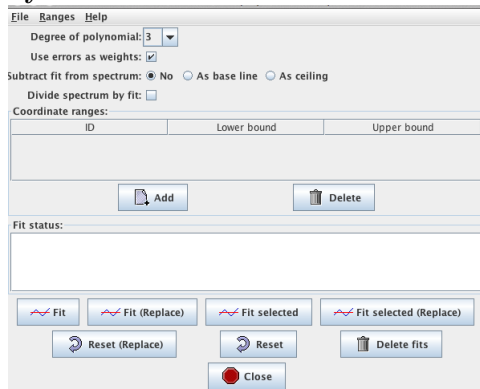



- ▷ 7 If you want to remove again the lines from the plot, just go to the main SPLAT-

VO window, click on *SDSS_refines* and uncheck the box in the **Views of the current spectra**. To visualize it again, just drag it to the plot window.

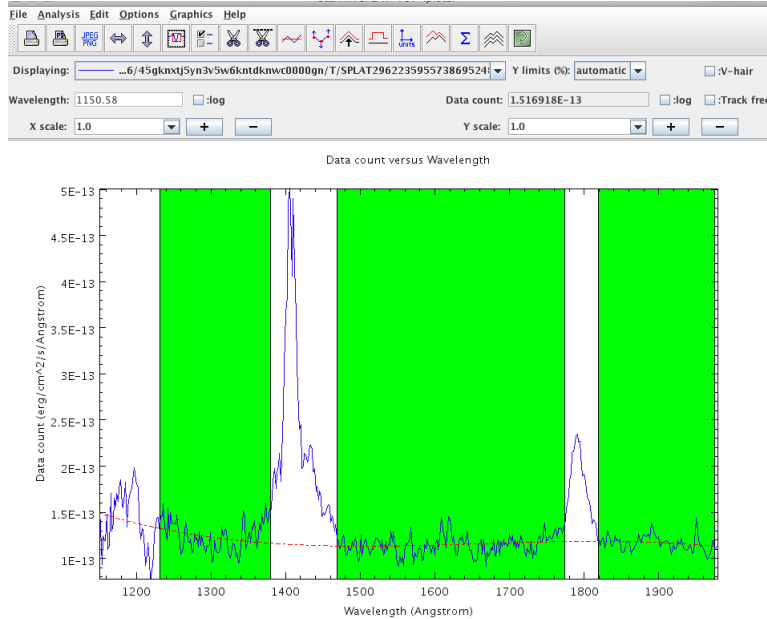
Continuum fitting and measuring the peak's wavelength


- ▷ **8** *Fitting the curve* – First of all, we need to fit the curve to a continuum. Open the  **Fit polynomial to a spectrum** window. Chose **Degree of polynomial: 3**; **Subtract fit from spectrum: No**. Leave **Divide Spectrum by fit** unchecked.



- ▷ **9** Now select several coordinate ranges where the spectrum is relatively flat, leave the strong peaks out. When you are ready, click on the **Fit (Replace)** button. The polynomial fit curve will be shown on the plot, and will be listed on the **Global list of spectra** in the main SPLAT-VO window. Close the  **Fit polynomial to a spectrum** window to remove the green marked ranges. You'll see the fit curve on the plot window.

Compute Redshifts of Quasars Using SPLAT-VO



- ▷ **10** *Finding the peak centre* – On the plot window, open the  **Measure Spectral Lines** window. Check **Types of fit:** Gaussian, **Background type:** polynomial, and **Background fit:** the previously computed fit (it has a name starting with "Polynomial Fit"). Click on **Add** button to add the frequency range. Mark the area of the plot you want to select (the area containing the peak - yellow in the example figure). You may want to zoom for better visualisation. When finished, click on **Fit**. You will get the fitting results for quick fit and Gaussian. The **Centre** value is the frequency of the peak, which is your observed Lyman alpha wavelength.

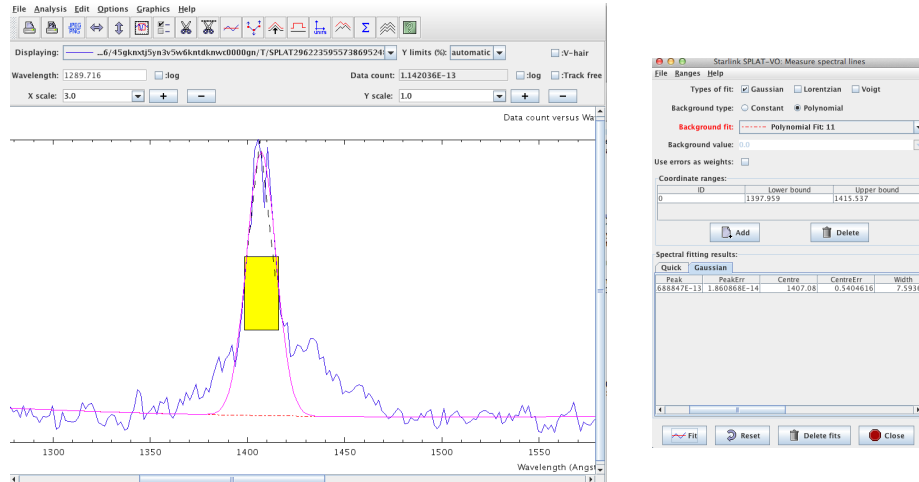
Computing the redshift and radial velocity

- ▷ **11** Now the redshift can be computed using the following equation:

$$z = \frac{\lambda_{obs} - \lambda_{emit}}{\lambda_{emit}} \quad (1)$$

where λ_{obs} is the centre wavelength and λ_{emit} is the rest wavelength of the Lyman alpha emission line (1215.67 Angstroms). After computing the redshift, you can

Compute Redshifts of Quasars Using SPLAT-VO



compare it to the value from the NASA/IPAC Extragalactic Database (NED), <http://ned.ipac.caltech.edu/forms/byname.html>.

▷ **12** The radial velocity can be computed with:

$$rv = c * z. \tag{2}$$

where c is the speed of light and z the previously computed redshift.

Other examples to try

As an exercise, you can do the same for the following galaxies: 3C 186, PKS 1127-14, 3C 286, 3C 298, PKS 1143-245