ISYA 2012

Exercise 1 - NASA/IPAC Extragalactic Database (NED)

Part 1 – Spiral Galaxy 'M83'

Summary

In this activity you will make use of an online database of galaxies called **NED** (**NASA/IPAC Extragalactic Database**). This database contains a wealth of material –including photometric measurements, spectra, images and maps – of several million galaxies.

Learning outcomes

• Use a web browser to gather information from an online database.
• Recognize the different ways of plotting the broadband spectrum of an object and their relative advantages.
• Appreciate how broadband spectra can be used to help distinguish different types of galaxy.

The activity

• Start up your web browser and connect to the Internet.
• Go to the **NED** homepage at **http://nedwww.ipac.caltech.edu**
• The panel at the bottom of the page gives information about the number of objects in the database.

How many names are on the database? How many objects?

To start with, we are going to look at the **Spectral Energy Distributions** (**SED**s) of some of the types of object. The main part of the **NED** homepage is the table with five columns (labelled **'OBJECTS'**, **'DATA'**, **'LITERATURE'**, **'TOOLS'**, **'INFO'**). Links in the cells of this table take you to different kinds of information.

• In the column headed **DATA** click on the link **Photometry & SEDs**. This will take you to a new page headed '**Photometric Data Search Based On An Object Name**'. The first galaxy we will look at is a spiral galaxy called **Messier 83** (**M83**), a type Sc Spiral. In the box labelled '**Enter object name**' type **M83**.

• Leave the next three boxes as they are. (In order, they should read: 'Data as Published and Homogenized (mJy)', 'Error Bars', and 'No Point Labels'). The fifth box allows you to

choose either frequency or wavelength units for the horizontal axis (x-axis) of the **SED**. Click on the arrow to the right of the fifth box and select **X=log(Wave.)(microns)** from the drop-down list. When the **SED** is plotted it will have a scale on the horizontal axis which is the logarithm of the wavelength in micrometres.
• The sixth box allows us to specify the flux units. For now, select **Y=log(Fnu)(W/m2/Hz)** from the drop-down list. This will produce a scale on the vertical axis which is the logarithm of the spectral flux density (Fν) in units of watts per square metre per hertz (W m−2 Hz−1).

• The final box should be left as it is ('Fixed data range (for comparisons)'). Click the Photometry button and wait!

You will now get a long page of data with a graph at the top. Information about each data point and its source is given in the table below the graph. For the purposes of this activity just concentrate on the graph at the top of the page.

What is the title of the graph?
What are labels on the horizontal axis (at the bottom) and the vertical axis (to the left)?
What part of the spectrum does the graph cover?

Now that you understand what the graph is showing, we can start to look at the data itself.

• To the right of the graph (you may have to use the horizontal scroll bar) are the boxes for changing the plot. Select **Y=log(NuFnu)(W/m2)** and click on the '**Plot Again**' button to get a new graph. You should now see the same data plotted with log(νFν) (in W m−2) on the vertical axis.

How do the X-ray and radio energies compare now?
This galaxy emits in X-rays and also in radio waves. In which of those two regions does it emit more strongly?

Examine the **SED** of **M83** between the ultraviolet and millimetre wavelengths.

How could you describe the shape of the spectrum in this region?
What could be causing these two peaks? What kind of galaxy might this be?
(Hint- M83 is an example of a starburst galaxy.)

You may want to save the **SED** that you generated, so that you can refer to it again, or compare it with those of other galaxies. The simplest way to do this is as follows:

• Click on the "**Postscript version of the SED plot**" to save current plot in Postscript format. (Note that if you left click on the plot – a new window will open which zooms in on the part of the spectrum that you have selected.)

Finally, while you have the **M83** plot on the screen, we want to show you how to access more information about specific objects.

• Click on the link to **MESSIER 083** in the title of the **SED**. You will now see a page of information about **M83**.

The first table contains the position and redshift information. The second table lists the many other designations for **M83** from various catalogues and surveys. At the bottom of the page are links to other databases where more information can be found.

• Scroll back to the middle of the page where there is a small image of the galaxy (this is a negative image with the sky shown as white).

• Click on the images link (to the left of the image). It may take a few minutes for the page to finish downloading as the many images amount to a little over a megabyte.

The large table you now see gives information about each of the images in the **NED** database. It shows a preview image on the left and, among other things, lists the wavelength at which the image was made, the telescope used and a reference to the paper where it was first published. Many of these images use a format called **FITS** (which stands for '**Flexible Image Transport System**') which is in widespread use in the astronomical community but is not supported by web browsers.

• Your browser will, however, display images marked '**JPG**'. For example, click on the 8th image from the bottom, labelled '**45KB JPG image**', that is from the '**Einstein_Obs**'.

This is a map of X-ray emission from **M83**, made with the Einstein X-ray Observatory. The X-ray contours are superimposed over a photograph of the galaxy. You can see that the emission is concentrated on the nucleus of the galaxy which is the source of the energy.

This page provides preview images taken by various ground as well as space based telescope such as **Chandra**, **GALEX**, **ROSAT**, **CTIO**, **2MASS**, **VLA** in **UV**, **Optical**, **NIR**, **X-ray** and **Radio** wavelength. Thus **NED** provides professional astronomers with a very quick and relatively easy way to review what is known about a particular galaxy, and is an invaluable tool for planning further observations.

Part 2 - Elliptical galaxy "M32"

Next we are going to look at an **Elliptical Galaxy**. One of the best known ellipticals is **M32**, a companion to the Andromeda Galaxy.

• Use your browser's Back button to return to the page called '**Photometric Data Search Based On An Object Name**'. This time, enter '**M32**' as the object name and select a log(νFν) plot with a wavelength scale as before (i.e. select **X=log(Wave.)(microns)** and **Y=log(NuFnu)(W/m2)**).

• Click on the Click the **Photometry** button and you should now see an **SED** of **M32**. This SED has a broad peak in the optical–infrared region and there are no X-ray measurements at all.

What do you think the downward pointing arrows in the IRAS and radio parts of the spectrum mean?

Part 3 - Quasar "3C273"

Now we are going to look at a **Quasar**, a type of active galaxy.

• By following similar steps as you used to generate the **SED** of M32, obtain the **SED** of the quasar **3C273**. To do so, you should enter '**3C273**' in the object name box on the page called '**Photometric Data Search Based On An Object Name**'. Make sure you specify a wavelength scale and a **log(vFv)** plot.

Looking at the **SED** produced by **NED** you may also have noticed a warning message printed on the plot that says '**Data outside fixed range. Plot again using autoscaling**.' This means that there are some measurements that fall outside the limits of the wavelength range that has been used. To see all the data, you should re-plot the **SED** as follows:

The lowest of the five boxes on the right-hand side of the **SED** provides a choice between '**Fixed data range** (for comparisons)' and '**Autoscale data range**'. Select the latter option, and press the **Plot Again** button.

In what part of the electromagnetic spectrum is the additional data that is shown on this SED?

Here are some other examples of active galaxies that you might like to inspect and compare. (In each case it may help to save a plot of the **SED** as described earlier so that you can view several **SEDs** at once.)

NGC 1068 – a nearby (type 2) Seyfert galaxy.
BL Lac – the original blazar to be discovered
M84 – the radio galaxy
Both M84 and M32 are elliptical galaxies. What is the main difference between their SEDs?

You can repeat this process for any SED that you generate using NED.
There is much more to explore in NED, but we have now finished with the online part of this activity, so you can now disconnect from the Internet.