ISYA VO Exercise

X-ray Spectroscopy of Supernova Remnants

Background:

Tycho's Supernova Remnant - In the year 1572, the Danish astronomer Tycho Brahe observed and studied the sudden appearance of a bright "new star" in the direction of the constellation Cassiopeia. Now known as Tycho's supernova remnant, the event created a sensation in Tycho's time because until then stars were thought to be unchanging. Tycho's observations of this event marked the beginning of the study of astronomy as a science. This object is a Type Ia event - the thermonuclear destruction of a white dwarf.

SNR G292.0+1.8 - The Type II core collapse of a massive star that produced this supernova remnant ~1600 years ago is located in the direction of the constellation Centaurus. SNR G292.0+1.8 is interesting because it is one of only three oxygen-rich remnants and one of the primary sources of the heavy elements necessary to form planets and people.

Purpose: To determine types of supernovas by examining Chandra X-ray Observatory images of supernova remnants (SNRs) and by identifying the elements in their energy spectra.

Procedure:

1. Open **SAOImage ds9**. From the menus, choose **Analysis>Virtual Observatory>Chandra-Ed Archive Server.**
2. In the new window that comes up, click "**ObsID 115 - ACIS OBSERVATIONS OF TYCHO AND KEPLER**". Do not close this window - you will need it later.

OR if you are unable to get images due to UCT proxy settings, do following -

1. Download image from following URL and save it on your desktop -

   http://www.saao.ac.za/~barway/vo/vo_project/xray/ObsID115.fits

2. Open SAOimage ds9 and load image using File -> Open

3. Click in the center of the **Tycho SNR** and drag a circular region completely around the whole remnant.
4. Choose **Analysis>Chandra Ed>CIAO: Sherpa Spectral fit**. For "**Model Type**", choose **"bremsstrahlung"** (when you click on "**power law**", a menu will appear). It may take a few minutes for the plot to appear. NOTE: If this takes to long, or you are unable to get the plot, try **Analysis>Chandra Ed>Quick Energy Spectrum Plot.** Note that the unit on the x-axis on this plot is **eV** rather than **keV**.

5. On the graph window that comes up, choose Graph>linear-log. Maximize the screen by clicking the square in the upper right corner.
6. Print the graph by using the Print Scrn button on the keyboard and then pasting it into a PowerPoint or Word document and printing from there.
7. To get the energy of each emission line, create a zoom box on the graph by holding the left mouse button down and dragging a box around the area of the emission line (peak). When you click again, a close-up of that area will appear. Right clicking the mouse returns you to the original graph.
8. Record the energies and identify the elements for each X-ray emission line/ peak in the Data section and on your printed graph, using **Table 1**. If you have lines whose energy is not close to that of one of the elements in the chart, leave those lines unidentified.
9. On the **chandra-ed.cfa.harvard.edu window**, click the back arrow to go back to the previous page. "**Obs ID 126 - G292.0+1.8 A REMARKABLE OXYGEN-RICH SUPERNOVA REMNANT**". Again, do not close this window.

OR if you are unable to get images due to UCT proxy settings, do following -

1. Download image from following URL and save it on your desktop -

http://www.saao.ac.za/~barway/vo/vo_project/xray/ObsID126.fits

2. Open SAOimage ds9 and load image using File -> Open

10. Repeat steps #4-10 for **SNR G292.0+1.8**. To see the emission lines better, you can zoom in.

Conclusions and Analysis:

11. What are the similarities and differences between these two spectra?
12. From your analysis of **Tycho's SNR** and **SNR G292.0+1.8**, what elements are more predominant in a Type Ia supernova? Which are more predominant in a Type II? Are there elements present in one that are not in another?
13. Explain how you might be able to classify a supernova event as type Ia or type II from its spectrum based on your observations of **Tycho's SNR** and **SNR G292.0+1.8**. Sometimes, due to interstellar absorption, emission lines less than 1.5 KeV are not seen. How could this affect your classification of a supernova remnant?
14. Analyze the spectra of any three of the following SNRs using the same procedure as **Tycho's SNR** and **G292.0+1.8**. Construct your own data tables.

    a. Obs ID 117 - ACIS OBSERVATIONS OF W49B
    b. Obs ID 116 - Kepler's SNR
    c. Obs ID 2758 - SNR 0103-72.6: AN UNSUALLY BRIGHT REMNANT IN THE SMC ALTERNATE TARGET
    d. Obs ID 775 - A SYSTEMATIC STUDY OF LMC SNRS WITH AXAF (this is

the SNR called DEM L71)
e. Obs ID 114 - ACIS OBSERVATIONS OF CAS A

15. From your analyses, classify these SNR by type. What is the basis for your conclusions? How sure are you of your classifications? What features of the spectra helped with your classifications? What features made it difficult to classify these SNR?

16. Write a report on above analysis with figures and diagrams and answers the questions asked in various steps. If you have any doubt or would like to know more, please write to **Sudhanshu Barway** at **barway@saao.ac.za**.

Table 1. Energies of X-ray Emission Lines

Element	Energy (KeV)	Element	Energy (KeV)	Element	Energy (KeV)
Mg	1.33	Ar	3.32	O	0.18
Mg	1.45	Ar	3.69	Mg	0.25
Fe	1.66	Ca	3.86	Mg	0.27
Si	1.87	Ca	3.89	O	0.64
Si	1.98	Ca	4.11	O	0.66
Si	2.14	Ca	4.95	Fe	0.80
S	2.42	Fe	6.47	Fe	0.81
S	2.44	Fe	6.54	Ne	0.92
S	2.63	Fe	6.97	Ne	0.93
Ar	3.10	Fe	7.80	Ne	1.02

Example Data

Tycho's SNR (Type Ia)		SNR G292.0+1.8 SNR (Type II)	
Energy of emission line (KeV)	chemical symbol of element	Energy of emission line (KeV)	chemical symbol of element
