The Chandra Spectrum of a Spiral Galaxy

The ultimate goal of this exercise is to produce and fit a global spectrum for a galaxy. To do this correctly is actually a very time-consuming exercise. The following procedure is suitable for a rough analysis and should be possible in the period of this school. I have tried to note where short-cuts are made, and prompt the student to think about what difference the short-cuts make.

Intro: Due to the relatively small size of the Chandra FOV, there are a limited number of nearby galaxies that can be/have been studied with Chandra. For many of them we need the complementary XMM data. For a full analysis we also need HI data (sometimes available from the THINGS survey) but there are very few galaxies with both good Chandra data and good HI data, so we will have to adjust our analysis appropriately. It is often helpful to have K band (from 2Mass of better surveys) and UV images (usually from the GALEX survey).

The following list contains galaxies for which reasonable spectroscopic analysis should be possible without the need for XMM data. All of these galaxies were observed with the S3 chip. None of these galaxies are observed in a “windowed mode”.

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NGC628   Sc    104ks in 4 obs
NGC1672  Sbc(S) 40ks in 1 obs (no HI)
NGC3184  Scd    24ks in 2 obs
NGC3351  Sb()  119ks in 3 obs
NGC3631  Sc     90ks in 1 obs (no HI)
NGC4214  Im     83ks in 3 obs
NGC4303  Sbc(S) 28ks in 1 obs (no HI)
NGC5055  Sbc(L) 28ks in 1 obs
NGC7793  Sd     49ks in 1 obs
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Basic Steps:

0. What are the reasons for the selection criteria described above?
   Why might one need XMM together with the Chandra data?
   Why is the ACIS S3 selection important?
   What is the windowed mode and why is it to be avoided here?
1. In the archive, find the Chandra observation for the galaxy of interest, and download the data.
   Which data files are essential for the data reduction?
2. Filter the data using the standard grade filters. Construct a light-curve.
   How much of the data is effected by the soft background flares?
   At what energy would it be best to detect the flares?
4. Create a “first look” image of the galaxy.
   What energy band maximizes the galactic emission compared to the background, and how would you figure this out?
5. Detect (and remove) the point sources (using wavdetect).

Given the spectral shape of typical point sources, the Chandra response, and the Chandra background, what energy band would be best for detecting the point sources?
Would detection in more than one band be useful, and if so, how?
What is the limiting sensitivity to point sources, and how does it vary with position? How large a region needs to be removed for each point source?

6. Set the source region for the galaxy. It is usually a good idea to remove the bulge, in order to isolate the spectrum of the disk.
   How does this region shape and size compare to the D25?
   For how small a region can one extract a useful spectrum?
   How much spectral variation could one detect in this galaxy?
   How would select sub-regions for spectral analysis?
7. Set the background region.
8. Construct the spectrum, the .rmf, and the .arf for both the galaxy and the background.
9. Construct the particle background spectrum from the “stowed data”.
   Since this is only a rough reduction, it is probably not necessary to worry about the spatial variation of the particle background, but how much difference would it make?
   How does one normalize the particle background spectrum for your observation?
10. Fit the background spectrum by itself. When you’ve got a good fit, fit the background together with the galaxy spectrum.
    How many thermal components do you need for a good fit, and how would you determine that adding another component is not significant?
    How significant are your fitted temperatures?
    What did you assume about the metallicity, and why?
    To what extent can you constrain the abundances with the fit?

More Advanced Topics

1. What steps does one need to take to create a background subtracted narrow band image?
2. Given the typically low count rates from galaxies, how would you construct a hardness ratio map?
3. If the galaxy filled the FOV, what would you do for a background spectrum?
4. How would you determine the remaining contribution from unresolved point sources?

Suggested Reading

Kuntz, K., & Snowden, S., 2009, ApJ, 188, 46
Kuntz, K., & Snowden, S., 2008, A&A, 478, 575
Townsley, L., et al 2011, ApJS, 194, 16