Databases, software, etc. for X-ray astronomy

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What I will cover

Archives

CALDB

Data reduction and analysis software

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Databases

HEASARC

heasarc.gsfc.nasa.gov/docs/archive.html

Chandra Data Archive

asc.harvard.edu/cda

XMM Science Archive

xmm.vilspa.esa.es/xsa/

Mirror sites

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HEASARC

Provides access to all the publically available X- and gamma-ray datasets. Also many general catalogs and datasets held at other data centers (eg Chandra and XMM-Newton).

Powerful search engine (Browse) with a uniform interface across missions.

Batch processing and cross-correlation capabilities.

Includes bibliographic links to datasets where available.

If you haven't used browse before read the introduction at heasarc.gsfc.nasa.gov/W3Browse/w3browse-help.html

Chandra Data Archive

Provides access to all the Chandra datasets using an interface tailored for Chandra (http://asc.harvard.edu/cda).

ChaSeR (java) and WebChaSeR (web page) provide search and retrieval of datasets.

Chandra Fast Image is a simplified interface intended for the general public but can also be used to get quick looks at data before deciding whether to download it.

Bibliography search for Chandra papers on a given object or observation.

XMM Science Archive

Java-based interface provides access to all XMM-Newton datasets.

Many XMM-specific search options including on attributes in the EPIC source catalog.

Optical images from the source ID program.

New users should take the guided tour at
http://xmm.esac.esa.int/external/xmm_data_acc/xsa/docs/tour.shtml

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Mirror sites

Several sites mirror some datasets. You should use these if you are physically located near them.

LEDAS at Leicester University in the UK has mirrors of the Chandra, ASCA, ROSAT archives and the XMM source catalog (http://ledas-www.star.le.ac.uk).

DARTS at ISAS in Japan has several archival datasets including a mirror of the ROSAT All-sky survey (http://darts.isas.jaxa.jp).

ASDC in Italy has BeppoSAX, ASCA, and ROSAT datasets (http://www.asdc.asi.it).

CALDB

One of the problems in X-ray astronomy is the large number of files that are usually required to store all the calibration information for an instrument. Keeping track of these and making these available to the data analysis software is challenging.

The CALDB is a directory structure and indexing system for FITS files which enables software to read the correct calibration data without needing to know the filename or directory.

Users can either install a CALDB locally or for occasional use access the calibration files from the HEASARC site.

CALDB is used for HEASARC archival and current missions and for Chandra but not (alas) for XMM.

Software packages

HEAsoft - heasarc.gsfc.nasa.gov/docs/software/lheasoft

CIAO - asc.harvard.edu/ciao

SAS - xmm.vilspa.esa.es/external/xmm_sw_cal/sas_frame.shtml

All these packages operate on FITS files with standard formats defined for each type of dataset. We have attempted to make it possible to mix and match tools from different packages.

HEAsoft

Large and diverse package distributed by NASA Goddard.

Latest release is 6.3.1. Runs under Linux, Solaris, OS-X, and Cygwin.

Can be downloaded as either source code or binaries. The latter is usually adequate unless you want to apply source patches.

Contains generic multi-mission tools as well as packages for current missions RXTE, Swift, Suzaku and a number of archival missions.

For help : heasarc.gsfc.nasa.gov/cgi-bin/ftoolshelp

HEAsoft components

- XANADU - High-level, multi-mission tasks for X-ray astronomical spectral, timing, and imaging data analysis
- FTOOLS - General and mission-specific tools for FITS files
- FITSIO - Core library responsible for reading/writing FITS files
- fv - General FITS file browser/editor/plotter with a graphical user interface (distributed with FTOOLS)
- XSTAR - Tool for calculating the physical conditions and emission spectra of photo-ionized gases

- PROFIT - Visualizing and modelling high-resolution spectra.

CIAO

Written for Chandra by the CXC but contains many tools that can be used for other purposes.

Current version is 3.4.0 which is supported on Solaris 8, Redhat 6.2, Redhat 8, and Mac OS X (both PowerPC and Intel). The Redhat 8 distribution should run on most modern Linux versions.

The CIAO source is available but it is recommended that you download the binaries and not try to compile it yourself.

CIAO v4.0 development is under way and a Beta 1 distribution is available.

For help : asc.harvard.edu/helpdesk

CIAO components

Chandra-specific tools

Multi-mission DM (DataModel) tools

ds9 image display

ChIPS plotting package

Sherpa multidimensional fitting engine

GUIDE tool for identifying atomic features in spectra (uses the APED atomic physics database)

SAS

Tools to be used on data from XMM-Newton.

Current version is 7.1.0 and is supported for Redhat 9.0, RHEL 3,4, Fedora Core 3, SuSE 7.3, 8.2, Solaris 8, 9, Mac OS X 10.3, 10.4 (PowerPC only), Windows via a virtual machine running Fedora Core 4.

Binary versions only are available.

Requires the user to have installed : ds9, XPA, Grace, HEAsoft

For help :
xmm.vilspa.esa.es/external/xmm_user_support/xmmhelp_frame.shtml

Hera

Run your analysis remotely on machines at GSFC.
(http://heasarc.gsfc.nasa.gov/hera/startinghera.html)

Uses fv as a front-end. fv is a small stand-alone program that runs on Windows, Linux, Mac OS X.
(http://heasarc.gsfc.nasa.gov/docs/software/ftools/fv)

Through Hera you can run programs from HEAsoft, CIAO, and SAS without having to install any of them on your computer.

Hera has high-speed access to the HEASARC archive.

On Linux and Mac OS X systems there is a command line interface :

   fv -r <HEAsoft, CIAO or SAS command>

Software overview

Divide X-ray astronomy software into several classes

- Calculating event attributes - sky position, PI, grade,…

- Cleaning and filtering events

- Extracting products - images, spectra, lightcurves,…

- Creating observation calibration files

- High-level analysis - source detection, spectral fitting

Filling event columns

The first step is to calculate various event attributes such as the sky position, the energy, and, for CCDs, the grade. Usually this will be performed automatically for you in pipeline processing. However, if calibration files change you might want to reprocess.

For Chandra this is performed using the CIAO routines acis_process_events or hrc_process_events. Reprocessing involves setting the input parameters correctly and making sure that you have the latest calibration files.

XMM reprocessing is performed using emproc, epproc, rgsproc for the MOS, PN, and RGS respectively.

Cleaning and filtering

The next step is to remove events that do not meet some criterion for validity, remove events during any times of particularly bad background. You might also want to select only events within a particular region on the sky or on the detector.

There are many tools to select rows out of FITS files however you do need to be a bit careful about which ones are used. Other software may need to know what selections were made. For instance : suppose you select events within some time interval. You can't reconstruct this selection just from the events left in the file because there might be real gaps in the data.

Cleaning and filtering II

Selections are tracked by storing additional information in the file either in keywords or extra extensions.

In CIAO this is done using the DataModel filtering. See ahelp dmfiltering for details.

The SAS has either a command line option called evselect or a GUI called xmmselect (xmm.vilspa.esa.es/sas/current/doc/evselect).

HEAsoft has a program xselect which can be used to perform filtering (through the filter command). xselect actually runs an ftool called extractor, which is available for the sophisticated user (http://heasarc.gsfc.nasa.gov/docs/software/lheasoft/ftools/xselect/xselect.html).

All these methods *should* be equivalent.

Extracting products

Images, energy spectra, and lightcurves are histograms on event attributes so again one could use general software to create these but in many cases subsequent software requires particular keywords or extensions so it is better to use our standard tools.

The HEAsoft program xselect has a command extract which can be used to make these products.

evselect and xmmselect in SAS have options to create these products.

In CIAO dmextract is used to make energy spectra and lightcurves and dmcopy to make images.

Creating observation calibration files

Once you have your products you may need to create other files in order to continue with scientific analysis. For instance, analysis of images may need exposure maps and spectra require responses.

These tools are always mission-specific since they depend on details of the instruments in use. For Chandra you will want to look at the appropriate analysis threads in : http://asc.harvard.edu/ciao/threads/index.html

For SAS a good place to start is the XMM ABC guide at : http://xmm.gsfc.nasa.gov/docs/xmm/abc/abc.html

Analysis of products

Finally, you can get to the scientific analysis you wanted to do in the first place. Source detection in images, fitting models to energy spectra, searching for periods in lightcurves,…