AN ARCHIVE OF CHANDRA OBSERVATIONS OF REGIONS OF STAR FORMATION (ANCHORS). B. D. Spitzbart, *Harvard-Smithsonian Center for Astrophysics, Cambridge MA 02138, USA, (bspitzbart@cfa.harvard.edu)*, S. J. Wolk, N. S. Bizunok, *Harvard-Smithsonian Center for Astrophysics, Cambridge MA 02138, USA*.

Introduction

ANCHORS is a web based archive of all the point sources observed during Chandra observations of regions of star formation. It is designed to aid both the X-ray astronomer with a desire to compare X-ray datasets and the star formation astronomer wishing to compare stars across the spectrum. Through cycle 5 the database contains about 60 Chandra fields, yielding 10,000+ sources. The data consists of X-ray source properties including position, net count rates, flux, hardness ratios, lightcurve statistics and plots. Spectra are fit using several models, with final parameters and plots recorded in the archive. Multi-wavelength images and data are cross-linked to other archives such as 2MASS and SIMBAD. The pipeline processing ensures consistent analysis techniques for direct comparisons among clusters. Results are presented on-line with sorting, searching, and download functions via a HTML/XML interface. We will demonstrate the system and solicit users' feedback.

Typical nuances and judgement calls in data analysis lead to many difficulties in comparing published data from different observers or from different observation dates. The data reduction and analysis software itself changes over time which can affect the final results even on the same dataset. In most cases different spectral models, parameter settings, and classification criteria will be applied based on the observer's preferences and familiarity. The goal of our catalog is to provide a uniform (not necessarily optimal) database for the comparison of data from different stellar clusters. This type of catalog provides added science return as well as a convenient set of observatory health and performance metrics. The catalog will make it possible to treat science quantities in similar ways to how databased spacecraft temperatures and voltages are treated for monitoring and trending. The full benefit of ANCHORS will be realized in sorting and searching on any property (temperature, absorption, age, mass, etc.) across numerous stellar clusters.

Processing Overview

The ANCHORS automated pipeline consists of software tools from various sources. We, of course, use the Chandra archive to identify and download available datasets as they are released from their propriety period. Chandra X-ray Center's CIAO analysis tools are used throughout. Namely, we use wavdetect for source detection with the significance set to yield about 1 false detection per field. Source positions are then adjusted with a centroiding routine and elliptical extraction regions around each source are formed based on PSF modelling as a function of chip position at one or more encircled energies.

A main component of the pipeline is YAXX (Yet Another X-ray eXtractor). This package by Tom Aldcroft (CXC) uses our source regions to form the calibration files needed for spectral fitting (ARFs and RMFs) and runs Sherpa to perform the fitting and output results including absorption column (nH), temperature (kT), fluxes and statistical significance. We currently attempt three model fit iterations: a) 1 temperature Raymond-Smith thermal plasma model on all sources with more than 30 counts, b) a 2 temperature Raymond-Smith on sources with at least 100 counts, and c) the 2 temperature Raymond-Smith with metallicity as an added free parameter only for sources with more than 200 counts.

We also perform another classification of spectral properties using the quantile technique [1]. This method divides the photons into fractions of the total counts. The result is the energy at which 25%, 50%, and 75% of the the photons are found. This is in contrast to the traditional predetermined energy bins of hardness ratios and X-ray colors and is especially useful in low count regimes.

The last major analysis performed by the pipeline is timing analysis. For this we employ Bayesian block routines [2]. This technique splits the lightcurve into periods of constant flux at a given significance level.

The pipeline runs on a 4 CPU (900 MHz each) Sun Ultra. End-to-end processing time is approximately 3.3 minutes per source or about 8 hours for a typical 150 source cluster.

User Interface

ANCHORS will soon be available on the internet at http://cxc.harvard.edu/ANCHORS. The pages are EXtensible Markup Language (XML) based for easy conversion between formats. The analysis results are seen on the website and available for download. Plots of spectra and lightcurves are shown. One arcminute X-ray, infrared, and optical thumbnail images are also shown for each source. 2MASS magnitudes (J,H,K) are collected and presented. Any available data from the literature are imported at the cluster level (mass, age, distance, etc.) Finally, useful links are provided to the Chandra data archive, SIMBAD, and other references.

Future enhancements include the addition of more multiwavelength data (Spitzer, VLA, optical) and additional X-ray analysis such as more spectral models and K-S tests on lightcurves. We will extend the functionality and interactivity of the web site with advanced sorting, searching, retrieval and analysis tools. We intend to conform with Virtual Observatory standards and practices.

Following is a partial list of clusters that are or soon will be available on ANCHORS: RCW38, NGC 346, NGC 1333, NGC 2068, NGC 2024, IC 348, NGC 2264, LYNDS 1551, OMC 2/3, Orion (COUP), Lambda Ori, Chameleon 1 North.

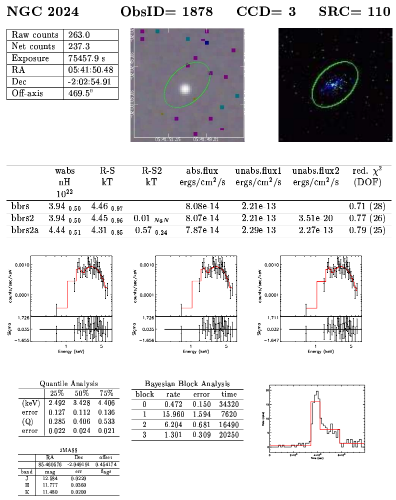

Figure 1: An example ANCHORS report page with sections, top to bottom, for X-ray photometry, X-ray spectral fits, lightcurve, and multi-wavelength counterparts.

Science Applications

The archive is designed to aid both the X-ray astronomer with a desire to compare X-ray datasets and the star formation astronomer wishing to compare stars across the spectrum. It brings together Chandra data on open clusters and other bright, variable, young stars for the study of the various physical mechanisms indicated by the X-ray emission. Chandra's superb spatial resolution allows the resolution of stars in crowded regions 2-3 kpc away. With good sensitivity between 2 and 8 keV, Chandra can penetrate star forming clouds to levels rivaling near-IR telescopes. These features allow novel investigations of star formation which is more massive, more embedded and more distant than previously possible. Using the point source database, one could follow the progression of luminosity and variability for various mass stars from the birthline to the present day without having to weigh the impact of the different analysis assumptions made by each team. While much can be learned about stellar evolution from the study of individual clusters, science return is enhanced when the clusters are viewed as a group. As a pilot study, we examined brown dwarfs observed by Chandra during AO1-2. We found almost 70 candidate brown dwarfs had been detected by Chandra [3] (though only 8 bona fide). Trends indicate that the younger brown dwarfs are hotter in X-rays than the field brown dwarfs, but the total X-ray luminosity of detected brown dwarfs are similar. Another study [4] examined only the 43 X-ray sources in the ONC between 0.7 and 1.4 solar masses in order to understand the mean properties of the young Sun at 0.5 Gyr. They conclude that the flares which occur during the protoplanetary phase can cause significant production of unusual nuclieds including Al-26. Using the point source database, one could follow the progression of luminosity and variability for sun-like stars from the birthline to the present day without having to weigh the impact of the different analysis assumptions made by each team. Similar studies can be performed on intermediate mass stars. These studies are particularly interesting since flares imply the presence of confined plasmas which should be absent in these stars. For an example of studying flares with ANCHORS see N. Bizunok's poster at this meeting.

Observatory Performance Metrics

The ANCHORS catalog will provide ready metrics for monitoring Chandra's performance. This directly benefits researchers through better calibration of data products and possible early detection and mitigation of anomalies resulting in an extended and efficient mission life. Using point spread function (PSF) and spectral line measurements from all the brightest point sources observed ($>$ ˜200 counts) gives a baseline than could not be available from a necessarily limited calibration campaign. Chandra sources falling far off-axis are elongated and rotated due to the cylindrical shape of Chandra's mirrors. The elongation and rotation as a function of chip position is an important quantity to measure and track over time, as any shifts must be explained. For sources combined from throughout the Chandra mission, filtering on time or energy we can detect shifts in this fit which indicate any mirror alignment problems. ANCHORS will also aid in the calibration of aimpoint shifts. Spectral characteristics can be used to monitor charge transfer inefficiency (CTI) and to monitor for a systematic appearance of any new absorption features indicating contamination on the mirror or focal plane surfaces. No unexpected image distortions are recognized to date. The point source catalog will confirm this result and provide a method of continued monitoring.

Acknowledgements

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References

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