Data Analysis Challenges in the Chandra Orion Ultradeep Project


ABSTRACT

The Chandra Orion Ultradeep Project (COUP) combines 6 consecutive ACIS observations of the Orion Nebula Cluster obtained in January 2003, with a total exposure time of 0.84 Ms. Over 1650 point sources are detected in this star-forming region; most show variability in their lightcurves. We describe some of the data analysis challenges specific to this observation, including: source detection with complex backgrounds due to bright sources, resolving crowded sources, spectral fitting of sources lying under readout streaks, and time-varying pile-up. We show examples output from the custom software we have developed to automate the spatial, spectral, and timing analysis of these sources and to collate the results into user-friendly viewing formats.

INTRODUCTION OF CHANDRA COUP OBSERVATIONS

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Fig. 1 - (Left) Chandra three color raw image of the merged event 2 fl. It was constructed from the 0.5-1.5 keV (red), 1.5-2.0 keV (green), and 2.5-8.0 keV (blue) raw images. The merger of all six observations was greatly simplified by keeping the aim point and the roll angle constant! A few dozens of X-ray sources suffered mild photon pileup (10% - 30%) in the CCD detector. At the middle of the mosaic the X-ray 1% threshold line covers half of all channels, suffer from very significant pileup. Dozens of readout strobkas from bright pixels at the bottom of the mosaic are easily seen in this image. The sensitivity of sources rapidly deteriorates as one approaches within ~ 2'' of 01 Ori C due to the background from the O star's PSF wings (right). Enhanced view of the central (7.5 ' x 7.2' ~ size of the deep near-IR VLT 2.5-8.0 keV (blue) raw images.

DATA REDUCTION ROADMAP

1. Run acis_extract (see details in [12]) in order to: 1. refine the accuracy of source positions; 2. extract event lists for each source, using the polygonal on 02346 grades, status, and time-varying pile-up. We show example output from the custom software we have developed to automate the spatial, spectral, and timing analysis of these sources and to collate the results into user-friendly viewing formats.

ABSOLUTE ASTROMETRY

Fig. 3 - Cumulative distributions of offsets between X-ray and IR positions. Our X-ray positions are superb! Median offsets are 0.15'' for 2MASS counterparts, 0.22'' for 2MASS counterparts, and 0.15'' for MLLA counterparts. There is virtually no ambiguity between catalogued sources and COUP sources, except for a couple dozens of close doubles, where Chandra often sees a double star with a single IR counterpart, and vice-versa.

DOUBLE SOURCES

We found a few dozens cases in which ACIS resolved close (1''-3'') doubles, but detect programs failed. As an example, three of these are shown in the figure. (Left) Raw ACIS images of double doubles at sub-subpixel resolutions. (Right) To confirm our findings we ran IDL tool "mask pro" [11] to create PSF deconvolved images. A few other tricks can be used to resolve faint sources. For example, photon arrival diagrams indicate two different flares, which occurred from each of the components, the flare at ~50s for the first component and the flare at ~80s for the second component.

REFERENCES


Fig. 4. - The source detection programs often confuse resolved sources easily resolved by eye; this failure begins for source separation ~ 2.5'' on-axis. We employed the tool "cop view" [7] to perform a visual search for faint sources and close doubles. We found a few dozens cases in which ACIS resolved close (1''-5'') doubles, but detect programs failed. As an example, three of these are shown in the figure. (Left) Raw ACIS images of double doubles at sub-subpixel resolutions. (Right) To confirm our findings we ran IDL tool "mask pro" [11] to create PSF deconvolved images.

SOURCES ON READOUT TRAILS & PSF WINGS

Fig. 5 - The other tricks can be used to resolve faint sources. For example, photon arrival diagrams indicate two different flares, which occurred from each of the components, the flare at ~50s for the first component and the flare at ~80s for the second component.

ATLAS

Fig. 9 - The atlas is a PDF file summarizing each source on a page: it has light curve; photon arrival diagram; spectral fits, raw, PSF reconstructed and smoothed images, postage-stamps of the source neighborhood; as well as various tabulated quantities. Eric Feigelson (PI of COUP Project) predicts that these atlas pages will prove very useful to the science efforts. As an example, the current version of atlas for a single source is shown below.