The Future of astronomical archives: reaching out to and engaging broader communities

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Abstract. The importance of archival science increases significantly for astrophysical observatories as they mature and their archive holdings grow in size and complexity. Further enhancing the science return of archival data requires engaging a larger audience than the mission reference community, mostly because of the growth of interest in multi-wavelength and transient/time variability research. Such a goal, though, can be difficult to achieve. In this paper I will describe a different approach to this question that, while minimizing technological friction and leveraging existing services, makes archival observations more accessible and increases our capability to proactively engage astronomers on potentially interesting archival records. Inspired by this strategy, the Chandra Data Archive team is working on two specific experimental projects that will hopefully demonstrate their potential while contributing to the maximization of the scientific return of the Chandra mission.

1. Introduction

Archive-based science becomes more and more important as astronomical missions mature and archive holdings grow. Increased usage of public archival observations in the literature has been observed for more than a decade for all NASA Great Observatories (White et al. 2009; Peek et al. 2019) (Figure 1). The Chandra archive makes no exception, as shown in Figure 2, but there are some evidences that re-usage of archival observations is plateauing. Further enhancing the scientific return of archival data will require development of tools and services to engage a larger audience than the mission reference community. Such goals, though, can be cost-prohibitive and technically challenging if pursued through the continuous expansion of existing tools and interfaces that were designed to cater to the needs and requirements of the mission core community. Sustaining this growth in the medium/long term within realistic budgetary and technical constraints will be challenging for several different reasons, including:

- Potential saturation of the core archival science opportunities.
- Degradation of the utility of public interfaces, that cannot evolve as quickly as community needs.
- Challenge and cost of using a unique technology to cater to well-established and new use cases.
- An evolving and expanding science focus can become a moving target (transients, multi-wavelength & multi-messenger research, etc.)
So, the question is: how can archives try to sustain and push archival science towards unexplored territories without relying on new toolkits and resources that might not be available? One of the possible approaches is to develop smart methods to contact and engage a wider community than the reference one, stimulating new interest in the data available in the archive and "out of the box", innovative scientific applications. In this paper, we suggest that this goal can be accomplished by leveraging the large body of connections between archival observations with the literature, and taking advantage of external data collections to enrich its own holdings.
2. Sustaining growth of the CDA

The Chandra Data Archive (CDA) is working on two different projects to reach out to a larger audience than the core Chandra community and generate additional, original interest in its holdings. This experimental approach leverages both the valuable internal collections of data/literature links accumulated over the first 20 years of operations of CXO in the Chandra bibliography (Winkelman 2018; Winkelman et al. 2018), and the existence of heterogeneous astronomical knowledge bases that can be used to enhance the knowledge content of the archive.

2.1. ...from within...

By taking advantage of the comprehensive collection of bibliographic linkages between Chandra observations and the scientific and technical literature using them, we have defined multiple classes of interesting “archival events” based on public observations or Chandra-related publications. The categories of events and the definition of quantitative thresholds needed to select events are entirely data-driven, in order to guarantee objectivity, and relieve humans from the responsibility of the choice.

![Diagram of Chandra Data Archive and recommendation engine](image)

Figure 3. Schematic representation of the Chandra Data Archive and its “archival recommendation engine” in the context of the automatic extraction of interesting archival events for the Twitter CDA program.

The “events” are automatically extracted from the archive by a suite of customized DB queries and scripts developed for the purpose, that we have called the “archival recommendation engine”. In the future, archival events will be daily evaluated by CDA staff for publication through Twitter (Becker et al. 2018). Figure 3 shows a diagrammatic representation of how the recommendation engine harnesses the Chandra bibliographic archive: the bibliographic database is searched for potential interesting events fitting the pre-defined categories, that are then passed with all the salient information to the
operators in a human-friendly format. At this point, all necessary ingredients are available and the creative process that will lead to the publication of the Tweet describing the event can start.

2.2. ...and the outside

In the case of most archival interfaces, searches are limited to metadata of the observations (space/time location, size, target, instrumental parameters, duration, mode). While there has been discussion about how to bring natural language searches into the astronomical research, progress has been relatively slow, and a general mechanism to allow more useful questions like the one reported below is still missing:

“What are the ACIS observations containing Seyfert 2 galaxies with redshift between 0.5 and 0.8 and located less than 0.15 degrees from the coordinates of the pointings of the Chandra observations with exposure (at the location of the galaxies) longer than 25 ks?”

The Chandra archive does not know what Seyfert 2 galaxies and redshift are. In CDA, we plan to address this issue by harnessing an external service that collects, combines and curates heterogeneous astronomical information, namely the SIMBAD Astronomical Database (Wenger et al. 2000) managed by the Centre de Données astronomiques de Strasbourg (CDS). We will annotate the footprint of all Chandra public observations and provide an additional layer to the current public interface that will make these type of questions answerable.

3. Conclusions

Simple recipes can be found to enhance the scientific impact of archival data leveraging internal and external resources to increase the astronomical value of the data and raising interest for its re-usage. In this paper, I have described two ongoing projects at the CDA that will ensure a proactive role for single mission archives in the future.

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