Chandra's High Impact Science Papers

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The *Chandra* X-ray Center (CXC) is periodically asked to give examples of the scientific impact *Chandra* has in astronomy. One such measure is to identify High Impact Science Papers (HISPs) that represent the most influential types of science coming from the observatory. Observatories classically identify these papers based on the total number of refereed citations to the papers. For *Chandra* that has been a list of the 50–100 highly-cited refereed *Chandra* Science Papers (CSPs). But total citation count alone is an incomplete measure of the scientific impact from *Chandra*. Absolute total number of citations is skewed towards older papers that have accumulated citations over the years. HISPs can be relatively new and still have a great impact. By using a differential analysis of the citation history of a paper, we can identify those papers which have a large number of citations over a limited period as another indicator of science impact.

Establishing importance of *Chandra* observations in a given CSP is an essential step in determining the publication's scientific contribution (see last year's *Chandra* Newsletter article "The *Chandra* Bibliography" for further details). Since the scientific contribution from *Chandra* in CSPs varies widely, citation history must to be combined with an assessment of whether the science contribution from *Chandra* is integral to the findings in the paper. It is only after such consideration that we can identify a HISP. At the moment, we prefer to err on the side of caution and retain a comprehensive subset of CSPs that qualify as potential HISPs. The metadata generated for this list of papers allows for easy revision should the criterion on the *Chandra* contribution to the scientific content of the paper change. Our list of resulting *Chandra* HISPs contains 139 refereed journal articles or about 2% of the total CSPs. The list was last compiled in June 2018 by applying the objective measures to all CSPs (giving us 165 potential HISPs) and then applying the subjective evaluation to whittle the list to 139 [1][2]. The general characteristics of the *Chandra* HISPs are:

- 105 papers have more than 200 refereed citations
- 72 papers have more than 40 refereed citations in a single year (with 9 papers having more than 70 citations in a single year)
- 50% of the papers include multi-observatory analysis of some sort (compared to 43% for non-HISPs)
- 28% of the papers with direct analysis of data are purely based on archival observations where neither the PI nor observer of any of the data linked to the paper are authors of the paper.

Recently we were asked to provide a list of high impact papers to help identify *Chandra* science topics for future *Chandra* articles and workshops. This question lead to an exploration of scientific impact based on the science topics covered in CSPs. Our initial list of science topics is based on the science categories used for *Chandra* proposals, in part because all *Chandra* data are linked to one of these categories and the majority of CSPs use data that originated from within a single science category. While the science categories are broad, the distribution of total time awarded in each science category roughly represents the amount of time proposed for in each category. We assigned one of the 10 science categories to each HISP in our current list using the title, abstract, and keywords in the paper. The process was very informative and highlighted some perhaps not so unexpected discoveries:

- The distribution of HISPs between proposal science categories does not track the distribution of time awarded in those categories. This is not too surprising given that data are often used for science studies other than what they were proposed for.
- The proposal science categories are too broad to be used to classify CSPs and some science studies can span more than one category. This was particularly true for studies of x-ray binary populations. There are two binary categories, one for black hole and neutron star binaries and one for white dwarf binaries and cataclysmic variables and classification is not always straightforward.
- A more descriptive set of science topics (and perhaps subtopics) for papers can be derived from the keywords, title, and abstract. These three elements tend to focus on the science goals of the paper in a succinct manner.
- The Unified Astronomy Thesaurus (UAT) is proving to be a useful resource for developing a relatively short list of science topics and subtopics to assign to papers by providing relationships between broader, related, and narrower terms for the concepts expressed in a paper. Development of a list of science topics for *Chandra* is a manual process, but as journals adopt the use of the UAT for their keywords, it may be possible to match the UAT URIs to the *Chandra* science topic list in an automated fashion as an initial assessment of the science topic(s) for a paper.
- The publication and citation rates for different branches of astronomy must be accounted for when determining the scientific impact and identifying HISPs in order to fairly represent the broad range of astrophysics being explored with *Chandra* data.
- Multiple science topics are essential for some papers.

We have embarked on a process of assigning science categories and subcategories to CSPs to better identify, with higher granularity, the branches of astronomy and astrophysics where *Chandra* has made contributions. We plan to apply our HISP analysis by science topic to gain a more detailed picture of the overall scientific impact *Chandra* has made in astronomy.

Finally, we present a list of the top two papers in each of the *Chandra* proposal categories based on our simplistic approach to gauge the science impact of *Chandra*. Enjoy.

Active Galaxies and Quasars

Ueda et al. (2003), "Cosmological Evolution of the Hard X-Ray Active Galactic Nucleus Luminosity Function and the Origin of the Hard X-Ray Background" (2003ApJ...598..886U)

Ranalli et al. (2003), "The 2-10 keV luminosity as a Star Formation Rate indicator" (2003A&A...399...39R)

BH and NS Binaries

Baganoff et al. (2003), "*Chandra* X-Ray Spectroscopic Imaging of Sagittarius A* and the Central Parsec of the Galaxy" (2003ApJ...591..891B)

Yuan et al. (2003), "Nonthermal Electrons in Radiatively Inefficient Accretion Flow Models of Sagittarius A*" (2003ApJ...598..301Y)

Clusters of Galaxies

Clowe et al. (2006), "A Direct Empirical Proof of the Existence of Dark Matter" (2006ApJ...648L.109C)

Vikhlinin et al. (2006), "*Chandra* Sample of Nearby Relaxed Galaxy Clusters: Mass, Gas Fraction, and Mass-Temperature Relation" (2006ApJ...640..691V)

Extragalactic Diffuse Emission and Surveys

Alexander et al. (2003), "The *Chandra* Deep Field North Survey. XIII. 2 Ms Point-Source Catalogs" (2003AJ....126..539A)

Gilli et al. (2007), "The synthesis of the cosmic X-ray background in the *Chandra* and XMM-Newton era" (2007A&A...463...79G)

Galactic Diffuse Emission and Surveys

Wang et al. (2002), "A faint discrete source origin for the highly ionized iron emission from the Galactic Centre region" (2002Natur.415..148W)

Revnivtsev et al. (2009), "Discrete sources as the origin of the Galactic X-ray ridge emission" (2009Natur.458.1142R)

Normal Galaxies

Martin et al. (2002), "The Metal Content of Dwarf Starburst Winds: Results from *Chandra* Observations of NGC 1569" (2002ApJ...574..663M)

Gilfanov (2004), "Low-mass X-ray binaries as a stellar mass indicator for the host galaxy" (2004MNRAS.349..146G)

SN, SNR, and Isolated NS

Smith et al. (2007), "SN 2006gy: Discovery of the Most Luminous Supernova Ever Recorded, Powered by the Death of an Extremely Massive Star like η Carinae" (2007ApJ...666.1116S)

Soderberg et al. (2006), "Relativistic ejecta from X-ray flash XRF 060218 and the rate of cosmic explosions" (2006Natur.442.1014S)

Solar System

Cravens (2002), "X-ray Emission from Comets" (2002Sci...296.1042C)

Gladstone et al.(2002), "A pulsating auroral X-ray hot spot on Jupiter" (2002Natur.415.1000G)

Stars and WD

Preibisch et al. (2005), "The Origin of T Tauri X-Ray Emission: New Insights from the *Chandra* Orion Ultradeep Project" (2005ApJS..160..401P)

Landi et al. (2013), "CHIANTI—An Atomic Database for Emission Lines. XIII. Soft X-Ray Improvements and Other Changes" (2013ApJ...763...86L)

WD Binaries and CV

Papitto et al. (2013), "Swings between rotation and accretion power in a binary millisecond pulsar" (2013Natur.501..517P)

Guillot et al. (2013), "Measurement of the Radius of Neutron Stars with High Signal-to-noise Quiescent Low-mass X-Ray Binaries in Globular Clusters" (2013ApJ...772....7G)

References

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