frontiers | Frontiers in Astronomy and Space Sciences

TYPE Editorial
PUBLISHED 20 May 2025
DOI 10.3389/fspas.2025.1549342

OPEN ACCESS

EDITED AND REVIEWED BY
Julio Navarro,
University of Victoria, Canada

*CORRESPONDENCE
Daniel Stern,
daniel.k.stern@jpl.nasa.gov

RECEIVED 20 December 2024
ACCEPTED 30 April 2025
PUBLISHED 20 May 2025

CITATION
Stern D, Madsen K and García JA (2025) Editorial: High-energy astrophysics research enabled by the probe-class mission concept HEX-P.
Front. Astron. Space Sci. 12:1549342.
doi: 10.3389/fspas.2025.1549342

Editorial: High-energy astrophysics research enabled by the probe-class mission concept HEX-P

Daniel Stern[1]*, Kristin Madsen[2] and Javier A. García[2]

[1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, United States, [2]X-ray Astrophysics Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD, United States

KEYWORDS

X-ray, HEX-P, mission science, spectroscopy, black holes

Editorial on the Research Topic
High-energy astrophysics research enabled by the probe-class mission concept HEX-P

Introduction

The High Energy X-ray Probe (HEX-P) is a sensitive, broad-band (0.2–80 keV) X-ray mission concept submitted in response to NASA's Astrophysics Probe Explorer (APEX) Announcement of Opportunity in November 2023 (Figure 1). This was the first time NASA competed an Astrophysics mission of this scale, constrained to a cost cap of ≤\$1.0 B, not including launch, managing the Guest Observer (GO) program, or contributions. Notably, this was also the first time NASA competed a GO facility. This Research Topic includes 17 papers that describe the HEX-P mission and its science. Madsen et al. provides an overview of the HEX-P instrument and mission profile and García et al. provides an overview of the HEX-P science. In brief, HEX-P entails two coaligned telescopes: the Low Energy Telescope (LET) which covers 0.2–20 keV with an angular resolution of $<5''$ (half-power diameter, or HPD), and the High Energy Telescope (HET) which covers 3–80 keV with an angular resolution of $<20''$ (at 20 keV, HPD).

APEX missions are intended primarily as community observatories. No data exclusive-use periods are allowed and at least 70% of the baseline 5-year mission must be allocated through competed GO opportunities. The remaining time is directed by the science team. For HEX-P, the latter science centers on three primary topics: supermassive black holes (SMBHs), resolved high-energy galactic populations, and time domain and multi-messenger (TDAMM) astrophysics. The PI-led science motivated the instrument and mission design, though providing a powerful, flexible GO capability to serve the broad astrophysics community was always at the core of the HEX-P design. Indeed, this was identified as a Major Strength by the NASA review which highlighted the ability of HEX-P to provide "*…a substantial program of GO observations that has a strong potential to produce significant scientific advances.*"

The independent peer review evaluated HEX-P as selectable, noting the mission's "*…significant science merit and science implementation strength, coupled with a modest level*

FIGURE 1
Cover of the submitted HEX-P proposal. [Image credit: JPL-Caltech/Shan Jiang (The Jacky Winter Group).].

of technical, management, and cost risk." However, HEX-P ultimately was not selected to proceed to a Phase A study. This is clearly not the end of broadband X-ray astrophysics, and the HEX-P team hopes that this Research Topic will serve as an inspiration for future projects that take on the mantel of addressing this science that is only accessible with an X-ray mission covering a wide bandpass.

Below, we briefly outline key science enabled by HEX-P, as described in greater detail in this Research Topic. These contributions were led co-investigators and collaborators on the HEX-P team, as well as the broader high-energy community.

Supermassive black hole growth and galaxy evolution

HEX-P will be a powerful facility for investigating how SMBHs grow and drive galaxy evolution, highlighted as a key question by Astro2020 Decadal Survey. Models and observations point to most black hole growth occurring in obscured sources, hidden at optical and low-energy X-rays by thick columns of absorbing material. High-energy (>10 keV) photons can penetrate this material, enabling HEX-P to study the full population of sources responsible for SMBH growth. Civano et al. simulates deep, pencil-beam surveys with HEX-P and shows how they will finally directly identify the sources responsible for the peak of the cosmic X-ray radiation, discovered more than 50 years ago. Boorman et al. discusses how HEX-P studies of nearby, heavily obscured accreting SMBHs will reveal the inner structure around the central engine, while Pfeifle et al. shows how HEX-P will be an unprecedented facility for the study of SMBH mergers, which preferentially occur in obscured systems and are therefore best studied by broadband X-ray facilities, sensitive above 10 keV.

Broadband X-ray spectroscopy also accesses spectral features that only appear above 10 keV. Kammoun et al. discusses how HEX-P will reveal the X-ray corona, the hot, shining plasma that exists just beyond the event horizon and produces most of the X-rays in the Universe. Measuring the temperature of the corona requires high-energy observations and is a key diagnostic of the poorly understood coronal physics. Observing samples of luminous and variable SMBHs, HEX-P will test theories of the corona and shed light on this foundational enigma of X-ray astrophysics. Broadband X-ray observations also constrain the spin of black holes by measuring relativistic broadening of the Fe K (~6.5 keV) and Compton hump (~30 keV) features. Piotrowska et al. show how a dedicated survey to measure SMBH spins of several dozen local, bright active galaxies over a range of black hole mass will reveal whether SMBHs grow primarily from accretion or mergers.

Resolved binary populations

With unrivaled angular resolution above 10 keV, HEX-P will investigate how binary systems live and die, highlighted as a key question by Astro2020. Mori et al. discusses the range of science enabled by HEX-P surveys of the Galactic Center and Galactic bulge, ranging from measuring the masses of white dwarfs to monitoring flares from Sgr A*, the four million solar mass SMBH at the center of the Milky Way. Lehmer et al. focuses on resolved binary populations in nearby galaxies. Crucially, while soft (<10 keV) X-ray observatories such as Chandra regularly identify off-nuclear sources in other galaxies, without access to higher energy X-rays, it remains unclear if these sources are stellar mass black holes or neutron stars. In addition, X-ray binaries are one of the best laboratories to study the accretion process and probe strong gravity. Connors et al. describes how HEX-P will study evolving accretion flows and coronae of binary compact object systems in the Milky Way and Local Group.

Time-domain and multi-messenger astrophysics

HEX-P will investigate what powers the diversity of extreme time domain and multi-messenger events, also identified as a Priority Area by Astro2020. Mori et al. describes how HEX-P will reveal the nature of the most extreme accelerators in our Galaxy by measuring high-energy (>40 keV) X-ray emission from Galactic gamma-ray sources. Brightman et al. surveys how HEX-P will explore the dynamic universe across the X-ray band, studying phenomena ranging from tidal disruption events to stellar explosions to electromagnetic radiation from gravitational wave merger events. Finally, Marcotulli et al. discusses how HEX-P will inform our understanding of the powerful, relativistic jets that are often associated with accreting SMBHs and are strong emitters from X-ray to gamma-ray energies. Notably, many of these phenomena, such as jets, mergers, and tidal disruptions, are also important multi-messenger events that produce cosmic rays, neutrinos, and/or gravitational waves.

HEX-P capabilities

The science described above requires sensitive broadband X-ray observations covering the full X-ray range and motivated the design of the HEX-P mission. Madsen et al. details the HEX-P instrument and mission design. In brief, operating at L2 with a 20-m focal length and designed to achieve a low background, HEX-P reaches fainter fluxes in a fixed clock time than all current X-ray satellites. The LET reaches at least 2–10 times fainter fluxes below 10 keV in 1 M than the current flagship soft X-ray facilities, XMM-Newton and Chandra. The HET reaches ≥7 times fainter fluxes above 10 keV in 1 M than NuSTAR, the most sensitive hard X-ray telescope. The fields of view of the HEX-P instruments are $11.3' \times 11.3'$ for the LET and $13.7' \times 13.7'$ for the HET. HEX-P achieves an average response time of 12.3 h to target-of-opportunity observations, with a guaranteed response time of <24 hr.

Additional science

With the ability to obtain imaging, spectroscopic, and timing data for both bright and faint targets across the entire X-ray band, HEX-P will enable extensive science to excite a large, active GO community. Contributions to this Research Topic delve into just some of this potential, including HEX-P's contributions to studying neutron stars (Ludlam et al.), magnetars (Alford et al.), ultraluminous X-ray sources (Bachetti et al.), supernova remnants and pulsar wind nebulae (Reynolds et al.).

In summary, HEX-P is a powerful mission that will provide the most sensitive X-ray observations at both low and high energies. The program defined by the science team provides a legacy that directly addresses multiple key questions identified by the Astro2020 Decadal Survey, while the broad capabilities of the mission enable a diverse suite of science, from studying how stellar activity affects planet formation to finally understanding the physics and demographics of the accreting black holes that are responsible for most of the X-rays generated across cosmic time.

Author contributions

DS: Writing – original draft, Writing – review and editing. KM: Writing – original draft, Writing – review and editing. JG: Writing – original draft, Writing – review and editing.

Funding

The author(s) declare that no financial support was received for the research and/or publication of this article.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The authors declare that no Generative AI was used in the creation of this manuscript.