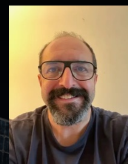
The High Energy X-Ray Probe (HEX-P)

Mission Overview



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Overview:

HEX-P is a probe-class mission concept that will combine high spatial resolution X-ray imaging (<10 arcsec FWHM) and broad spectral coverage (0.1-150 keV) with an effective area far superior to current facilities (including XMM-Newton and NuSTAR), to enable revolutionary new insights into a variety of important astrophysical problems. We will present simulations of HEX-P observations of ultraluminous X-ray sources (ULX) in nearby galaxies, showing how HEX-P will (1) study in detail populations of ULXs in a fraction of the time required by NuSTAR, pushing by a factor ~25 the high-energy sensitivity. (2) characterize their hard-energy spectrum, with much higher sensitivity than NuSTAR, looking for high-energy cyclotron resonance features; and (3) perform detailed timing studies of these sources thanks to the very low background and the enhanced response in the energy ranges where pulsations are stronger. More information on HEX-P, including the full team list, is available at https://hexp.org.

HEX-P is designed around four science pillars: (1) obtaining a complete census of black hole growth, (2) understanding the extreme physics of accreting objects, (3) resolving compact object populations in the local universe, and (4) exploring the dynamic universe. While the HEX-P Science Team will lead key observations designed around these primary goals, the vast majority of the 5+ year HEX-P mission will be available to the community through a competed Guest Observer program. The pillars have been designed to provide a "workhorse" instrument capability that will enable a broad range of science for the 2030s and beyond.

The Complete Census of Black Hole

With unprecedented sensitivity at the 20-30 keV, HEX-P will measure the full history of black hole growth by determining the demographics and properties of the accreting supermassive black holes responsible for the peak of the cosmic X-ray background. Approximately half of black hole growth is obscured by thick columns of gas and dust which absorb the UV, optical, and low-energy (<10 keV) photons. Observing more penetrating, higher energy X-ray photons, HEX-P is able to find and study both unobscured and obscured populations, including the most heavily obscured, or Compton-thick ($N_H > 10^{24}$ cm^{-2}) active galactic nuclei (AGN). While NuSTAR was only able to obtain sensitive (i.e., SNR>50) observations of a few (<5) nearby Compton-thick AGN, HEX-P will be provide similar sensitivity to dozens of sources, thereby probing key properties of the obscuring material, including its opening angle, clumpiness, and inclination angle.

Do you have ideas for how HEX-P would revolutionize your science? Get in touch!

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The Extreme Physics of Accreting Objects

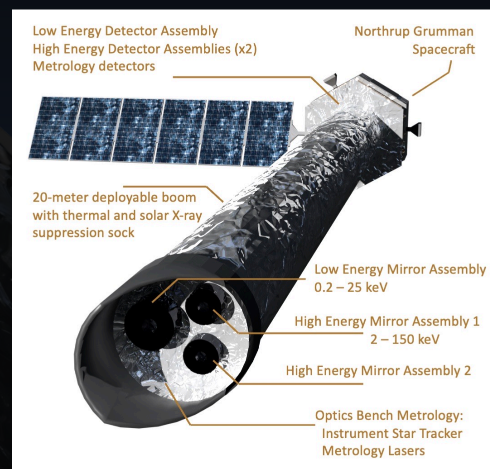
The broadband sensitivity of HEX-P enables unique and powerful diagnostics for understanding the extreme physics of accreting objects. With unprecedented sensitivity to FeK (~6.5 keV), its surrounding continuum, and the Compton hump (~25 keV), HEX-P provides more robust measurements of accretion disk inner radii and compact object spins. With a systematic survey of nearby AGN, HEX-P will distinguish between hypotheses regarding the primary accretion mode of supermassive black holes (e.g., major vs. minor mergers). The high-energy (>40 keV) sensitivity of HEX-P will also distinguish models of the X-ray corona, the high temperature plasma near compact objects which drives the high-energy emission and yet is so poorly understood. HEX-P will provide robust temperature measurements for dozens of high-energy sources, probing the physics, geometry, and dynamics of the corona, and determining if multi-component (i.e., hybrid) coronae are required. In addition, through measurement of cyclotron resonant scattering features (CRSFs) and FeK emission in ultraluminous X-ray sources (ULXs), HEX-P will determine the role of magnetic fields in these extreme sources, which can reach Eddington ratios of several hundred. The broadband sensitivity of HEX-P, which also has photon-counting timing capabilities, will provide a workhorse facility for high-energy observations in the 2030s (and beyond), enabling unique and powerful studies that are inaccessible to low-energy facilities and are not possible with current or approved missions.

Resolved Populations in the Local Universe

With 6-10x improved angular resolution relative to NuSTAR, HEX-P will provide unprecedented capabilities for studying resolved populations in the local universe. Importantly, measuring X-ray colors over the 0.5-30 keV range enables systematic separation of compact object types (i.e., neutron stars vs. black holes), which is not possible with soft X-ray (<10 keV) observations alone. HEX-P will survey the Galactic Center, studying flaring activity by Sgr A*, probing the past accretion history of Sgr A* through reflection nebulae, and uncovering the compact object populations in the innermost regions of the Galaxy. HEX-P will also study compact object populations in nearby galaxies. With this census of the end points of stellar evolution, particularly binary star evolution, HEX-P will provide key diagnostics for understanding the source populations for gravitational wave merger events.

The Dynamic Universe

Finally, the broadband sensitivity of HEX-P and its designed capability to rapidly respond with target-of-opportunity observations will provide a unique and important facility for time-domain and multi-messenger astrophysics, studying the dynamic universe. Key planned programs include constraining models of gravitational wave merger events, studying tidal disruption events, and exploring the physics and environments of supernova explosions.



The conservative, non-cryogenic HEX-P design emphasizes flight-proven technologies. All new technologies are not aggressive and have funded development plans to reach TRL 6 within 2 years.

HEX-P
HIGH ENERGY X-RAY PROBE

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