STROBE-X: X-ray Timing & Spectroscopy on Dynamical Timescales from Microseconds to Years

Paul S. Ray (NRL), Colleen A. Wilson-Hodge (NASA/MSFC), K. Gendreau (NASA/GSFC), D. Chakrabarty (MIT), M. Feroci (INAF-IASF/INFN), S. Brandt (DTU), T. Maccarone (TTU), M. Hernanz, S. Zane (UCL), Z. Arzoumanian (GSFC), R. Remillard (MIT), K. Wood (Praxis/NRL), C. Griffith (NRC/NRL), P. Jenke (UAH) on behalf of the 60+ member STROBE-X collaboration
Why a Flexible, High-Throughput Observatory?

• The high-energy sky is highly dynamic – requires catching the right source at the right time
  – Necessitates both wide field monitoring and the ability to repoint quickly (as RXTE and Swift have demonstrated)

• Large areas with low dead time access the shortest timescales

• Both soft and hard X-ray bands are needed to accurately measure the continuum spectral shape, constrain absorption, and understand the relationship between thermal and non-thermal components
Programmatic Context

• RXTE combined a scanning sky monitor with large area hard X-ray timing, but it ended in 2012
• Swift provides hard X-ray monitoring and a versatile, but small, X-ray telescope with limited timing capabilities
• XMM-Newton’s EPIC-pn provides soft X-ray timing but very constrained scheduling
• NICER will break new ground in soft X-ray timing with extremely high precision and 2x EPIC-pn area

But what will come next?
Technical Context from LOFT and NICER

• Solid state detectors like Silicon Drift Detectors can provide high time resolution with low dead time and CCD-like spectroscopy

• Thin, light micropore collimators a much lower mass and volume than traditional X-ray collimators, enabling large missions and modest cost

• Lightweight, inexpensive foil optics can provide large collecting area with low background at low cost
Spectroscopic Time-Resolving Observatory for Broadband Energy X-rays (STROBE-X)

- **X-ray Concentrator Array (0.2-12 keV)**
- **Large Area Detector (2-30 keV)**
- **Wide Field Monitor (2-50 keV)**

Large effective area ~10m$^2$ @ 6 keV

STROBE-X combines the strengths of NICER and LOFT: High throughput X-ray timing with good spectroscopy

Proposed to NASA’s 2016 Call for Astrophysics Probe Mission Concept Studies  PI P. Ray (NRL)
X-ray Concentrator Array

• Low background, high throughput
• Enables high time resolution observations of the faintest sources, both extragalactic and galactic
• Sensitive timing and spectroscopy to thermal emission and iron lines
• Scaled up version of NICER concentrators with NICER SDDs
  – Focal length of 3 m and 2’ focal spots for enhanced throughput >2.5 keV
  – Inexpensive Foil optics: large areas w/ low background
  – Energy resolution: 85-175 eV FWHM
  – Effective area @ 1.5 keV: 3.4 m²
Large Area Detector

- High time resolution and CCD quality energy resolution over the 2-30 keV range
  - Best sensitivity to QPOs; most prominent in harder X-rays
  - Sensitive to non-thermal emission and Compton hump
- SDDs and lightweight microcapillary plate collimators developed for ESA’s LOFT M3 & M4.
  - Energy resolution: 200-240 eV FWHM (CCD quality)
  - Effective Area @ 10 keV 7.6 m²
Wide Field Monitor

- Wide-field coded-mask imager
- Instantaneous FoV: >1/3 of sky; 50% of sky accessible to LAD
- Sensitive to transients from milliseconds to years
- LOFT SDDs and mask
- Energy resolution: 300 eV FWHM
- Identifies new transients and source states for main instruments, while monitoring long-term source behavior for a large fraction of the sky.
STROBE-X Key Science Goals

• Probing stationary spacetimes near black holes (BHs) to explore the effects of strong-field general relativity and measure the masses and spins of BHs.
  – Access spins via continuum fitting, reflection spectra, and HFQPOs

• X-ray reverberation mapping of the geometry of BH accretion flows across all mass scales, from stellar-mass BHs in our Galaxy to supermassive BHs in active galactic nuclei.
  – Observe changes on short timescales and across spectral states

• Fully determining the ultradense matter equation of state by measuring the neutron star mass-radius relation using >20 pulsars over an extended mass range.

• Exploring cosmic chemical evolution by measuring bulk metallicity for ~100 high-redshift (z>2) galaxy clusters

• Continuously surveying the dynamic X-ray sky with large duty cycle and high spectral and time resolution to characterize source behavior over a vast range of time scales, and to enable multi-wavelength and multi-messenger studies through cross-correlation with high cadence surveys at other wavelengths and in gravitational waves and neutrinos.
Summary

- STROBE-X is a probe class (<$1B) observatory concept designed for X-ray timing and spectroscopy in the 0.2-30 keV band
- STROBE-X has huge collecting area, fast timing, and good spectral resolution
  - Specific configuration to be worked out during design study over the next year
- STROBE-X is based on existing technology and builds on experience with NICER and LOFT.
- STROBE-X will serve a large community in a decade of time-domain astronomy with complementary capabilities to the large high spectral and spatial resolution missions