**EXIST: Surveying the birth and evolution of Black Holes**

The Hard X-ray Polarization Sensitivity of EXIST

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**What is EXIST?**

- EXIST (J13) is a proposed Medium Class infrared/X-ray observatory to conduct the most sensitive full sky surveys for black holes on all scales (stellar to supermassive).
- A leading candidate to be the Black Hole Finder Probe (BHFP) as one of the 3 Einstein Probe missions (3) (launch hopefully in 2027, next after the Joint Dark Energy Mission).
- A mission currently under study for the Advanced Mission Concept Study (AMCS) program, in preparation for review by the next Astronomy/Astrophysics Decadal Survey.

**EXIST Components:**

- The High Energy Telescope (HET) operates in the hard X-ray band (5 keV to 600 keV) and has a 2.0–2.6 m field of view.
- The Infrared Telescope (IRT) has a 1.1 m primary mirror and operates in the wavelength band, and has imaging, low-resolution (~10) and high-resolution (~1000) spectrometry capabilities.
- The soft X-ray imager (SXI) is an optional pointed X-ray telescope that operates from 0.5 to 2 keV and has a 3.5 m field of view.

**Hard X-ray Polarization – Scientific Motivation I**

- The EXIST High Energy Telescope uses finely pixilated Cadmium Zinc Telluride (CZT) detectors and has inherent polarimetry capabilities in the energy range from 60 keV to 250 keV.
- Observations of Binary Black Holes: Diving to all-sky coverage, EXIST will observe sources in different emission states without losing major flaring events. EXIST’s large energy bandpass from 5 keV to 600 keV and excellent timing capabilities are ideally suited to constrain the emission states and to track the evolution of the emission components.
- At ~100 keV energies, the EXIST hard X-ray polarimetry observations will shed light on the origin of the non-thermal emission, and they will make it possible to test hypotheses about the origin of the hard X-ray emission as emission from the jet and/or from a disk corona.
- Observations of Neutron Stars, Young Pulstars, and Magnetars: The emission mechanism and the propagation of the X-rays through the highly magnetized plasma surrounding neutron stars might lead to polarization degrees of several % (4-5). At high energies, photon-splintering (a higher order QED effect) is expected to produce strong polarization leading up to a high-energy cut-off in high-magnetic-field pulars and magnetars (5-7). This effect cannot be observed in terrestrial laboratories and would provide a test of QED in extreme conditions.

**Polarization Measurements with EXIST**

- Photon scatter preferably perpendicular to the photons’ electric field vector.
- The distribution of Compton scattering angles can be used to measure the X-ray polarization.
- The EXIST Polarimetry measurements use ≥2 pixel events; for each event, the azimuthal angle is determined from the position of the two pixels with the maximum signal.

**Energy Range for Polarization Measurements**

- The requirement of a substantial fraction of Compton interactions and photon mean free paths comparable to the pixel pitch result in a low-energy threshold of ~60 keV.

**Systematic Uncertainties & References**

- HET properties leading to relatively small systematic uncertainties.
- Large number of independent detector elements (1.2 million pixels) with a small distance between adjacent pixels (60 microns) compared to the size of the instrument.
- If there are large scale background non-uniformities, they will have little impact on the polarization measurement, as the latter use only pixels that are closer to each other. Gain variations of pixels or individual CZT detectors can be determined and corrected for with high precision making use of the background data acquired during the mission.

**References:**