

Terms of Reference: Hi-ReX SAG for an Ultra-High Angular Resolution X-ray Observatory

Recent advances in X-ray optics, precision formation flying, and high-resolution detectors have made it feasible to pursue milli- to micro-arcsecond (mas to μ as) imaging in the X-ray band. Such capability would exceed Chandra's angular resolution by more than two orders of magnitude and could enable transformative discoveries across a broad spectrum of high-energy astrophysics.

The High angular Resolution X-ray (Hi-ReX) imager Science Analysis Group (SAG) will assess the scientific potential of a future flagship-class or probe-class mission with mas to μ as imaging resolution, identifying key science drivers, performance requirements, and initial technical considerations, while remaining focused on science. This effort will build on previous and current conceptual studies and recent progress in optics and lens designs.

This SAG will address the scientific opportunities enabled by ultra-high angular resolution X-ray imaging across broad scientific categories such as:

1. **Exoplanet Habitability and Exoplanet Host Stars**
 - a. Imaging of stellar coronae and flares on scale unresolved by current X-ray observatories.
 - b. Characterization of exoplanet host stars to enable direct comparisons to resolved studies of the solar corona, thereby linking Solar System studies to extrasolar contexts.
2. **Star Formation and Evolution**
 - a. Mapping proto-stellar disks and the interaction of binary stellar systems on scales unresolved by current X-ray observatories.
3. **Galactic Astrophysics**
 - a. Mapping the structure of pulsar wind nebulae, accretion flows, and relativistic outflows.
 - b. High-resolution studies of shock fronts and interaction regions in supernova remnants and binaries.
4. **Extragalactic and Black Hole Physics**
 - a. Imaging the immediate surroundings of supermassive black holes, including coronae and jet-launching regions. These efforts will complement the recent advancements by the Event Horizon Telescope Collaboration.
 - b. Resolving microlensing speckle patterns in lensed quasars to probe dark matter substructure.
5. **Fundamental Physics and Cosmology**
 - a. Testing General Relativity near event horizons via direct imaging and reverberation mapping.

To support this effort, the SAG will also evaluate the high-level impact of various technical capabilities, including:

- Angular resolution benchmarks (e.g., 1 mas, 100 μ as, 10 μ as)

- Formation flying architectures and baselines
- Energy range, throughput, and field of view requirements
- Feasibility of diffractive, reflective, or hybrid optics architectures
- Feasibility of image reconstruction from sparsely filled apertures

The SAG will be chaired by Kim Weaver, Herman Marshall, Mark Schattenburg, and Breanna Binder with working group leads selected by the SIG chairs. Membership, including volunteers from the PhysPAG and broader astrophysics and technology communities, will be open.

The SAG will organize its work into scientific thematic working groups (WGs) corresponding to the five science categories above. The WGs will be tasked with identifying technical capabilities (including but not limited to energy bandpass, imaging resolution, field of view, throughput, effective area, etc.) required to achieve significant progress in the “state of the art” scientific understanding of each thematic area. Each WG will be responsible for gathering community input through email solicitations, teleconferences, and meetings at venues such as the HEAD and AAS meetings.

The SAG will hold regular virtual meetings and coordinate across WGs. The final deliverable will be a community-vetted report to NASA HQ in June 2026 detailing the science case, technical drivers, and recommendations for future studies of an ultra-high angular resolution X-ray mission.