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Next Generation X-ray Optics: High-resolution, Light-weight, and Low-cost

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X-ray telescopes are essential to the future of x-ray astronomy. This paper describes a comprehensive program to advance the technology for x-ray telescopes well beyond the state of the art represented by the three currently operating missions: Chandra , XMM-Newton , and Suzaku . This program will address the three key issues in making an x-ray telescope: (1) angular resolution , (2) effective area per unit mass, and (3) cost per unit effective area. The objectives of this technology program are (1) in the near term, to enable Explorer-class x-ray missions and an IXO type mission, and (2) in the long term, to enable a flagship x-ray mission with sub-arcsecond angular resolution and multi-square-meter effective area, at an affordable cost. We pursue two approaches concurrently, emphasizing the first approach in the near term (2–5 years) and the second in the long term (4–10 years).

The first approach is precision slumping of borosilicate glass sheets. By design and choice at the outset, this technique makes lightweight and low-cost mirrors. The development program will continue to improve angular resolution, to enable the production of 5-arcsecond x-ray telescopes, to support Explorer-class missions and one or more missions to supersede the original IXO mission.

The second approach is precision polishing and light-weighting of single-crystal silicon mirrors . This approach benefits from two recent commercial developments: (1) the inexpensive and abundant availability of large blocks of monocrystalline silicon, and (2) revolutionary advances in deterministic, precision polishing of mirrors. By design and choice at the outset, this technique is capable of producing lightweight mirrors with sub-arcsecond angular resolution. The development program will increase the efficiency and reduce the cost of the polishing and the lightweighting processes, to enable the production of lightweight sub-arcsecond x-ray telescopes.

Concurrent with the fabrication of lightweight mirror segments is the continued development and perfection of alignment and integration techniques, for incorporating individual mirror segments into a precision mirror assembly. Recently, we have been developing a technique called edge-bonding , which has achieved an accuracy to enable 10- arcsecond x-ray telescopes. Currently, we are investigating and improving the long-term alignment stability of so-bonded mirrors. Next, we shall refine this process to enable 5-arsecond x-ray telescopes. This technology development program includes all elements to demonstrate progress toward TRL-6: metrology; x-ray performance tests; coupled structural, thermal, and optical performance analysis, and environmental testing.