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An X-ray beamsplitter/combiner for astronomical imaging interferometry

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Abstract

Unlike optical, infrared, and radio wavelengths, astronomical interferometry in the x-ray band is in its infancy. A few concepts have been proposed, but no functional observatories have been funded. In the early 2000's, Cash et al. demonstrated x-ray interference fringes using a simple "X" configuration of grazing-incidence collecting and combining mirrors. Soon after, Willingale presented a modified, somewhat asymmetric design that overlaps the combined light paths using an optic with periodic slots cut or etched through the final mirror. This allows one arm of the interferometer to transmit through the "slatted" mirror while the polished surface of the slatted mirror reflects the other arm. This concept significantly reduced the very long focal length required for an interferometer with a useful baseline, but that long focal length still limits the volume to be used for a larger interferometric baseline. We present a new concept for a single combiner optic that uses an ultra-thin substrate with a deposited thin film tuned in thickness such that the substrate/thin-film combination acts as a grazing-incidence pellicle beamsplitter for x-rays. Replacing the two combiner mirrors in previous designs with this beamsplitter has many advantages including simplification of the optical train, performance over a wide range of x-ray energies using a single combiner optic, elimination of the long focal lengths inherent in previous designs, and an ability to vary the field-of-view of the instrument by adjusting the combiner mirror's modulation angle. We present an instrument design that theoretically achieves 73 micro-arcsecond resolution at 1 nm wavelength with viable effective area from 1 to 7 keV in a 2.2-meter diameter by 9-meter-long end-to-end volume.