

We are developing soft X-ray polarimetry. Our new designs can enable polarimetry below 0.8 keV to be an integral part of future X-ray astronomy missions, ranging from small explorers to larger observatory class facilities that may be built within the next 30 years.

We espouse the use of multilayer (ML) coated mirrors as Bragg reflectors when used at the Brewster angle [2, 5]. Because multilayer coatings are highly chromatic reflectors we developed a design that couples a dispersive grating-based spectrometer with ML coated mirrors where the layer spacing varies along the dispersion line, matching the dispersed energy to the Bragg peak positionally [3, 4]. The resultant instrument has an achievable bandpass extending from 0.8 keV to below 0.1 keV.

There are three essential elements of the design: 1) grazing incidence mirrors to focus X-rays in the 0.1-1.0 keV band, 2) high efficiency gratings to disperse X-rays, 3) a set of laterally graded ML coated mirrors, and 4) soft X-ray imagers as readouts. Of these elements, only the laterally graded ML mirrors have not yet been flown successfully.

Multilayer coatings consist of thin layers of contrasting materials - usually one with a high index of refraction and the other with a low value. The input wave is divided at each layer into transmitted and reflected components. When many layers are placed on a surface, then the reflected components may constructively interfere, enhancing the overall reflectivity of the optic. The Bragg condition will be satisfied at $\lambda = \alpha x$, where x is the distance (from 0th order) to which the gratings disperse wavelength λ , and α is the gradient of the Bragg peak wavelength specified by the mirror coating. When used at 45° to the incident beam, the reflectivity of p-polarization is reduced by orders of magnitude, so that nearly 100% of the exiting beam. The layers would coat flat mirrors smoother than $1\text{\AA}$ rms in order to obtain peak reflectivities of order 20%. Subdividing the aperture of the entrance mirror and dispersing the subapertures in at least 3 different directions then provides intensity variation with position angle in order to compute three Stokes parameters (I , Q , and U) as a function of λ .

The laterally graded ML mirrors and high efficiency gratings are the critical components of the system and require continued development. A few multilayer coatings have been constructed for ground-based use (and for testing in our polarimetry lab) but have not been flown on a NASA mission and have not been optimized to improve reflectivity. Furthermore, it is important to test the fabrication linearity in laboratory tests. Blazed gratings with high efficiencies into first order would be ideal for our use and are still under development for a future high resolution X-ray spectrometer [1].

References

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