Smart X-ray Optics for the next generation of X-ray telescopes

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The Smart X-ray Optics (SXO) project is a UK based consortium consisting of seven UK institutions investigating the application of active/adaptive optics to traditional grazing incidence X-ray optics. Research is being undertaken both on large and small scales, with intended applications for the next generation of X-ray telescopes and medical research respectively.

The current state of X-ray telescope technology is being driven by the need for large collecting area/high sensitivity across the full X-ray spectrum, for example, IXO (a combined ESA and NASA mission previously called XEUS and Constellation-X respectively), Simbol-X and NeXT. However looking beyond the next decade of X-ray telescope development, proposals have been made for an X-ray telescope capable of high sensitivity coupled with high angular resolution, NASA's Generation-X mission. It is envisioned that Generation-X would be able to achieve an angular resolution of 0.1 arc-seconds by using an active/adaptive piezoelectric actuator system, achieving a factor of five improvement on the Chandra X-ray Observatory [1].

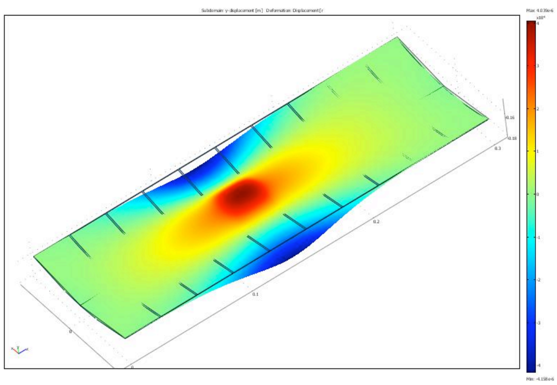
With Generation-X in mind, the SXO project is developing a large scale active X-ray prototype capable of being tested in the X-ray beam facility at the University of Leicester. The active optic is a nickel ellipsoidal shell (optic dimensions 300mm x 100mm, with a thickness of 0.4mm), the back of which will be populated by a grid of 30 curved piezoelectric actuators (actuator dimensions 29mm x 32mm x 0.2mm).

The prototype optic has been produced at University College London, using a nickel sulphamate electroforming procedure; the actuators are manufactured at the University of Birmingham and are then bonded on the reverse of the nickel shell using a low shrinkage adhesive. The actuators are controlled using a 32 channel voltage output drive, connected in series to a high voltage amplifier, providing a possible voltage range of -200V to 200V.

Deformations of the thin optical shell are expected due to the effect of gravity and handling/mounting stresses. The control algorithms that will ultimately determine the form of the optic, includes deformations due to gravity and the actuator influence functions calculated using finite element analysis (FEA). These algorithms will accurately predict the voltages required for each actuator to precisely correct the optic's form.

The piezoelectric actuators will be controlled by an iterative algorithm based on the detected full width half maximum (FWHM) or half energy width (HEW). With each iteration it is hoped that the FWHM will be reduced and the angular resolution of the optic will be improved. A series of basis patterns, created using a fast Fourier transform method, will be used and implemented by the piezo actuators in the algorithm.

Research will be presented on the continuing efforts to produce the SXO's first active X-ray focusing prototype. This will encompass: software development for the actuator control, manufacturing of the shells and theoretical computer simulations of the proposed prototype.



An FEA simulation of a central actuator at 10V, the displacement range is from -2.7 microns (blue at the wings) to 2 microns (red in the centre).

REFERENCES

[1] R. A. Windhorst et al, *New Astronomy Reviews*, 50 (2006) 121 – 126

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