Conference 9510: EUV and X-ray Optics: Synergy between Laboratory and Space

Among the methods to focus photons the crystal diffraction results as one of the most effective for high energy photons. An assembling of properly oriented crystals can form a lens able to focus x-rays at high energy via Laue diffraction in transmission geometry; this is a Laue lens.

Several approaches are considered to maximize the diffracted intensity; for instance crystals with high atomic number (such as Au, Ag, Cu) have been proposed. However according to x-ray diffraction theory, the maximum diffraction efficiency is achieved in ideal mosaic crystals, that are ideally imperfect crystals made of small misoriented domains. Unfortunately real mosaic crystals are not ideal ones, due to the uncontrolled size of crystalline tiles which form the crystal itself. This technological difficulty in controlling the mosaicity of the crystals leads to a diffraction efficiency several times lower than the ideal case.

An alternative and convenient approach is the use of curved crystals. We have recently optimized a method based on the surface damage of crystals to produce self-standing uniformly curved Si, GaAs, and Ge tiles of thickness up to 2-3 mm and curvature radius R up to a few meters.

We show that perfect crystals with permanent curved diffracting planes (obtained with our surface damage method) have a diffraction efficiency two orders of magnitude higher than perfect similar flat crystals, thus very close to that of ideal mosaic crystals.

Moreover, in a configuration with diffracting planes perpendicular to the curved crystal surface, a significant focussing effect is demonstrated.

These results were obtained for several energies between 17 and 210 keV with lab sources and at high energy facilities such as LARIX at Ferrara (Italy), ESRF at Grenoble (France), and ANKA at Karlsruhe (Germany).

This makes self-standing curved crystals excellent candidates as optical elements to form efficient lenses for gamma ray focussing at energies of several hundreds keV.

9510-7, Session 2

ISS-Lobster: a low-cost wide-field X-ray transient detector on the ISS

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This talk presents ISS-Lobster, a wide-field X-ray transient detector proposed to be deployed on the International Space Station. Through its unique imaging X-ray optics (known as Lobster optics) that allow a 30 deg by 30 deg FoV, a 1 arc min position resolution and a 10-11 erg/(sec cm²) sensitivity in 2000 sec, ISS-Lobster will observe numerous events per year of X-ray transients related to compact objects, including: tidal disruptions of stars, supernova shock breakouts, neutron star bursts and superbursts, high redshift Gamma-Ray Bursts, and perhaps most exciting, X-ray counterparts of gravitational wave detections involving stellar mass and possibly supermassive black holes. The mission includes a 3-axis gimbal system that allows fast Target of Opportunity pointing, and a small gamma-ray burst monitor.

9510-8, Session 2

Polarizers for a spectral range centered at 121.6 nm operating by reflectance or by transmittance

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Polarimetry is a powerful tool to interpret how the coronal plasma is involved in the energy transfer processes from the Sun's inner parts to the outer space. Space polarimetry in the far ultraviolet (FUV) provides essential information of processes governed by the Doppler and Hanle resonant electron scattering effects. Among the key FUV spectral lines to observe these processes, H I Lyman alpha (121.6 nm) is the strongest one. Some developing or proposed solar physics missions, such as CLASP, SolmeX, and COMPASS, plan to perform polarimetry at 121.6 nm. Hence there is an interest to develop efficient linear polarizers at this wavelength. Classical solutions, such as a parallel plate of a transparent material, either MgF₂ or LiF, result in a modest efficiency of the passing polarization component. A significant efficiency increase can be obtained with the use of coatings.

A research has been conducted to develop polarizers based on (Al/MgF₂)_n multilayer coatings in a band containing 121.6 nm. Coatings operating by reflectance result in a high efficiency after approximately one year of storage under nitrogen. Coatings following various designs with good polarizing performance in a 7-to-8-nm wide FUV range were prepared. In parallel, coating polarizers operating by transmittance have been prepared for the first time. Transmissive polarizers have the advantage that they involve no deviation of the beam. As a further benefit, the developed transmittance polarizers additionally incorporate filtering properties to help reject wavelengths both shortwards and longwards of a band containing 121.6 nm. These filtering properties, properly enhanced, could enable a polarimeter for solar physics with an improved global figure of merit if they make unnecessary the use of a filter to isolate the H I Lyman alpha line.

9510-9, Session 2

Transverse X-ray scattering on random rough surfaces

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The study of wave scattering from random rough surfaces has been a subject of investigation in physics and engineering for a very long time. The modeling of X-ray scattering at grazing incident angles is difficult because of the short wavelength (compared to the scale of the surface roughness) and the small angle between the wave propagating direction and the surface. Most traditional approaches make the approximation that the scattering angle is much smaller than the incident grazing angle. This approximation is not practical for many of the applications involving X-ray mirrors.

In year 2002, we presented a SPIE paper entitled "A new method to model X-ray scattering from random rough surfaces" (SPIE Proceedings Vol. 4851, 124). This new method uses a novel approach to solve this century old problem. It provides the exact solution to scattering angles of any size, not limited to small scattering angles.

However, the above paper only gives the solution for scatterings in the plane of incidence. For actual two dimensional random rough surfaces, the outgoing rays can also be scattered out of the incident plane, i.e. the transverse scattering. Traditionally, the transverse scattering was approximated by multiplying the in-plane scattering by a factor of $\sin \alpha$, where α is the incident grazing angle.

This treatment is adequate with the traditional method of small angle approximation. With our new method, which is not limited to the small angle, this treatment is no longer valid.

This paper presents a new solution to the transverse scattering. It uses the same approach as we presented in our 2002 paper, but consider the scattering in the direction perpendicular to the incident plane.

For a given Power Spectral Densities (PSD), a model surface is constructed by assigning a random phase to each spectral component. The incident wave is reflected from the model rough surface and then projected to an outgoing wavefront. The outgoing wave then is redistributed onto an even grid in the transverse direction, with corrections for the wave densities and the phase shifts. Fast Fourier transforms are then performed to calculate the transverse scattering. The process is repeated with different model surfaces which are generated using different sets of random phases. This method provides the exact solution to transverse scattering angles of any size. This solution is generally applicable to any transverse wave scatterings on random rough