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Performance of an Imaging Polarimeter with a Transmission Multi Layer

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Introduction

A polarization of X-rays from celestial object will give us new information. However, the observation of the polarization is not well performed. The main reason might be a technical difficulty for a high sensitivity. So far only one object, Crab Nebula, had been detected a significant polarization. Since we do not know an actual polarization degree of the celestial object except for Crab Nebula, the satellite mission for the polarization measurement has a high risk to get a scientific yield.

Recently some kinds of technologies as a polarimeter were developed and achieved relatively high sensitivity. Each of them has its merit and demerit. In this work, we propose an imaging polarimeter with a transmission multi-layer and a CCD. It is well known that a reflectivity and a transmission of the multi layers have different values for the different polarization if we use it as an incident angle of 45 deg. We use the multi layers tilted with 45 degree as a filter. Thus we can image celestial objects by X-rays with a selected polarization angle. Since on/off operation is easy and the CCD detector is always on the optical axis of the optics, we can perform a normal spectroscopic imaging observation by removing the filter[1].

Polarization Properties of a Multi Layers

The reflection and transmission properties are calculated for a Mo/Si Multi layers. In our purpose, the incident angle was fixed at 45 deg, where the difference of the reflectivity between S- and P-polarization is maximum. The layer thickness, the number of layer pair, gamma-value are assumed to be 2d=20nm, 9 and 0.3. The calculated reflectivity and the transmission are shown in figure 1. Around 13.5nm, difference can be seen between S- and P-polarization.

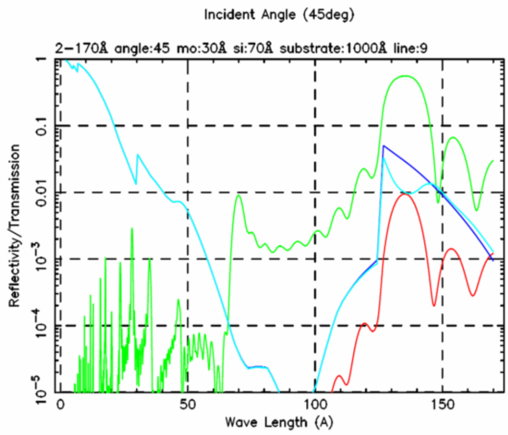

Figure1. The green and red lines are reflectivity of s- and p-polarization. The sky blue and thick blue lines are transmission of s- and p- polarization.

Experiment and Results

We prepared a film of a stand-alone Mo/Si multi-layers, and a back-illumination CCD. The multi layer is installed on tilted table with 45 degree. The table can be rotated around the normal direction of a CCD surface. These are installed in a small vacuum chamber. We connected this chamber to the BL-12A as the beam aligns to the rotational axis. The transmission was measured at a various wave lengths and a various rotational angles.

One example of a relative transmission as a function of the rotational angle is shown in figure 2.

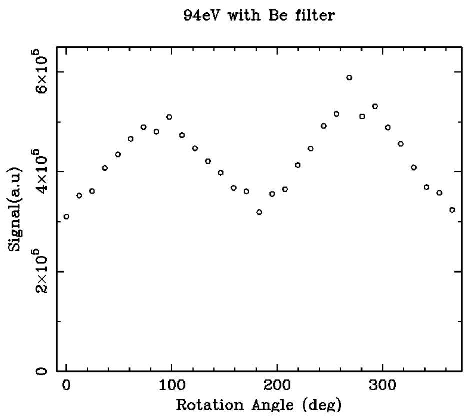

Figure 2. The signal intensity of the transmitted x-rays with 94eV as a function of the rotation angle of the multilayer around the beam line.

Discussion

We obtained a clear modulation according to the rotation of the multi layer by the transmission dependence on the polarization angle, in an energy range from 92eV to 100 eV. .In the other energy region, no modulation was seen as expected from the calculation. Thus we confirmed that this system works well as an imaging polarimeter in the certain energy range with a band pass of about 8 eV. Further quantitative characterization is required.

References

[1]S. Kitamoto et al., Proc of SPIE 6266-104 (2006).

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