High Energy Inelastic Scattering Beamline

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1. Introduction

The Compton scattering experiment provides the electron momentum distribution inaccessible to other k-resolved spectroscopies. Further when the incident X-rays are circularly polarized, one measures the spin-dependent electron momentum distributions (magnetic Compton profiles) of ferromagnetic materials. In the past decade, the advent of high-intensity, high-energy, well polarized synchrotron radiation sources have offered new opportunities of exploiting Compton scattering spectroscopy as a tool for investigating the electronic and magnetic structures of materials.

Up to the present, the highest energy of monochromatized X-rays with considerable intensity is 60 keV for the synchrotron based Compton scattering spectroscopy. The energy is suitable for the measurements of up to 3d metal and alloys. For heavier elements than 3d ones, however, 60 keV X-rays are not applicable since the photoelectric effect dominates the Compton scattering. Much higher X-rays than 60 keV are quite indispensable to Compton experiments on interesting materials containing heavier atoms than 3d elements.

With these motivations, SPring-8 is going to construct a dedicated beamline to Compton scattering spectroscopy. Achieving high resolution and good statistical accuracy in Compton spectroscopy on almost all elements is a technical goal of the beamline. The design is based on a use of an elliptic multipole wiggler (EMPW).

The schematic layout of the beamline is shown in Fig. 1. The beamline consists of two experimental stations; one is for very good statistical accuracy and moderate resolution experiments with 300 keV X-rays (station A) and the other is for high resolution and good statistical accuracy experiments with 100-150 keV X-rays (station B).

SPring-8 will provide a data-processing program as well, which is essential for many applications of Compton scattering spectroscopy to material science. A standard for processing Compton data is being developed as one of the subjects of the Compton project of the I.U.Cr Commission [1].

2. Insertion Device and Front End

The design of the EMPW is reported in detail in ref. 2. The periodic length of the magnetic array is 12 cm and the total length of the device is 4.44m. A maximum vertical deflection parameter K_y is 11.9, and the horizontal one K_x varies from 0 to 1.1. The critical energy is 42.6 keV at K_y=11.2 and K_y=0. The maximum total radiation power is 18.7 kW at a beam current of 100 mA. The calculated total flux spectrum of the synchrotron radiation emitted from the EMPW is shown in Fig. 2.

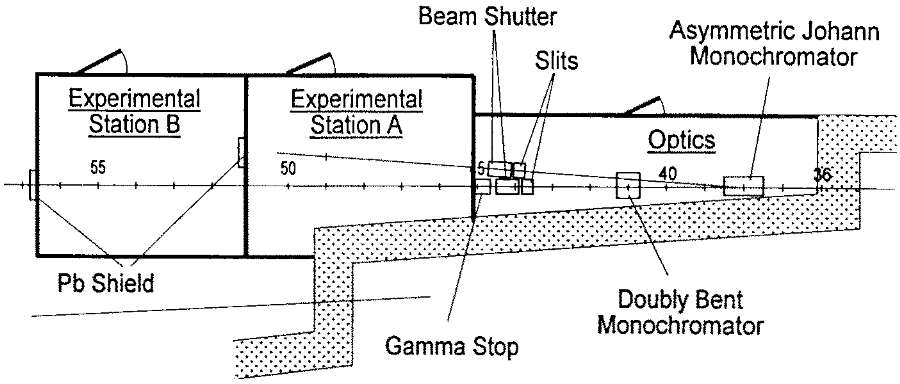
Graphite and metal plates are placed in the front end to eliminate the low and medium energy X-rays. The heat load can be reduced to a few hundreds W after the combination of 15mm thick graphite, 10 mm thick aluminum and 0.3mm thick copper plates. Calculated flux spectra after the filter plates is shown in Fig. 2.

3. Experimental Stations and Optics

(1) Station A

An X-ray spectrometer with a combination of a multi-segmented SSD detector and a

Fig. 1



superconducting magnet will be installed for magnetic Compton scattering experiments. The momentum resolution is expected to be 0.5au. The superconducting magnet will be equipped with a liquid He generator. A photon flux of as much as 5×10^{11} photons/s with an average degree of circular polarization greater than 0.5 and an energy resolution of 5×10^{-3} at the energy of 300 keV is required for the experiment. An asymmetric Johann monochromator will be installed to meet the requirements. The diffraction plane is Si 771 with an asymmetric angle of 1 degree. Figure 3 shows the focusing property of 300 keV monochromatized X-rays at the sample position calculated by a ray-trace program.

The use of intense, circularly polarized 300 keV X-rays makes it possible to measure statistically accurate magnetic Compton profiles of materials with small magnetic moments of the order of 0.1 μ_B/atom, *i.e.* weak ferromagnetic and paramagnetic materials.

(2) Station B

An X-ray spectrometer with a combination of a crystal analyzer and a position sensitive detector (PSD) will be installed to realize the high resolution measurement. The momentum resolution of 0.1 au is pursued. As a PSD with 512 channel CdTe elements with a spatial resolution of 250 μm is now being developed. A photon flux of as much as 10^{13} photons/s and an energy resolution better than 1×10^{-3} in the energy range of 100 - 150 keV are required for the experiment. To meet the requirements, a doubly bent monochromator will be used [3]. The diffraction plane is Si 400.

In the experimental station the research activities in the Fermiology and the many-body problem of electron systems will be extended to high-Tc superconductors, heavy electron system, 4d and 4f metals and alloys.

References

[1] W. Schuelke, IUCr Newsletter, 2, 16 (1994).

[2] X.M. Marechal, T. Tanaka and H. Kitamura, Rev. Sci. Instrum. 66 (2), 1937 (1995).

[3] H. Kawata, workshop on " Thermal Management of X-ray Optics Components for Synchrotron Radiation" in July 14-45, 1994, (ANL, Illinois, USA)

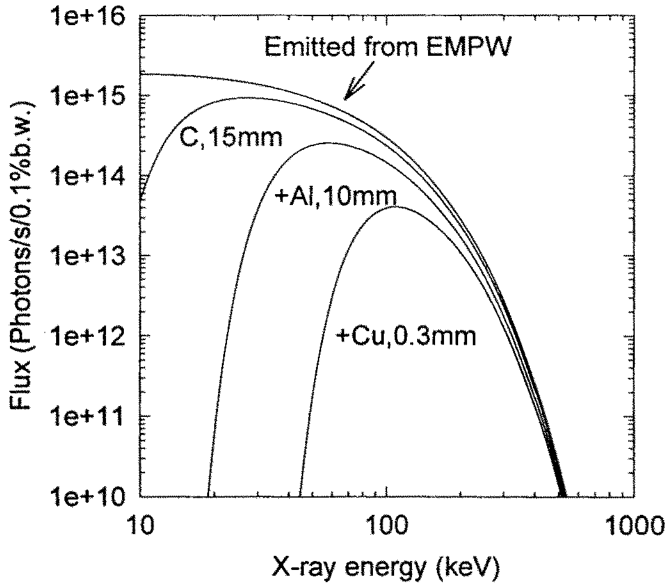


Fig. 2

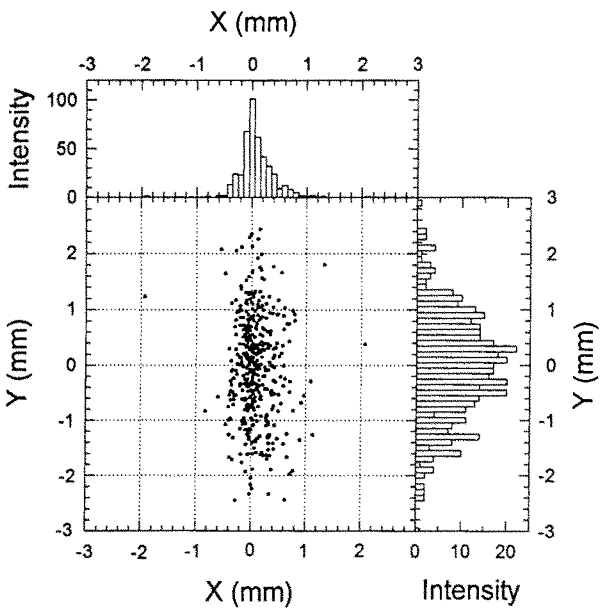


Fig. 3