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77. Generation of Linearly Polarized Resonant Transition Radiation X-ray Beam

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We have proposed a method to generate almost linearly polarized resonant transition radiation X rays by using a rectangular slit placed on an electron beam axis. Our calculation predicted that the linearity is 93.5% for the resonant transition radiation X-ray beam extracted through a slit of 0.5 mrad long and 0.2 mrad wide in case of 1-GeV electron beam irradiating a 7.5-μm thick Kapton foil stack.

Keywords: Resonant transition radiation, X-ray source, linearly polarized X-ray beam

1. Introduction

In recent years, resonant transition radiation (RTR) has been studied from a point of an X-ray source because of the increasing demand for an inexpensive intense X-ray beam in various fields [1-6 and refs. cited therein]. Transition radiation (TR) is an electromagnetic wave emitted when a charged particle crosses a boundary of different dielectric media. When a relativistic electron passes many thin foils placed periodically in vacuum, that is a foil stack radiator, TR X rays emitted from the respective boundaries can interfere with the others and the interfered TR is called RTR. RTR has a high energy-conversion efficiency from electron to photon, and X rays can be efficiently produced by lower energy electrons in RTR than in synchrotron radiation. Therefore, RTR is expected to be an alternative brilliant X-ray source on the laboratory accelerator basis.

In our previous study, we experimentally confirmed that the energy spectrum of RTR depends on the material and foil thickness of the thin-foil stack radiator. We showed that a brilliance of 10^{12} (photons/s/mrad^2/ mm^2/0.1%b.w. /mA) can be obtained and it is comparable to that of the synchrotron radiation emitted from a bending magnet in GeV-electron facilities [7]. The next step is to clarify the polarization property of RTR as an X-ray source. Here, we propose a method to obtain a linearly polarized RTR X-ray beam originating from RTR and show the calculated polarizability.

2. A method to obtain a linearly polarized RTR X-ray beam

RTR emitted when an electron is incident on a radiator to the surface normal is polarized in the radiation plane spanned by the emitted photon and the incident electron beam directions as shown in Fig. 1 [8]. The radiation planes are symmetric with respect to the electron axis because of the angular distribution property of RTR, whose cross sectional view is shown in Fig. 2. Therefore, the integrated RTR is not polarized, but RTR is linearly polarized if we extract a part of the RTR beam passing through a rectangular slit along the radial direction of radiation plane distribution.

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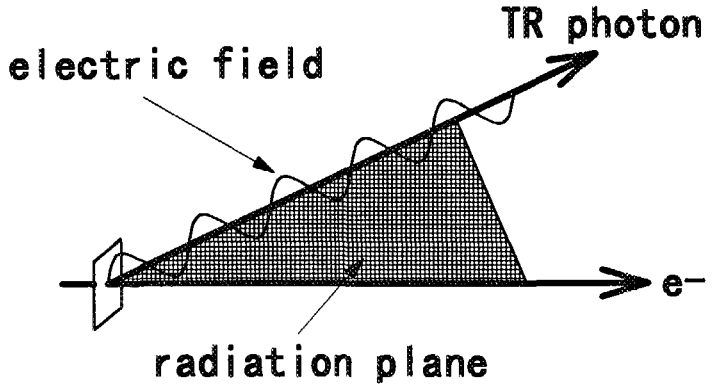

FIGURE 1. Polarization of RTR photon emitted when the electron beam is incident on a radiator to the surface normal. The hatched plane defined by two axes of the emitted photon and the incident electron is referred to as the radiation plane.

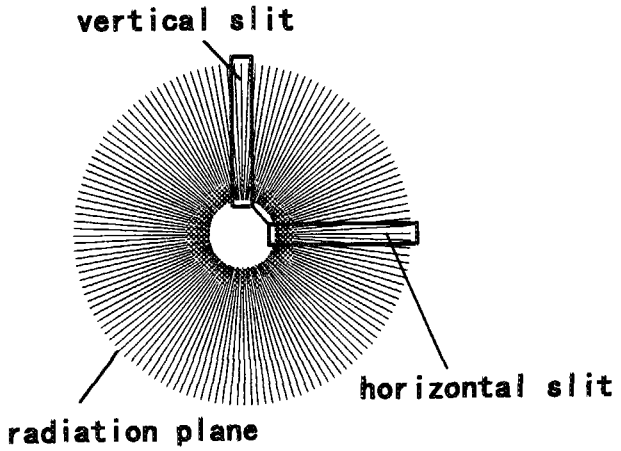

FIGURE 2. Cross-sectional view of the distribution of the radiation plane. The electron beam direction is normal to the paper. RTR X-ray beam extracted through a rectangular slit shown in the figure as a horizontal or vertical slit is expected to be almost linearly polarized.

3. Calculation

We have done a calculation for the linearity of the extracted RTR X-ray beam. RTR X rays are produced from a 7.5-μm thick Kapton foil stack radiator irradiated with a 1-GeV electron beam. Fig. 3 shows the calculated angular distributions of RTR X rays at a photon energy of 4.3 keV. As known from the Fig. 3, RTR X rays are concentrated in a small forward hollow cone. Then, we calculated the percentage of the horizontal and vertical components of the radiation plane direction, that is the polarization direction, for the X-ray beam passing through a rectangular slit of 0.5 mrad long and 0.2 mrad wide. For the case of horizontal slit as shown in Fig. 2, the horizontal and vertical components are 93.5 % and 6.5 %, respectively. It can be said from the result that the extracted RTR X-ray beam is almost linearly polarized.

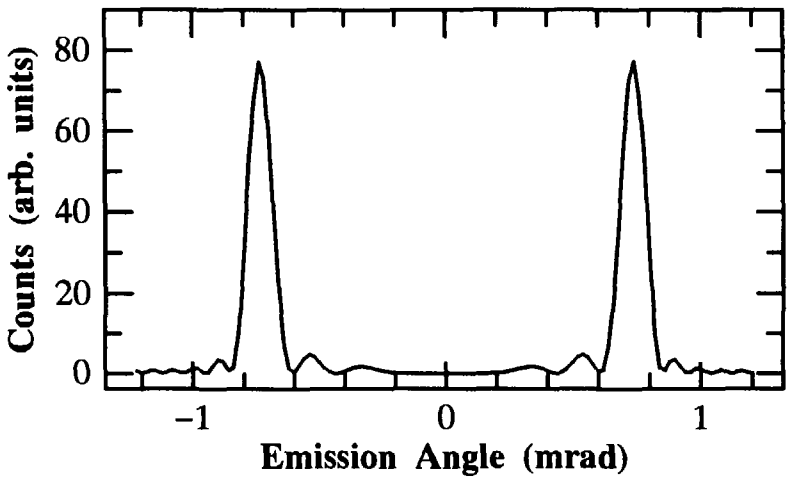

FIGURE 3. Calculated angular distribution of RTR X rays at photon energy of 4.3 keV. RTR has doughnuts like distribution if it is sliced normal to the electron beam axis.

4. Conclusion

We have proposed a method to generate linearly polarized RTR X-ray beam using a rectangular slit crossing an electron beam axis. The calculated result shows that the linearity of 93.5 % is achieved for the mentioned parameter, and we conclude that the proposed method can produce almost linearly polarized X-ray beam. We have already done an experiment to verify the calculated result and are going to persuade an analysis for its results now.

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