STUDY OF POLARIZATION X-RAY BREMSSTRAHLUNG OF FAST ELECTRONS IN MEDIA WITH DIFFERENT MICROSTRUCTURE

S.Blazhevich, N.Nasonov, LRP BSU, 308007 Belgorod, Russia
A.Chepurnov, V.Grishin, B.Ishkhanov, V.Petukhov, V.Shvedunov, Nuclear Physics Institute, MSU, 119899 Moscow, Russia

Abstract

Theoretical predictions of peculiarity of polarization X-ray bremsstrahlung from fast electrons in dense media with different microstructure are stated. Results of first experimental observation of such bremsstrahlung by 2.4 MeV electrons in an aluminum leaf are presented and discussed.

1 INTRODUCTION

Polarization X-ray bremsstrahlung (PB) takes place while a fast charged particle hits an atom and the Coulomb field of the incident particle is scattered on the atom electrons [1].

The feature of PB which makes this mechanism different comparably with a traditional bremsstrahlung radiation what occurs in the same collision is a high value of the collision impact parameter. This value is comparable with the atom size, while for ordinary bremsstrahlung characteristic values of impact parameters are of order of shielding radius in the Thomas-Fermi atomic model.

Due to the above circumstance the correlations between placements of various atoms in the media should act essentially on the PB characteristics in condensed matter. Condensed matter means that the distances between atoms in such substance are of order of atomic size. This effect is expected to allow the development of a method to test the structure of the substance with PB. Therefore the study of the PB characteristics versus the distribution of atoms is of a great interest for applications in the field of the condensed matter physics.

It is necessary to stress that the theory of PB is developed to describe the PB production in a collision with a certain separated atom [1,2]. From the other hand the parametric X-ray radiation of a fast particle in a crystal [3-5] is a good example of collective response of all atoms of medium to the electromagnetic perturbation from the fast particle. This parametric X-ray radiation is a coherent part of PB and is produced due to the ordered atoms distribution in a crystal [6]. The theoretical analyses [7] showed that PB in particularly ordered media - polycrystal differs both from PB in an amorphous medium (for amorphous media the interatomic correlations due to the finiteness of atomic size are also essential [8]) and from PB in a crystal. The result obtained causes the necessity to study PB experimentally in particularly ordered media.

..The goal of present work is the experimental analyses of spectral-angular distributions of PB produced by relativistic electrons in substances with various atomic structure.

2 EXPERIMENT

Experimental researches on PB were carried out basically in the resonant atomic frequencies region [1] with non-relativistic charged particles. In this region the interatomic correlation’s are negligible. Experiments on PB from relativistic particles were performed in NPI MSU at the electrons energy 6.7 MeV [9] and in NPI TPU [10] at the electrons energy 800 MeV. The data obtained were processed on the base of the PB theory on separate atom. Experimental data [9] are strongly inconsistent with the PB theory on separate atom (the diamond like carbon foil was used as a target).

The present work is aimed to study experimentally the properties of PB from relativistic electrons in aluminum leaf The experimental setup is very typical. The accelerated electron beam with energy 2.4 MeV is incident on the aluminum target with thickness 2 microns, placed in a vacuum camera under the angle 45 degrees to the beam direction. X-ray radiation from the target is measured by a cooled Si-Li detector placed on the vacuum photon channel. The photon channel is allocated under one of the angles to the incident electrons direction determined by the target camera construction: 0, 45, 90 degrees. Particularly to reach minimum contribution of ordinary bremsstrahlung from the target we used the observation angle equal to 90 degrees.

The preliminary spectrum is depicted in Fig. 1. On the same picture there is the background spectrum obtained when the photon channel was closed by lead shield. After subtraction of the background the spectrum takes in the energy region 2-7 keV the form showed in Fig. 2.

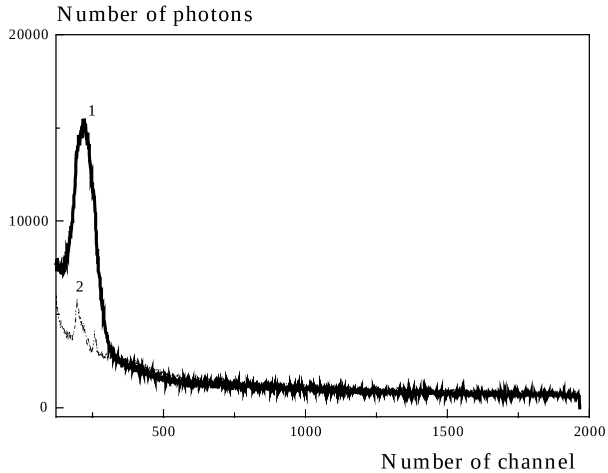

Figure 1: Experimental data. 1 - signal, 2 - background.

The data presented in both figures are demonstrating the difficulties of obtaining and processing an information in real PB-experiments. The peak of characteristic radiation (CR) from aluminum allocated at 1.55 keV has a maximum number of counts in the spectrum. Expected intensity of PB accordingly to the theoretical estimations is less than 0.1% from the CR intensity. Hence the important task of the experiment is to reduce the level of photon background and to provide a reliable measurement of the quantity of electrons passed through the target necessary to subtract the background correctly.

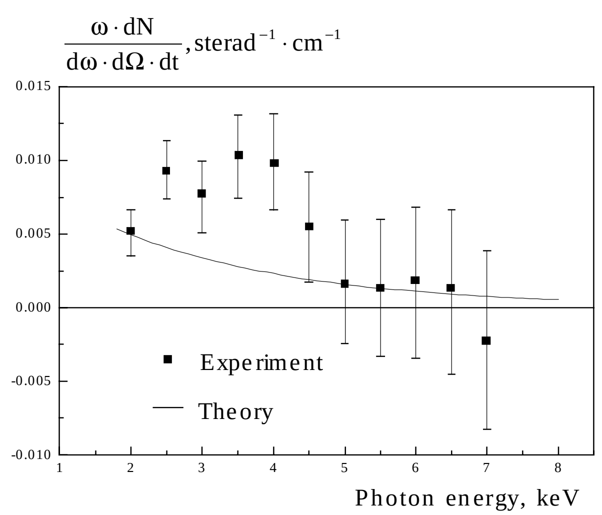

Figure 2: Spectral-angular distribution of PB emission intensity.

3 DISCUSSION

The comparison of experimental data with the presented in Fig. 2 theoretical curve describing the spectrum of a relativistic electron's polarization bremsstrahlung on a separate atom [8] shows the qualitative agreement only. It is not strange because of the high background in our experiment that allows to consider the obtained result as a preliminary one.

The remarks should however be done that the shape of the measured spectrum points out apparently a considerable difference between polarization bremsstrahlung properties in a carbon like diamond foil [9] and an aluminum leaf. The strong suppression of a polarization bremsstrahlung has been exposed at the experiment [9] in contrast to this experiment showed absence of the suppression effect.

The obtained result is in agreement with our assumption that the aluminum leaf is close to an amorphous medium. It should be noted that the difference between shapes of experimental and theoretical spectra in figure points out apparently the manifestation of polycrystalline fraction in our target [8].

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