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SHAPE OF THE BREMSSTRAHLUNG SPECTRUM NEAR THE HIGH FREQUENCY LIMIT

B. S. DOLBILKIN, V. A. ZAPEVALOV, V. I. KORIN, and F. A. NIKOLAEV

P. N. Lebedev Physics Institute, Academy of Sciences, U.S.S.R.

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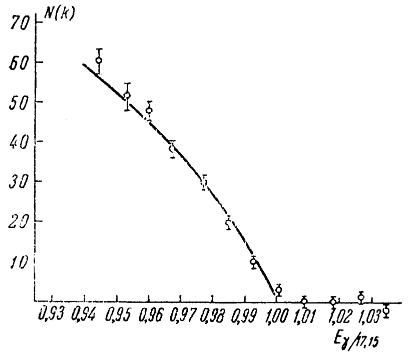
The shape of the bremsstrahlung spectrum with a limiting energy of 17.15 MeV is investigated with a magnetic pair spectrometer with a resolution ~ 150 keV near the high frequency limit. It is shown that the shape of the spectrum in the measured energy range is satisfactorily described by the relation given by Schiff.[1]

1. In the calculation of the cross section of photonuclear reactions from the yield curves, use is generally made of the theoretical value of the bremsstrahlung cross section as computed by Schiff.[1] However, these calculations are carried out under the assumption of the validity of the Born approximation and of relativistic energies of the electron in both the initial and final states. Both these conditions are violated close to the upper edge of the gamma-ray spectrum and, consequently, the Schiff results are not universally established in this energy region.

In this connection, the experimental test of the correspondence of the theoretical and real spectra close to the upper edge is of considerable interest. The measurements were carried out for the bremsstrahlung spectrum of a synchrotron of 30 MeV with a limiting energy of 17.15 MeV, in the range of photon energies of ~ 1 MeV from the upper edge of the spectrum. A magnetic pair spectrometer was used as the detector, with a resolving power in the given energy region of ~ 150 keV.

The bremsstrahlung beam from the internal target of the accelerator (${}_{78}$Pt foil 0.1 mm thick), located at a radius smaller than the radius of the synchrotron orbit, was collimated by a system of lead collimators, and was incident on the radiator of the magnetic pair spectrometer. The duration of the beam at the origin was ~ 20 microsec, which corresponds to a duration of the beam in the ordinary operating cycle of the synchrotron (without artificial tripping and stretching of the beam in time). The cross section of the beam at the radiator of the spectrometer, which is located at a distance of 515 cm from the target of the accelerator, was a rectangle of area 110 × 50 mm^2. The energy of the accelerated electrons was stabilized with an accuracy to within ~ 30 keV by an electronic system described in the work of Karpov et al[2], and was periodically checked by the break in the yield curve of the reaction (γ, n) on oxygen for the energy of 17.15 MeV.[3] The magnetic field of the pair spectrometer was maintained by a proton resonance stabilization system that remained constant in time with an accuracy to within 10^{-4} sec. The relative dose was measured by a thin-walled integrating monitor located in the collimated beam.



The results of the measurements are shown in the drawing [N(k) is the number of photons per energy interval, in relative units; the indicated errors are mean-square]. The solid curve is the Schiff spectrum, normalized for an experiment at 16.75 MeV, and computed numerically by Penfold and Leiss.[4] The calculations were used for a bremsstrahlung spectrum with an upper boundary of 16 MeV. The difference of the maximum energy at 1 MeV of the experimental and theoretical spectra is not significant, since the shape of the bremsstrahlung depends weakly on the limiting energy.

It is seen in the drawing that the shape of the bremsstrahlung spectrum is quite satisfactorily described by the relation obtained by Schiff (the discrepancy of the theoretical curve and the curve drawn through the experimental points does not exceed 4 per cent). However, this agreement is purely accidental, since the assumptions used by Schiff are invalid in this energy region. Nevertheless, the results obtained support the contention that the use of the Schiff relation in calculations of the transverse cross sections of photonuclear reactions does not lead to significant errors.

The same conclusions were reached by Fuller et al [5] in measuring the gamma quantum yield with energies of 15.11 MeV for a change in the energy of the electrons incident on the tungsten target from 15.0 to 16.0 MeV.

In conclusion, the authors consider it their duty to express their gratitude to L. E. Lazarev for discussion of the results, and to N. S. Kozhevnikov for help in adjusting the spectrometer and carrying out the measurements.

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