POLARIZATION OF BREMSSTRAHLUNG*

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An attempt has been made to measure the polarization of radiation from an 11·5 MeV synchrotron. The method used was to load a photographic emulsion with heavy water, expose it with its plane normal to the beam, and measure the orientation and range of photoprotons from the $^2H(\gamma,p)n$ reaction. It has been confirmed experimentally (Wilkinson 1952) that protons from this reaction exhibit a $\cos^2$ distribution about the direction of the electric vector of plane polarized radiation, which means that the reaction may be used to reveal polarization.

An Ilford Nuclear Research Plate, 50 μ, C2 was loaded with D_2O by soaking for about 5 hr resulting in an absorption of 16·7 mg D_2O per cm^2 of plate. It was mounted in a watertight aluminium holder containing excess D_2O and exposed in the beam at 51 cm from the target, receiving 6 r from a 5 mil platinum target. A 20 cm lead collimator having a conical aperture prevented radiation from the doughnut reaching the plate and limited the exposure to an area of 5 cm diameter. Half an inch of " Bakelite " was interposed to reduce electron fogging. A similar exposure was made on H_2O loaded plates. Weight and thickness measurements were made on the plates giving water uptake, swelling and processing contraction factors, and permitting a calculation of the range-energy relation for the swollen emulsion (using data from Wilkins (1951)).

It was essential to know where the centre-line of the radiation cone intersected the plate. This was located by ionization chamber measurement at a distance of 4 m from the machine and fixed by a telescope sighting back to the target. The error was estimated as $\lesssim$2 mm at the plate. Scans were distributed over the plate to obtain data from a variety of planes of γ-emission. However, all the data used were obtained at an angular radius between 1 and 2° both to avoid the worst effects of an error in the centre-line and to concentrate results where polarization is likely to be most pronounced, $\theta \sim mc^2/E$.

The orientation φ of the projections of 1165 protons relative to the plane of emission of the γ-radiation is shown in Figure 1 broken down into three energy groups, *A*, *B*, and *C*. Background distributions (from H_2O loaded plates) were isotropic and should be subtracted from Figure 1 to the extent of ~20 per cent. in *A*, ~14 per cent. in *B*, and a few per cent. in *C*.§ *A* is consistent with isotropy, a χ^2 test on *B* gave a probability $P=0\cdot3$ of getting this result if the distribution

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§ Backgrounds were found to be essentially the same on unexposed regions of the same plates and presumably arose from old thorium α-tracks and single cosmic tracks.

is actually isotropic, and the probability of getting C as 0·01. Plotted with respect to an *arbitrary direction* on the plate the same set of tracks gave an isotropic distribution ($P=0\cdot6$ for group C).

The 90° peak of Figure 1 C is consistent with a $\sin^2$ distribution and could be interpreted as a polarization perpendicular to the plane of emission. The 0° peak is more suggestive of a higher power of $\cos^2$ and its origin and shape, if taken seriously, are puzzling. Polarization can only give rise to a single peak, the electric vector being single-valued. However, the present work is not inconsistent with that of Phillips (1953) who reported peaks at 90° and ~25° in the total bremsstrahlung from a 20 MeV betatron.

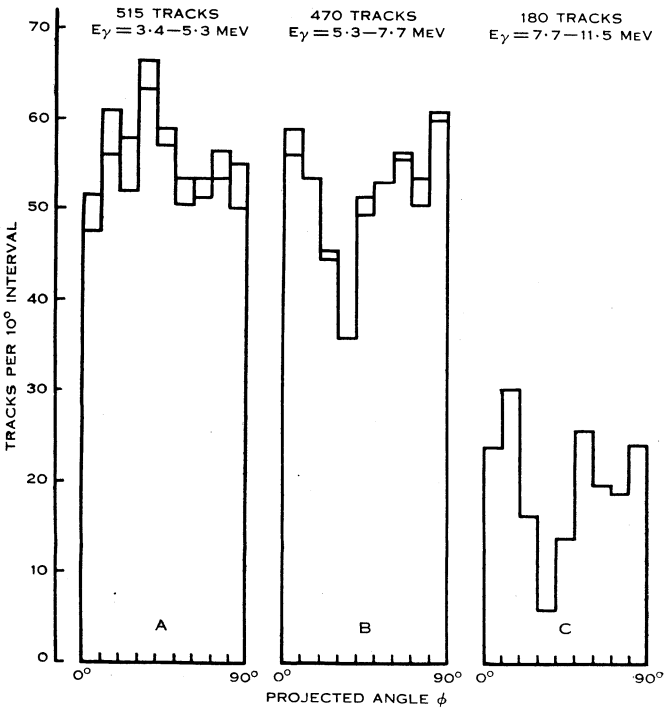

Fig. 1.—Projected angle, φ, distribution for three bremsstrahlung energy groups. φ is the angle between the projection of the track on the plane normal to the centre-line and the plane of emission of the γ-ray (p_0k plane of Gluckstern and Hull (1953)). The double ordinates in A and B indicate the number of tracks of uncertain origin.

A number of spurious effects have been considered and excluded as possible causes, e.g. multiple target traversals, a gross error in the centre-line determination, recoil protons, or deuterons knocked on by the photodisintegration neutrons in the loaded emulsion, etc. Contributions to the disintegration from effects other than the photoelectric (photomagnetic and tensor interaction) are of the order of a few per cent. and cannot appreciably alter the shape of the φ distribution.

The theory of polarization of bremsstrahlung (Gluckstern and Hull 1953) predicts a single peak at 90° which is expected to be more marked at energies corresponding to our cases *A* and *B*. However, before a quantitative comparison can be made, it is necessary to allow for effects of multiple scattering in the synchrotron target. Multiple scattering will reduce the degree of polarization predicted by Gluckstern and Hull towards isotropy. After due allowance is made for this effect it is difficult to reconcile the magnitude of the observed 90° peaks with theory. Work is continuing on this point and we are also repeating the experiment at 20 MeV.

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