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Production of Polarized γ-rays. G. C. Wick.

A number of interesting experiments would be possible with a beam of polarized γ-rays. Among these experiments of fundamental importance would be one in which the angular distribution of mesons produced by high energy polarized γ-rays would be observed. The results of such an experiment would assist materially in the evaluation of the various meson theories that have been advanced. Because of the great usefulness of such a polarized beam of γ-rays calculations have been carried out on the feasability of producing polarization by the methods that have been successful in the case of x-rays.

One method of polarizing x-rays is scattering through 90°. The Klein-Nishina formula with the polarization term shows that the intensity of this polarized beam is proportional to $4mc^2/E$. Thus the effect is very small at high energies and cannot be applied to γ-rays.

It has been observed that x-rays emitted by cathodes after they are struck by an electron beam are polarized. The electric vector of the x-rays oscillates in a plane parallel to the line of motion of the cathode rays. The direction of maximum polarization moves forward with increasing energy and one might expect that the intensity becomes negligible. This was not, however, found to be the case.

The physical situation that was analyzed was the production of quanta by the action of highly accelerated electrons on nuclei by bremsstrahlung such as occurs to produce the γ-ray beam of the synchrotron. In order to carry out the calculations, advantage was taken of the theory of Compton scattering of Klein and Nishina. For this purpose, the kinetic energy of the incident electron was assigned to the nucleus thereby exciting it to oscillation. The energy of oscillation was then Fourier analyzed into its components which were thought to be emitted as quanta to interact with the field of the stationary free electron. By integrating the product of the number of photons of frequency ν interacting with the electron and the number of quanta with frequency ν' deflected into a certain solid angle over the range of frequencies from 0 to ∞ it was possible to calculate the number of such quanta in the system in which the electron is at rest. The integral converged well and it was found that the largest contribution came from the region of the frequency spectrum that corresponds to mc^2 the rest energy of the electron. While the γ-rays are of low energy and polarized in the system in which the electron is at rest, the energy of the quanta is transformed to high values by the Lorentz transformation to which the system is subjected whereas the polarization is invariant. The intensity of the beam has been calculated as a function of the emitted frequency ν', and the angle θ between the direction of the electrons and the direction of the quanta, and the polarization angle ϕ:

$$\frac{d\Omega}{[1+(\theta/\theta_0)^2]^2}\left\{A(\nu') - \frac{B(\nu')\,4\,(\theta/\theta_0)^2}{[1+(\theta/\theta_0)^2]^2}\cos^2\phi\right\};$$

$$A = 1 + (1-\varepsilon)^2$$

$$B = 2(1-\varepsilon) \quad ; \varepsilon = \text{fraction of energy in polarized beam.}$$

The polarization reaches a maximum for $\theta=\theta_0 = \frac{mc^2}{\varepsilon}$ for an infinitely thin target. Calculations have shown that for 1 mil Pt target the angle of maximum polarization in the Berkeley synchrotron is 1/200 of a radian. For this angle the intensity of the polarized portion of the beam is about 1/10 of the intensity of the full beam. Since the angle is so small, the observation of a polarized beam is probably not possible at present. However, since the angle of maximum polarization increases with decreasing energy of the incident electrons, it might be possible to produce polarized beams in practice with machines that are not quite as powerful, i.e., with machines that accelerate electrons to velocities in the neighborhood of 20 Mev.

On the Nucleon-Nucleon Interaction. R. Jastrow.

A model of the nucleus has been devised in which an exponential attractive well is supplemented by a short range repulsive force. On the basis of this model are explained the qualitative features of p-p and n-p scattering data, namely the isotropy of protons scattered by protons between 20° and 90° and the anisotropy of n-p scattering in the region of high energies.

A complete discussion of the work is contained in "On the Nucleon-Nucleon Interaction" by Robert Jastrow, UCRL-819, August 2, 1950.

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