# EXPERIMENTAL INVESTIGATION OF THE POLARIZATION OF SCATTERED RADIATION IN THE COMPTON EFFECT ON RELATIVISTIC ELECTRONS

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The production of high-energy polarized gamma beams by Compton scattering of laser photons from relativistic electrons [1, 2] has many advantages over other methods of obtaining polarized gamma quanta [3]. According to the theoretical calculations [4, 5], the optical emission (photon energy ~ 2 eV is transformed in the case of scattering by high-energy electrons into gamma quanta with energies of tens and hundreds of MeV. The maximum energy of the scattered photons is observed in the case of head-on collisions of the photon and electron beams.

The most characteristic and important feature of Compton scattering is that the produced gamma quanta retain the polarization of the primary radiation almost completely. If the primary radiation is fully polarized, then the degree of polarization of the scattered quanta with energies close to maximal is nearly 100%. Unlike other methods, Compton scattering makes it possible to obtain also high-energy gamma quanta with circular polarization.

Real experimental conditions (circular electron trajectory in the beam-interaction region, betatron oscillations of electrons in an accelerator, solid angle of the recording apparatus) cause the polarization of the registered gamma quanta to differ greatly from the polarization of the scattered radiation in the case of strictly head-on collision.

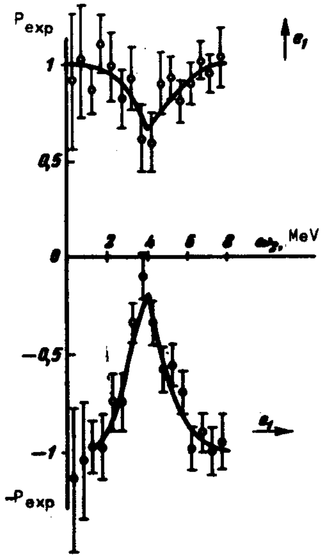
For an experimental study of the degree of polarization of the gamma quanta obtained with the setup described in [6, 7], we used a Compton polarimeter with amplitude addition, placed behind a collimator of 15 mm diameter located 11 meters away from the beam-interaction region. The polarimeter consisted of three scintillation counters; namely a scattering counter placed in the investigated gamma beam, and two counters that registered the secondary radiation from the scatterer. The scatterer used was a plastic scintillator (diameter 40 mm, length 130 mm) based on polystyrene. The analyzer crystals were cylindrical NaI(Tl) scintillators 120 mm in diameter and 100 mm long. The choice of the material of the corresponding crystals and their dimensions was determined by the desire to reduce to a minimum the photoeffect and pair production in the scatterer, to avoid multiple scattering of the gamma quanta, and to ensure as complete an absorption of the gamma quanta from the scatterer by the analyzer crystals as possible. The mutual placement of the crystals was such as to obtain an appreciable asymmetry coefficient at a high registration efficiency. The total signal from the scattering and analyzing counters determined the energy of the gamma quantum registered by the polarimeter. The counting asymmetry of the two mutually perpendicular scattering-analyzing counter systems is uniquely related to the degree of polarization of the gamma radiation.

The control system turned on the recording apparatus only during the time of laser emission. The signals from the polarimeter photo-multipliers were amplified and fed to a three-dimensional pulse-height meter and then to a printing unit.

The calibration of the polarimeter counter and of the entire analyzer as a whole was with the aid of a $Cs^{137}$ source and was maintained constant within 3%.

We measured the dependence of the degree of linear polarization of the scattered photons on their energy at two mutually perpendicular orientations of the electric vector of the laser photons, one of which coincided with the vertical direction (the electron orbit was in a horizontal plane). The results of the measurements and the corresponding theoretical curves are shown in the figure.

In the comparison of experiment with theory, we took into consideration the peculiarities of registration of gamma radiation by scintillation counters. To convert the amplitude




Degree of polarization $P_{exp}$ of scattered photons vs. their energy $\omega_2$. Solid curves - theoretical data, points - experiment. The arrows on the figure indicate the direction of the electric vector of the laser emission, which coincides with the preferred direction of polarization of the scattered radiation.

spectra registered by the two systems of the scattering and analyzing counters into energy spectra, appropriate matrices, analogous to those given in [8], were calculated by the Monte Carlo method.

It was convenient to measure in the experiment, instead of the degree of polarization $P = (I_{max} - I_{min})/(I_{max} + I_{min})$, the quantity $P_{exp} = I_{\uparrow} - I_{\rightarrow})/(I_{\uparrow} + I_{\rightarrow})$, where $I_{\uparrow}$ and $I_{\rightarrow}$ are the intensities of the scattered quanta with vertical and horizontal electric vectors respectively. The greatest influence on the degree of polarization $P_{exp}$ was exerted by the degree of polarization of the primary radiation, by the accuracy of the setting of the electric vector of the laser radiation relative to the plane of the electron orbit, and by the accuracy of the setting of the polarimeter relative to the direction of the polarization of the incident radiation. The maximum-likelihood method has shown that agreement between the theoretical and experimental data is observed at a significance level of 5% if the degree of polarization of the primary radiation lies in the range $95\%^{+5\%}_{-15\%}$ and $100\%^{+0}_{-15\%}$ for the horizontal and vertical orientations of the polarization vector of the laser photons, respectively.

In each acceleration cycle (number of electrons $3 \times 10^{10}$ particles/cycle, laser energy 4 J), approximately 60 scattered gamma quanta entered into the polarimeter. This meant that $6 \times 10^3$ scattered quanta were produced in each cycle under the experimental conditions.

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