ИНСТИТУТ ЯДЕРНОЙ ФИЗИКИ СО АН СССР

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A b s t r a c t

The experiment dealing with the observation of a change in the SR intensity during beam depolarization at the VEPP-4 storage ring is described. With a minute time of measurement, the magnitude of the effect exceeded ten statistical errors. The dependence of the sign of the effect on the sign of the magnetic field at the radiation point is demonstrated. The measured magnitude of the jump in the intensity is in agreement with the calculated spin- dependent contribution within a statistical errer (equal to 7%). The suggested method is shown to be effectively applied to the observation of the transverse beam polarization in electron-positron storage rings.

1. Introduction

The expression for the radiation intensity of a classical point charged particle moving with an acceleration $\dot{\vec{v}}$ transverse to its velocity, is of the form

$$W_0 = \frac{2}{3} e^2 \gamma^4 |\dot{\vec{v}}|^2, \quad (1)$$

where e is the charge of a particle and $\gamma = (1-v^2)^{-1/2}$ is the relativistic factor ($c = 1$). If the particle travels in a transverse magnetic field, its acceleration is equal to

$$\dot{\vec{v}} = e(\vec{v} \times \vec{H})/(m\gamma),$$

where m is the rest mass of this particle and $\vec{H}$ is the magnetic field vector. The spectral density of the intensity of the radiation occuring during such an acceleration of the charge has a maximum at the frequency $\omega \simeq \omega_c$, where

$$\omega_c = \frac{3}{2} \frac{eH}{m} \gamma^2$$

and is an universal function of $y = \omega/\omega_c$. The fact that the classical charged particle moving along a curved trajectory has its own angular momentum - the spin $\vec{s}$ - and the magnetic momentum - $\vec{\mu} = g\vec{s}$ results in an additional radiation.

This spin-associated radiation interferes with the usual radiation available from the accelerated charge. As a consequence, the expression for the intensity must contain a linear spin-dependent term. For the gyromagnetic ratio, $g = e/m$, this additional term proves to be equal to

$$W_s = 2 \frac{e^2}{m} \gamma^5 |\dot{\vec{v}}|^2 (\vec{v} \times \dot{\vec{v}}) \cdot \vec{s} \quad , \quad (2)$$

where $\vec{s}$ is the spin vector in the particle rest system.

When a relativistic electron moves in a storage ring, the energies of the characteristic emitted quanta are low compared with the particle energy. Therefore, expressions (1) and (2) are also applicable for calculations of the intensity of synchrotron radiation (SR). In this case, by the spin vector in expression (2) one should mean a quantum-mechanical average of the spin operator in the electron rest system:

$$\vec{S} = \langle \hat{\vec{S}} \rangle = \frac{\hbar}{2} \vec{n} ,$$

where $\hbar$ is the Planck constant and $|\vec{n}| = 1$.

For electrons and positrons in storage rings, there is a natural mechanism of radiative polarization /1/. Here the electrons are spin-oriented in a direction opposite to that of the storage ring field, and the positrons in a direction of the field. From the expression for W_S it follows that the naturally polarized beam of electrons and positrons in a storage ring will radiate more intensively in comparison with the unpolarized beam. Here the relative addition to the SR intensity will constitute

$$\delta = \frac{\hbar \omega_c}{m\gamma} \zeta = \chi \zeta ,$$

where ζ is the degree of beam polarization ($max\, \zeta = 0.92$ in an ideal storage ring).

For a homogeneous-magnetic field, the spin direction dependence of the SR intensity from an electron has been first calculated in the paper /2/. The spin dependence of synchrotron radiation in varying fields was obtained in a locally uniform approximation in Ref. 3. The works /4/ and /5/ show that this effect can be described in terms of a classical theory.

In the work (6) the suggestion has been made to use the spin dependence of synchrotron radiation in order to measure the polarization of electrons in storage rings. As the authors have pointed out, a short-wave spectral region (large values of y) is the most favourable for such measurements. At $y \gg 1$ the spin addition to the intensity grows linearly with y /2/:

$$\delta = y \chi \zeta$$

When the value of y is fixed (i.e. the number of photons is

fixed), the quantity δ is proportional to the magnitude of a magnetic field on the radiation section and to the particle energy:

$$\delta \sim H\gamma$$

In view of this, the SR intensity as a function of the spin direction becomes more intensive if a 'snake' is introduced into the straight section of a storage ring. In the simplest case, the 'snake' consists of three magnets with a strong vertical magnetic field whose average value is zero. The field in the central magnet is several times higher compared with that in the side compensating magnets and can be much higher, in magnitude, than the guiding field of the storage ring. It follows from expression (2) that the sign of the interference correction to the SR intensity is determined by the spin projection of an electron onto the magnetic field direction. Therefore, periodical changes of the sign of the 'snake' magnetic field enable the action of systematical errors in polarization measurements to be additionally weakened. Here the possibility arises to measure the degree of beam polarization without its destruction.

At $y \simeq 10$ the value of δ is, approximately, $10^{-4} \div 10^{-3}$ for storage rings at the energy $10 \div 100$ GeV, with a field in the 'snake' of the order of 10 kG. The number of SR-photons is still large enough. With operating currents in the storage ring of the order of few milliamperes, the flux of photons to a detector can be equal approximately to $10^{10} \div 10^{11}$ s^{-1}. Therefore, there is a possibility of measuring the polarization for the times of the order of several seconds.

The paper /7/ suggests the technique of polarization observation based on the comparison between the SR intensity of the polarized and unpolarized electron bunches, simultaneously circulating in a storage ring. The present paper is devoted to the description of the experiments dealing with the SR spin dependence observation. The measurements on the VEPP-4 storage ring have been made according to the scheme suggested in Ref. 7.

2. Scheme of the experiment

Since the spin correction to the SR intensity is small ($\delta \lesssim 10^{-4}$), the absolute measurements of this effect are connected with some difficulties: the device measuring the SR intensity the beam position in a storage ring, the beam energy etc. must be highly stable. To eliminate these problems, we have chosen such a scheme of measurements wherein a relative variation in the SR intensity from two electron (or positron) bunches, simultaneously circulating in a storage ring, was observed while one of these bunches having been depolarized by a special selective depolarizer. In this case, the different instabilities in the apparatus and in the storage ring have much smaller influence on the results of measurements.

For the hard SR to be produced, a special three-pole magnetic 'snake' (Fig. 1) was employed. The maximum value of the central magnet field is 21 kG. The total integral of the 'snake' field is close to zero. This allows the sign of the field in the magnets to be changed in the course of measurements.

From the central magnet of the 'snake' the SR beam was extracted at a detector. A conventional scintillation counter served as the detector. A polystyrene scintillator whose dimensions are 7x4x20 cm^3 is observed by a spectrometric photomultiplier (Fig. 2). Because the effect is more significant at the hard end of the SR spectrum, a 4 mm thick lead filter is placed in front of the scintillator. The spectrum of the SR photons, passed through the filter, is calculated by the Monte-Carlo method and is depicted in Fig. 3. The characteristic energy of the detected photons is of the order of 250 keV (y = 7+8). The dependence of the number of photons, that have interacted with matter in the scintillator, on the field in the 'snake' is shown in Fig. 4. The SR background from the side compensating magnets of the 'snake' as well as that of the storage ring guiding field is negligibly small (the field in the side compensating magnets is three times lower than that in the central magnet).

With a 0.5 mA current and a 5 GeV energy, about $5 \cdot 10^3$ SR-photons are detected per one beam turn in the storage ring. Approximately 30 photoelectrons available from the PM cathode correspond to one SR-photon arriving at the

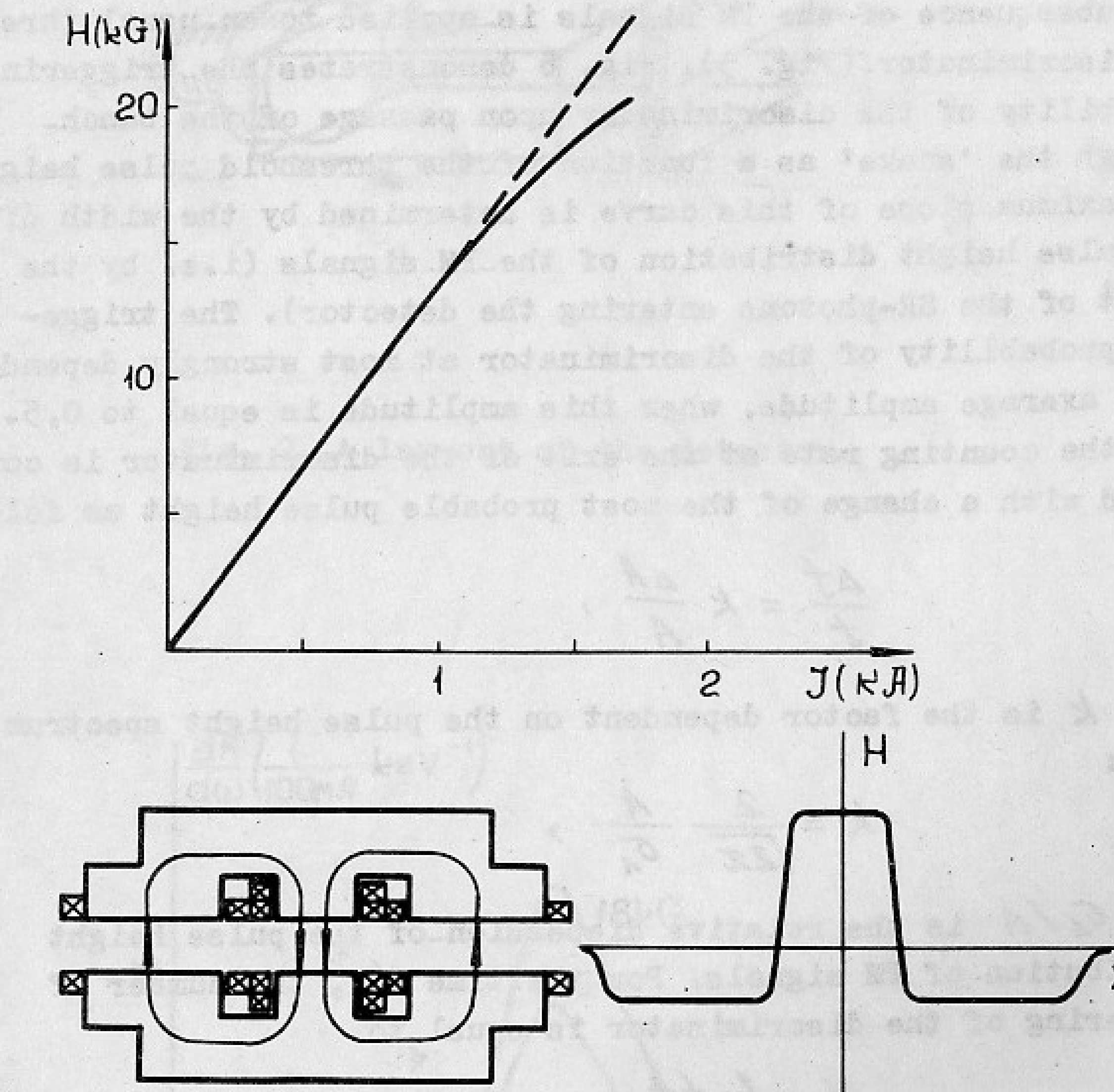

Fig. 1. The field vs. the current in the 'snake'. A schematic of the 'snake' and the field distribution along its axis are shown below.

scintillator. The width of the pulse height spectrum of the PM signals is determined by statistical fluctuations of the number of photons which have interacted in the detector. For comparison of the SR intensity from two bunches in the storage ring, the subsequence of the PM signals is applied to an usual threshold discriminator (Fig. 5). Fig. 6 demonstrates the triggering probability of the discriminator upon passage of the bunch through the 'snake' as a function of the threshold pulse height. The maximum slope of this curve is determined by the width of the pulse height distribution of the PM signals (i.e. by the amount of the SR-photons entering the detector). The triggering probability of the discriminator at most strongly depends on an average amplitude, when this amplitude is equal to 0,5. Here the counting rate at the exit of the discriminator is connected with a change of the most probable pulse height as follows:

$$\frac{\Delta f}{f} = k\,\frac{\Delta A}{A},$$

where k is the factor dependent on the pulse height spectrum width:

$$k = \frac{2}{\sqrt{2\pi}}\,\frac{A}{\sigma_A},$$

where σ_A/A is the relative dispersion of the pulse height distribution of PM signals. For the time t, the number of triggering of the discriminator is equal to

$$N = \frac{1}{2} f_0 t,$$

where f_0 is the revolution frequency. The statistical error is

$$\sigma_N = \sqrt{\frac{N}{2}}.$$

Thus the method enables the effect $\Delta I/I = 5\cdot 10^{-5}$ to be measured during the time

$$t \gtrsim \frac{1}{f_0}\,\frac{\sigma_A^2}{A^2}\,\frac{I^2}{(\Delta I)^2} \simeq 1\,sec.$$

For measuring a relative variation in the SR intensity from two bunches by this method, the mean pulse heights of the signals from the beams need to be equalized to an accuracy not worse than the width of the pulse height spectrum. In the expe-

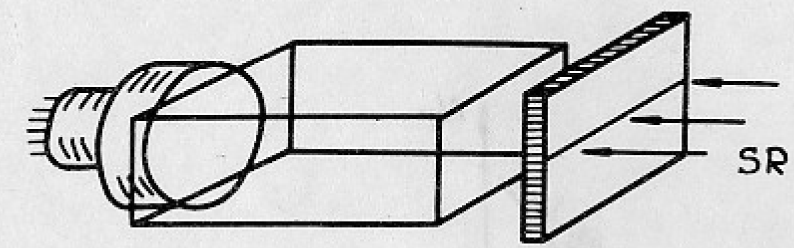

Fig. 2. A lay-out of the detector.

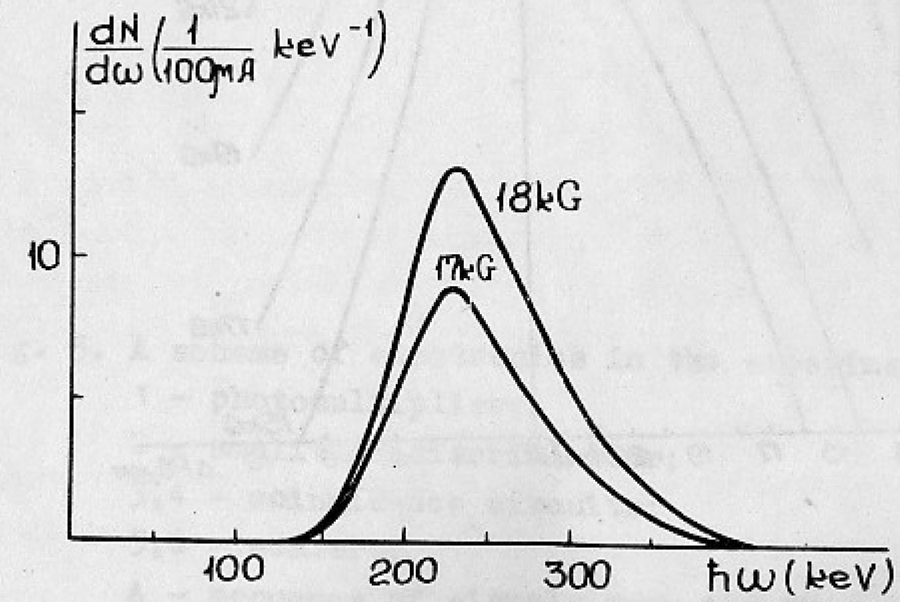

Fig. 3. The spectrum of SR photons passed through a filter (Pb, 4 mm) and interacted in the detector.

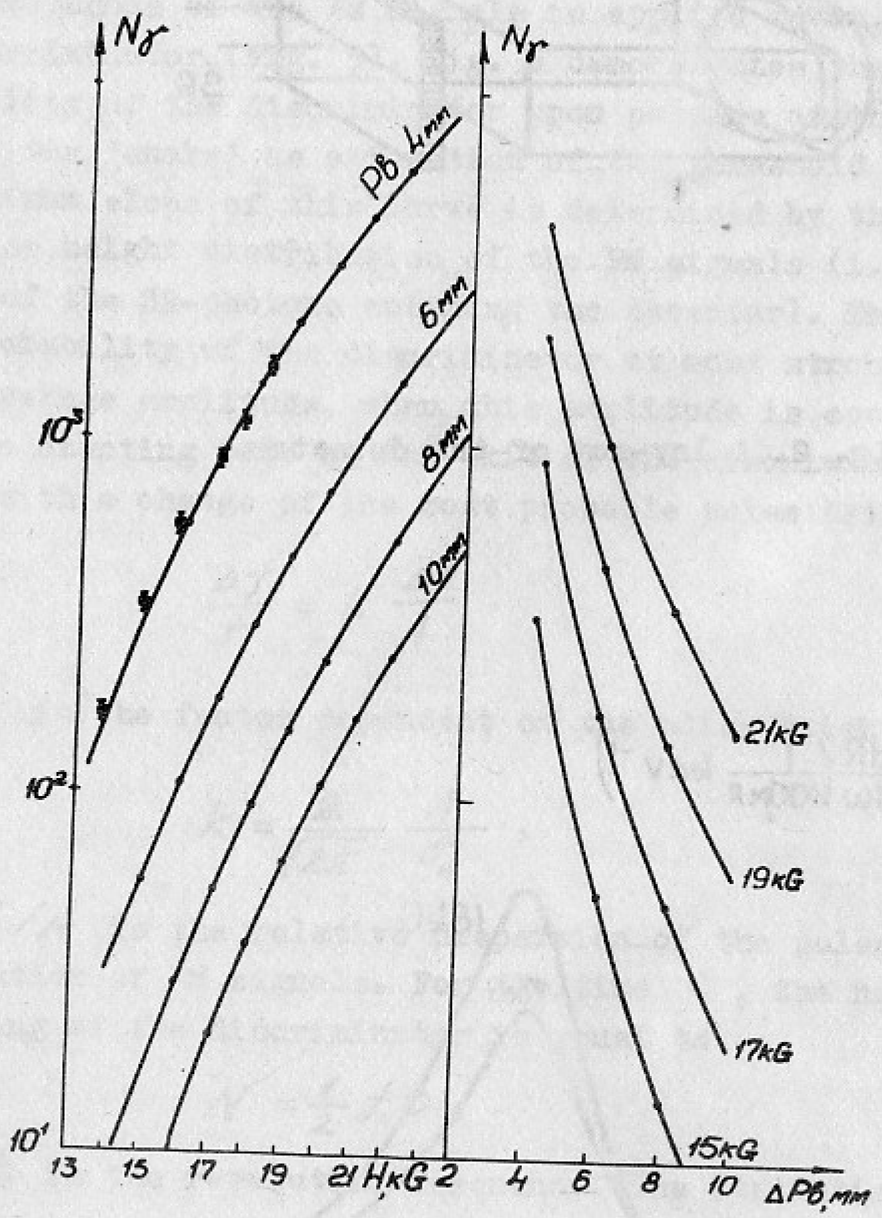

Fig. 4. The number of SR photons arrived at the detector in passing of the bunch of positrons through the 'snake' as a function of the field in the 'snake' and converter thickness. The number of positrons in the bunch is $0.8 \cdot 10^9$ (current 100μA energy 5150 MeV). The calculated and measured values are denoted by points and squares, respectively.

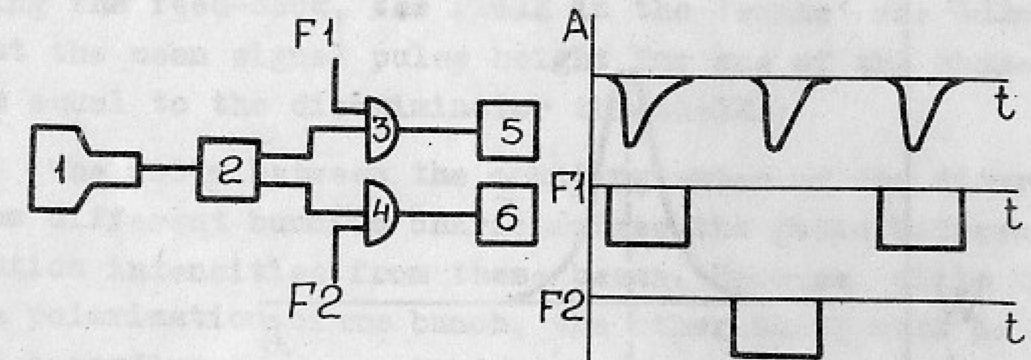

Fig. 5. A scheme of electronics in the experiment.
1 - photomultiplier;
2 - amplitude discriminator;
3,4 - coincidence circuits;
5,6 - scalers;
A - sequence of signals from the PM;
F1, F2 - control signals synchronized with the moment of bunch passage through the 'snake'.

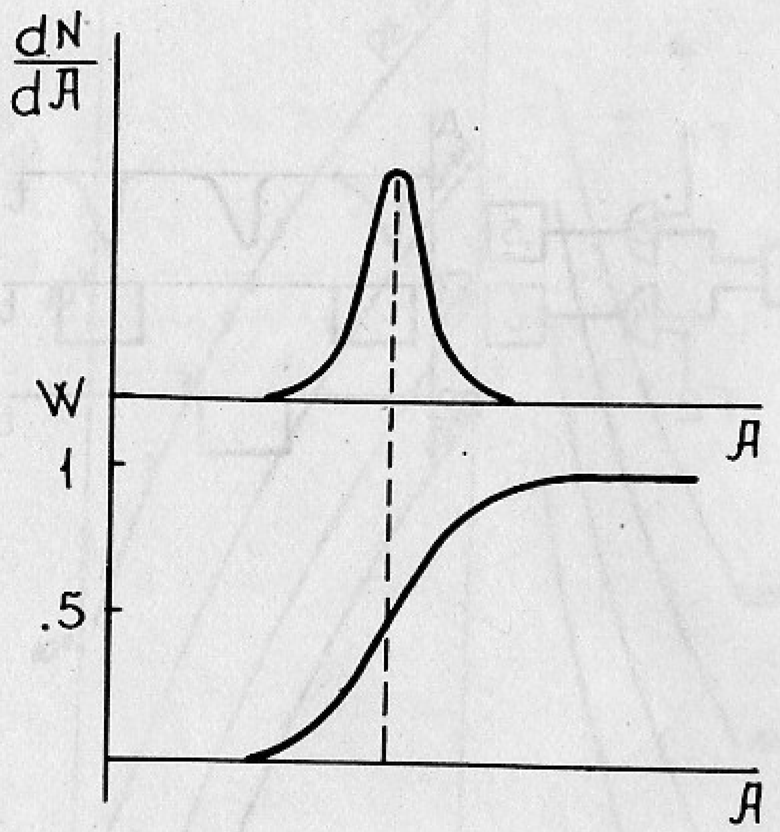

Fig. 6. The amplitude spectrum of PM signals and the dependence of the probability (W) of discriminator triggering with variation of the threshold (A).

riments, the pulse system exciting the beam coherent transverse oscillations have been used, which is intended for bunch equalization. At the moment of passage of a large bunch, a high--voltage pulse was applied to the special plates. A small fraction of the particles in the bunch was lost in the vertical probe, placed closely to the beam, as a result of such kick. The kicks (with a frequency of several times per minute) repeated until the detector signals from both bunches were equalized. Using the feed-back, the field in the 'snake' was maintained that the mean signal pulse height for one of the chosen beams was equal to the discriminator threshold.

The ratio between the counting rates of the discriminator from different bunches characterizes the ratio between the radiation intensities from these beams. Because while keeping the polarization of one bunch, the other bunch must be depolarized according to our method of measurements, a special selective depolarizer has been designed and built up. The principle of its performance is described in the following Section.

3. Depolarizer

A forced depolarization of the beam can be performed with the help of a periodical transverse electromagnetic field introduced at some place in one of the storage ring sections. Technically, it is convenient, for this purpose, to use a TEM-wave created by a pair of vertically-separated conducting plates connected to a r.f. generator. In these experiments the free plates from the VEPP-4 electrostatic beam separation system have been employed.

Let the magnetic field in the TEM-wave vary with time according to the law:

$$H(t) = H_0 \cos 2\pi \int (f_d + \Delta f_d \cos f_m t)\, dt$$

then, if the wave frequency f_d and the frequency modulation depth Δf_d fulfil the condition

$$| f_d \pm f_s + k f_0 | < \Delta f_d \ ,$$

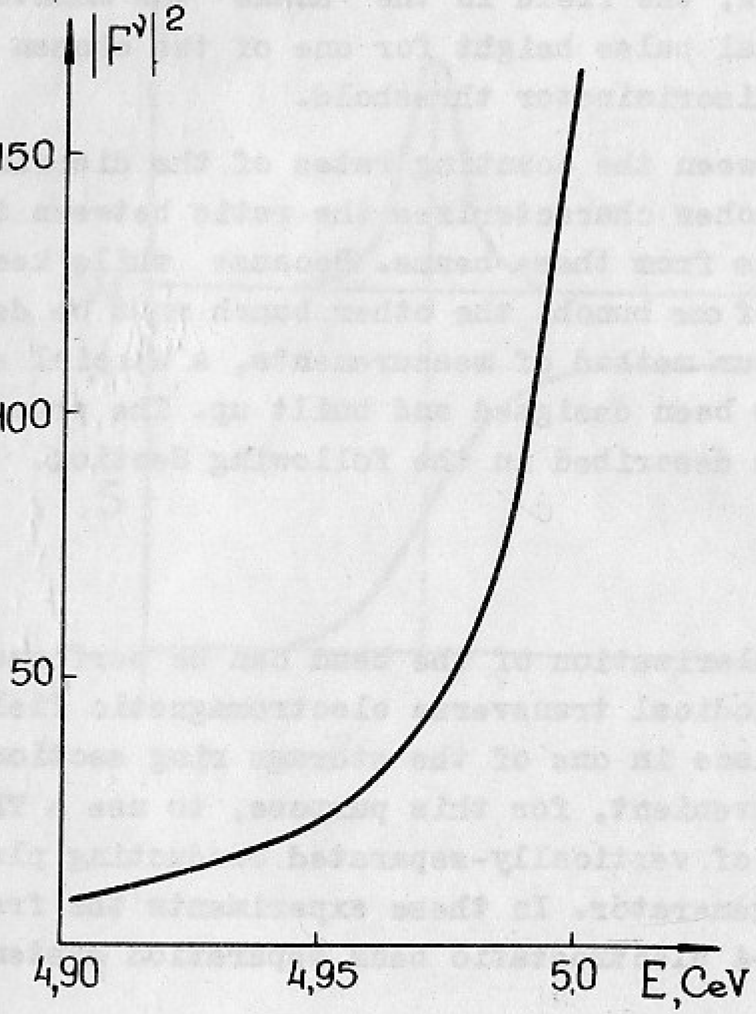

Fig. 7. The factor $|F^\nu|^2$ at the place of localization of the depolarizer plates as a function of the energy E.

where f_s is the spin precession frequency in the storage ring, f_0 is the revolution frequency and K is an integer, periodical crossings of the spin resonance occur. Under the assumption that these crossings are rapid and uncorrelated, the beam depolarization time τ_d is calculated by means of the formula /8/:

$$\tau_d^{-1} = \frac{(q' H_0 l f_0)^2}{2\pi \Delta f_d} |F^\nu|^2 , \qquad (3)$$

where $q' \simeq 10^{-3}$ e/mc is the anomalous part of the gyromagnetic electron ratio, l is the length of every plate and $|F^\nu|^2$ is the squared magnitude of the spin response function at the place of localization of the depolarizer plates. That the factor $|F^\nu|^2$ in the expression for τ_d is not equal to unity is explained by taking into account the integral depolarizing effect of the vertical particle oscillations excited by a transverse wave field. Fig. 7 presents the calculational results dealing with the factor $|F^\nu|^2$ at the place of localization of the depolarizer plates at the VEPP-4.

The limits of validity of the expression (3) for τ_d are determined by the following conditions.

The passings of the spin resonance are quick if

$$f_m \tau_d \gg 1 , \qquad (4)$$

where the value of τ_d is taken from formula (3). The uncorrelated nature of the successive spin resonance passings may be connected either with the natural noises of the r.f. generator or with the diffusion of the spin precession phase because of the quantum fluctuations of synchrotron radiation. For instance, in the first case the correlation condition is of the form

$$\Delta f_n > f_m , \qquad (5)$$

where Δf_n is the noise spread of the depolarizer frequency.

If the conditions (4) and (5) are fulfilled, the degree of polarization, with the depolarizer being switched on, decreases by $(1 + \tau_p/\tau_d)$ times during the time $\tau_p \tau_d/(\tau_p + \tau_d)$,

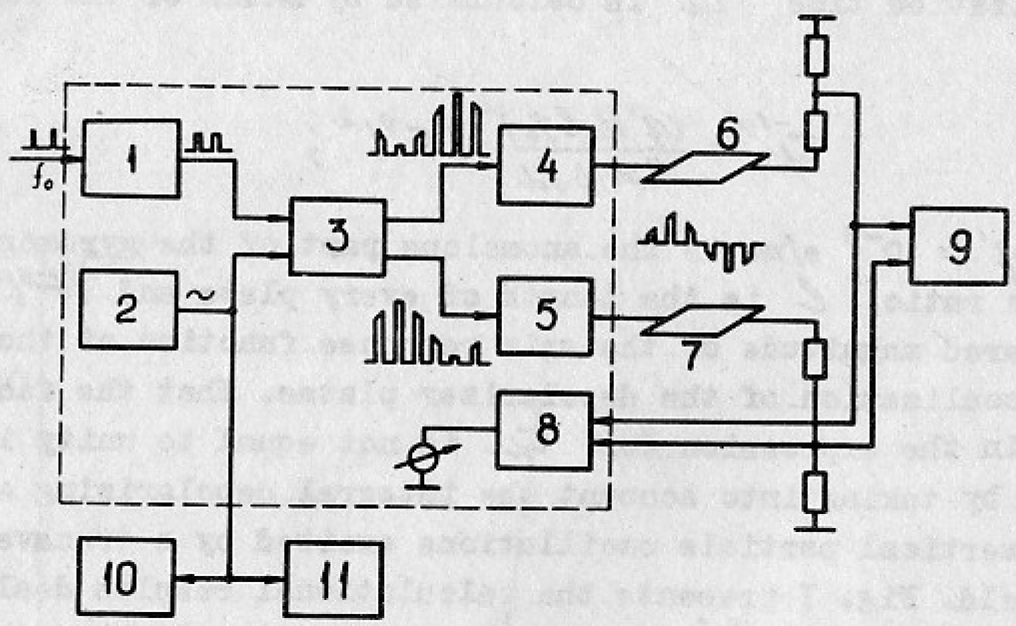

Fig. 8. A block diagram of the selective depolarizer.

1 - pulse former;
2 - generator;
3 - modulator;
4,5 - output amplifiers;
6,7 - plates;
8 - circuit for measuring the signal amplitude;
9 - oscilloscope;
10 - frequency meter;
11 - spectrum analyser.

where τ_p is the time of radiative polarization in the storage ring. Thus only under the condition $\tau_d \ll \tau_p$ one can say that the complete beam polarization with the relaxation time τ_d takes place.

A forced depolarization of only one of the bunches, which rotate in the storage ring one after another, can be provided by applying voltage, with the particle revolution frequency f_0 , to the plates. The pulse length is substantially less than the distance between the bunches. The resonance depolarization is carried out due to the amplitude pulse modulation with the frequency of spin resonance. To this end, it is sufficient that the operating range of amplitude modulation frequency lie within $0 \div f_0/2$. While depolarizing one of the bunches, the second will remain polarized if the parameter τ_d , calculated for it from Eq. (3), is much larger than τ_p .

In our experiment, we have employed a selective depolarizer whose block diagram is shown in Fig. 8. It incorporates the plates for TEM-wave forming, the matching wave loads (50 ohm), the pulse generator and the signal control system.

The generator is started by the pulses with the frequency f_0 , which are supplied by the r.f. generator of the storage ring r.f. system and coincide, in time, with the passage of one of the bunches between the plates. The pulse duration is 100 ns, and the time constant is 25 ns. These parameters are due to the high-frequency properties of the elements of an output amplifier and provide a sufficient attenuation (more than by a factor of 10^3) of the pulse to the moment of the second bunch passage, the latter is shifted by a half-turn relative to the first (f_0 = = 818.8 kHz).

In the absence of amplitude modulation the voltage pulses, applied to each plate are equal $U_1 = U_2$ = 50 V (the time interval ranges from 0 to t_1 , Fig. 9). The beam depolarization becomes possible if the amplitude pulse-type modulation is applied at the time t_1 (Fig. 9). Then the envelope of the difference voltage changes according to the law:

$$U_1 - U_2 = U \cos 2\pi f_d t,$$

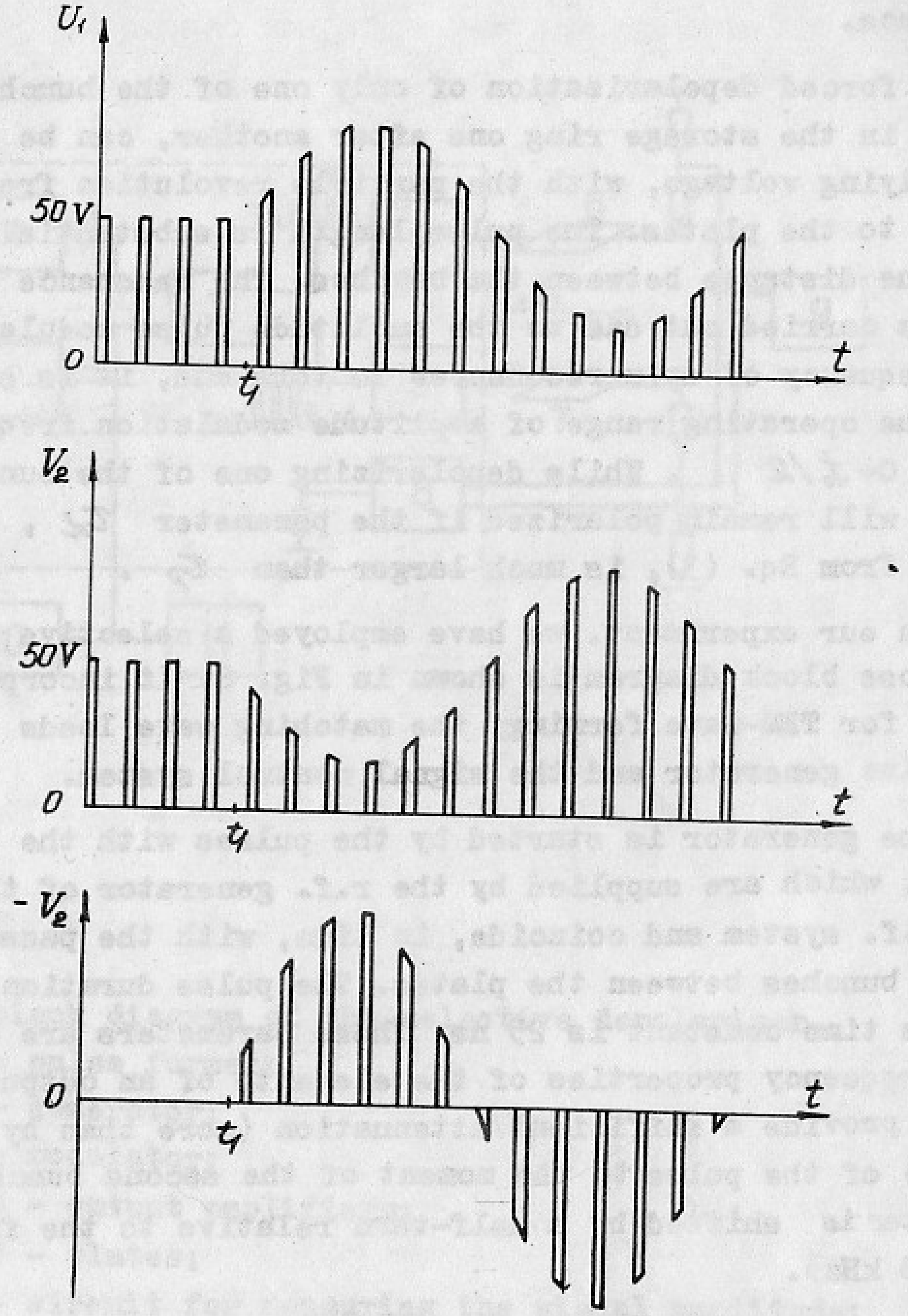

Fig. 9. Time diagrams of voltages at the plates.

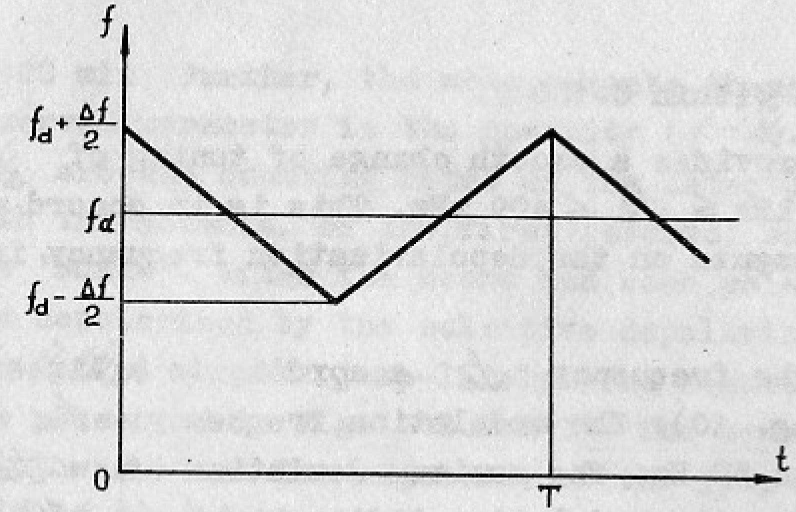

Fig. 10. The law of time-variation of the frequency when switching on the FM signal.

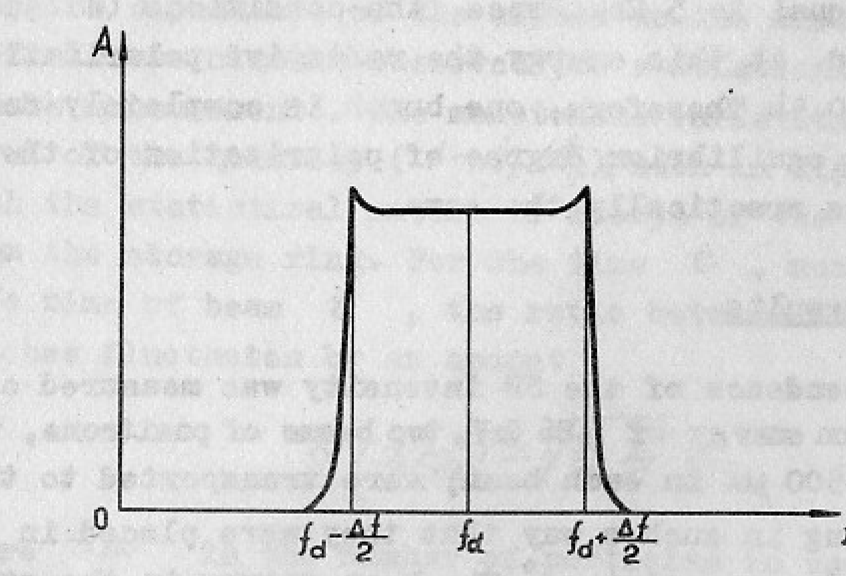

Fig. 11. The envelope of the spectrum for a signal with linear frequency modulation at large modulation indices.

where U is set within 0÷100 V.

The generator provides a smooth change of tuning of within the range 20 kHz $\leq f_d \leq$ 409 kHz. This is in accord with the physical requirements on the depolarization frequency interval.

Modulation of the frequency f_d according to a linear law is envisaged (Fig. 10). The modulation frequency f_m can vary from 5 Hz to 50 Hz. The maximum deviation of Δf_d is equal to 5 kHz. For the modulation indices $\Delta f_d / f_m \gg 10$, the typical shape of the spectrum envelope is shown in Fig. 11. The own width of the generator spectral line is $\Delta f_n \approx$ 100 Hz.

In our case, the length of the depolarize plates is ℓ = = 150 cm and the gap between them is 3.8. At a voltage amplitude of 40 B between the plates and with the amplitude of frequency modulation Δf_d = 1 kHz, the depolarization time τ_d, calculated by means of formula (3) at an energy of 4.98 GeV ($/F^{1/2}$= 73), is 10 s. In the experiments, the frequency f_m was taken to be equal to 5 Hz. Hence, the conditions (4) and (5) were fulfilled. At this energy the radiative polarization time constitutes 0.5h. Therefore, one bunch is completely depolarized whereas the equilibrium degree of polarization of the second bunch remains practically the same.

4. Measurements results

The spin dependence of the SR intensity was measured as follows. At an injection energy of 1.86 GeV, two beams of positrons, with the currents 200-500 μA in each beam, were transported to the VEPP-4 storage ring in such a way that they were placed in diametrically opposite separatrixes.* The beam energy in the storage ring was then increased to an operating one (5 GeV) and the field in the snake was switched on. The counting rate of the signals generated by the discriminator permitted one to find out what bunch is larger and the counting rates were equalized to an accuracy better than 10^{-3} by controlling a power of the hit at one of the bunches. The procedure of current equalization took about

* The utilization of so low currents in the measurements is connected only with the technical details of the 'snake' localization at the VEPP-4.

10÷20 min. Further, the measurements themselves were made. The observed parameter is the quantity $(1-\dot{N}_1/\dot{N}_2)$ where $\dot{N}_1$ and $\dot{N}_2$ are the counting rates of the detector in coincidence with the moments, of the first (second) bunches passage through the 'snake'. After the beams had been polarized, one of them was depolarized by the selective depolarizer. The quantity $(1-\dot{N}_1/\dot{N}_2)$ varies jump-likely. The results of our measurements are presented in Figs. 12 and 13. The measurement time at each point was 60 s. The magnitude of the jump is equal approximately to ten statistical errors. With the depolarizer switched off, the authors observed the beam polarization to recover.

To observe the dependence of the effect on the sign of the spin projection onto the magnetic field direction, the measurements were made of the quantity $(1-\dot{N}_1/\dot{N}_2)$ with periodical changes of a sign of the snake field. The results are given in Fig. 14. The measurement at each point took 50 s. The sign reversal of the 'snake' field occured in 120 s and the measurement process was repeated. Once one of bunches had been polarized, the dependence of the effect on the direction of the snake field was clearly observed (20 statistical errors during a minute measurement). The monotonous variation in the average level of the quantity $(1-\dot{N}_1/\dot{N}_2)$, seen in Fig. 14, is connected with the statistical nature of escape of the beam particles from the storage ring. For the time t, much less than the life time of beam τ, the ratio between the currents in two bunches fluctuates by an amount

$$\sigma(\mathcal{I}_1/\mathcal{I}_2) \simeq \sqrt{\frac{2}{n}\frac{t}{\tau}},$$

where n is the number of particles in each bunch. In our case, $n = 3\cdot 10^9$, $\tau = 10^5$ and $t = 10^4$; therefore, the current ratio, $\mathcal{I}_1/\mathcal{I}_2$ is possible to be made equal to $8\cdot 10^{-6}$. This constitutes 20% of the effect measured. Since these slow changes in the counting rate are independent of the direction of the 'snake' field, they can be calculated and taken into account if one constructs the time dependence of the half-sum neighbouring values of $(1-\dot{N}_1/\dot{N}_2)$ at different directions of the field in the 'snake'. Fig. 15 presents the experimental data shown in Fig. 14 after their processing by this method.

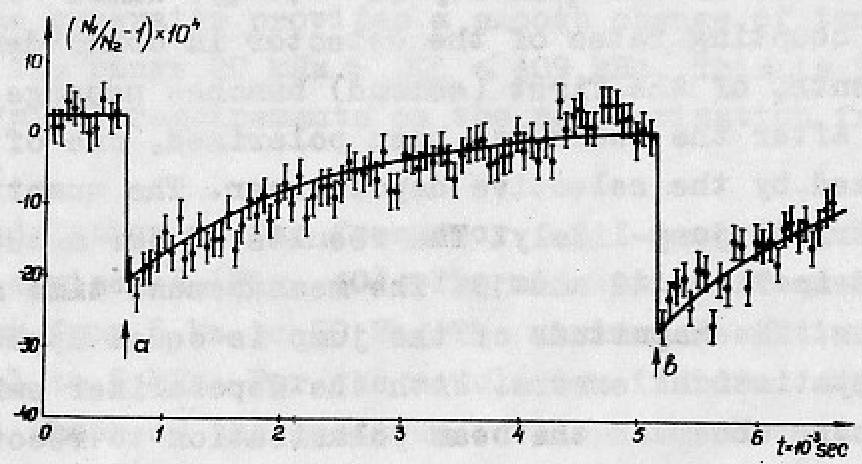

Fig. 12. The measurement results of the SR intensity as a function of the polarization degree of the beam. The field in the 'snake' coincides, in direction, with the storage ring guiding field. At points a and b one of the bunches (N_1) was quickly depolarized. The measurement time at a point is 60 s. The bunch polarization time is $\tau_p = 1740 \pm 20$ s ($\zeta = 0.726$).

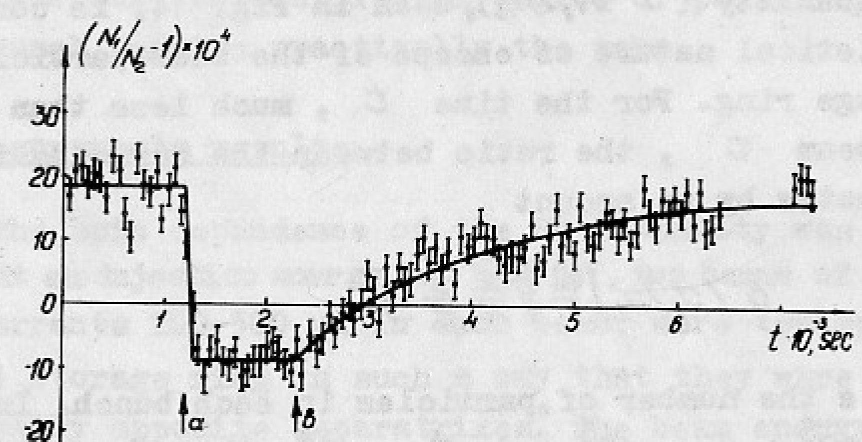

Fig. 13. The measurement results similar to those presented in Fig. 12. Point a corresponds to the moment of switching on the depolarizer and at point b the depolarizer is switched off (between these points the depolarizer remains switched on). The polarization time is $\tau_p = 1800 \pm 20$ s ($\zeta = 0.751$).

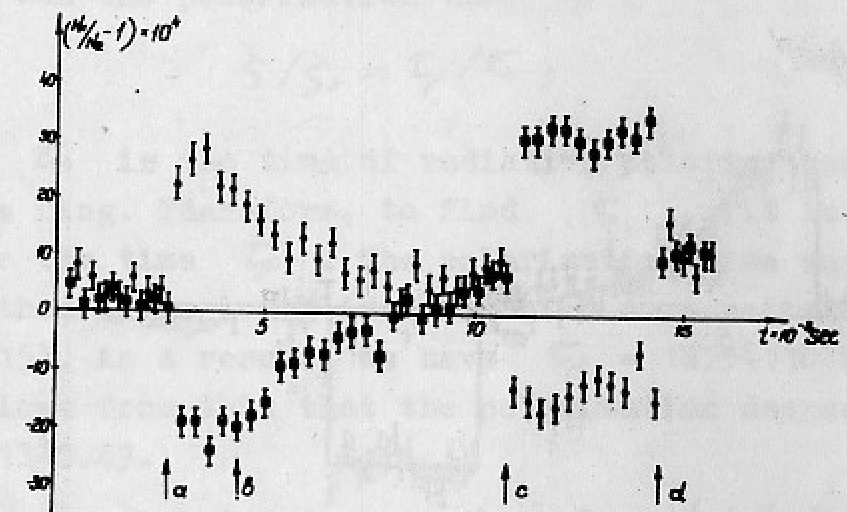

Fig. 14. The measurement results of the SR intensity vs. the field direction in the 'snake':

$\bar{\bar{\Phi}}$ - the sign of the field in the 'snake' central gap coincides with the sign of the storage ring guiding field;

$\bar{\Phi}$ - the sign of the field in the 'snake' is opposite.

Within the time interval (a, b) the first bunch is depolarized. In the time interval (b, c) the depolarizer is switched off. Within the time interval (c, d) the second bunch is depolarized. Starting with the moment d both bunches are depolarized simultaneously.

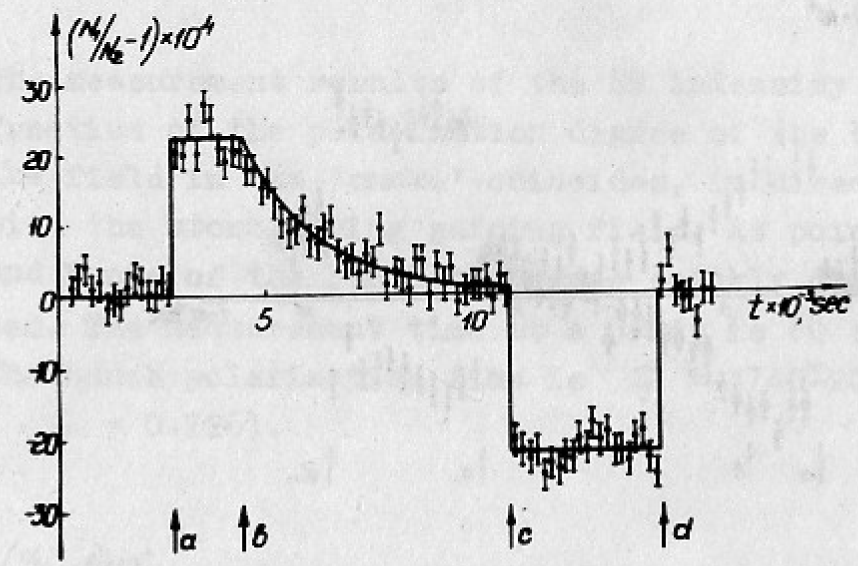

Fig. 15. The results of processing the measurements presented in Fig. 14 with allowance for the change in the ratio of the number of particles in the bunches, which is due to statistical fluctuations. The polarization time was fitted in the section $b \div c$: $\tau_p = 1825 \pm 110$ s; this corresponds to the polarization degree $\zeta_\tau = 0.713 \pm 0.043$. The jump on the section $c \div d$ is equal to $\Delta = 22.07 \pm 0.4 \times 10^{-4}$ ($k = 66 \pm 0.5$); this yields the polarization degree $\zeta_\Delta = 0.691 \pm 0.02$ ($\zeta_\tau / \zeta_\Delta = 1.032 \pm 0.067$).

It is possible to compare the magnitude of the observed effect with its calculated value, basing upon the data obtained. To this end, the polarization degree of the beam at the time of measurement must be known. The degree of equilibrium polarization of the beam in an storage ring is known and is equal to ζ_o. Because the imperfections in the storage ring magnetic structure exert a depolarizing effect, the equilibrium degree of polarization ζ is always less than ζ_o and its value can be predicted from calculations only in a probabilistic fashion. However, there is the exact relation between ζ and the polarization time τ_p:

$$\zeta / \zeta_o = \tau_p / \tau_o ,$$

where τ_o is the time of radiative polarization in an ideal storage ring. Therefore, to find ζ, it is sufficient to measure the time τ_p. The polarization time was matched by the method of maximum likelyhood for some points of section (bc) (Fig. 15). As a result, we have $\tau_p = 1825 \pm 110$ s and $P(\chi^2) = 70\%$. It follows from this that the polarization degree ζ of the beam is 0.713 ± 0.43.

For an expected jump in the value of $(1 - \dot{N}_1/\dot{N}_2)$ to be calculated, the amplification factor (k) in the relation

$$(1 - \dot{N}_1 / \dot{N}_2) = k \, (1 - W_1 / W_2)$$

must be known as well (W_1 and W_2 are the SR intensities from the first and second bunches respectively). As has already been mentioned, the quantity (k) depends on the number of SR photons arrived at the detector during a single passage of the beam through the 'snake'. The k was measured as follows. The dependence was found of the ratio $(J_o - \dot{N}_1)/J_o$ on the mean current of the PM upon variation of the field in the 'snake'. Just the derivative of this dependence at the point $\dot{N}_1 = J_o/2$ determines the value of k. The k^2 against the calculated number of photons detected is plotted in Fig. 16. The linear dependence is observed. This indicates that the value of k is indeed determined by statistical fluctuations of the number of photons, N_γ, entering the detector. In the course of the measurements shown in Figs. 14 and 15, the value of $k = 66 \pm 0.5$.

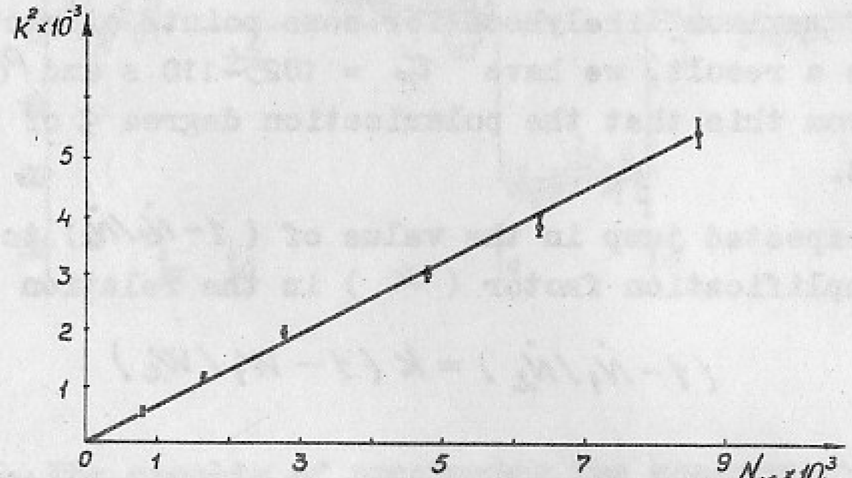

Fig. 16. The dependence of k^2 on the calculated amount of photons interacted in the detector (N_γ).

With the factor k being known, one can find the amount of photons entering the detector. For ζ = 0.713 and k = 66, the expected jump in $\Delta(1-\dot{N}_1/\dot{N}_2)$ was calculated to be equal

$$\Delta(1-\dot{N}_1/\dot{N}_2)_{th} = 22.78 \; 10^{-4}$$

in agreement with the results of computer simulation of an interaction between the SR-photons and the detector matter. The ratio of the calculated magnitude of the effect to its experimental value is

$$\frac{\Delta(1-\dot{N}_1/\dot{N}_2)_{th}}{\Delta(1-\dot{N}_1/\dot{N}_2)_{exp}} = 1.034 \pm 0.067$$

The above error is mainly determined by an error in the measurement of the polarization time. Thus the conclusion is possible to be drawn that the observed variation in the SR intensity, while the beam is being depolarized, is in agreement with a calculated one.

In conclusion, it is worth noting that, as the results of the present work show, the observation of the spin dependence of SR is an effective method for measuring the degree of transverse beam polarization in electron-positron storage rings. This method is even more attractive at high energies, 10÷100 GeV, because the magnitude of the effect raises with energy. Owing to a short time of response, low sensitivity to the beam parameters and the orbit stability, this method is suitable to a work on the revealing and compensation of the depolarizing effect of the imperfections of a storage ring magnetic field. Most of the modern storage rings are characteristic of the multi-bunch mode of operation, and therefore, the technique described above is also applicable for checking the particle polarization in high-energy physics experiments on colliding beams.

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