EPR paradox and a neutron experiment to reject it

Ignatovich V.K.

JINR FLNP

ISINN21 23.05.2013

12:05-12:30

EPR paradox

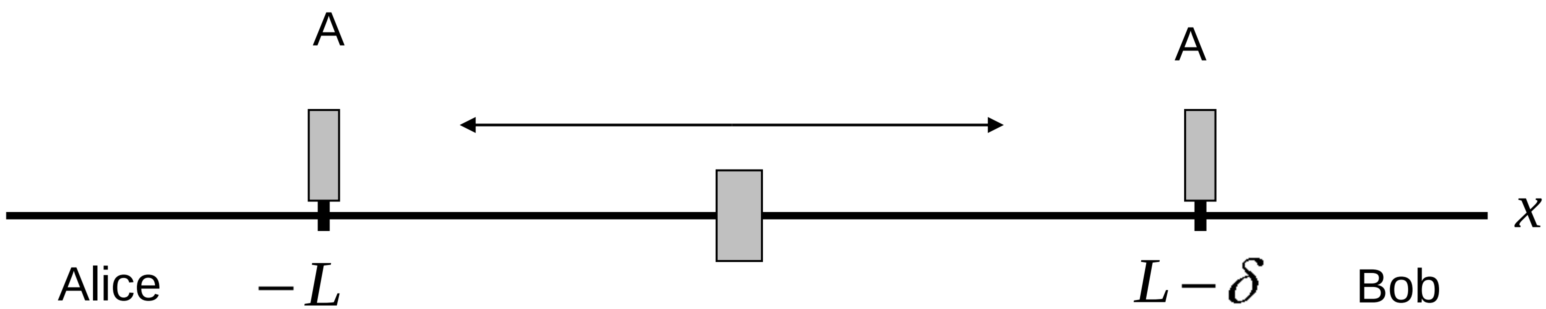
Let's imagine a fission of a nucleus with zero spin in two particles with spin ½. The spin function of two particles is

$$\left|\psi_0\right\rangle = \frac{1}{\sqrt{2}}\left(\left|u,d\right\rangle - \left|d,u\right\rangle\right)$$

or

$$\left|\psi_0\right\rangle = \frac{1}{\sqrt{2}}\left(\left|\mathbf{a},-\mathbf{a}\right\rangle - \left|-\mathbf{a},\mathbf{a}\right\rangle\right)$$

According to EPR: if Bob puts his analyzer along a direction **b,** he immediately defines quantization axis along **b** near Alice.



$$|\psi_A\rangle = |\mathbf{b}\rangle \qquad\qquad |\psi_B\rangle = |\mathbf{b}\rangle$$

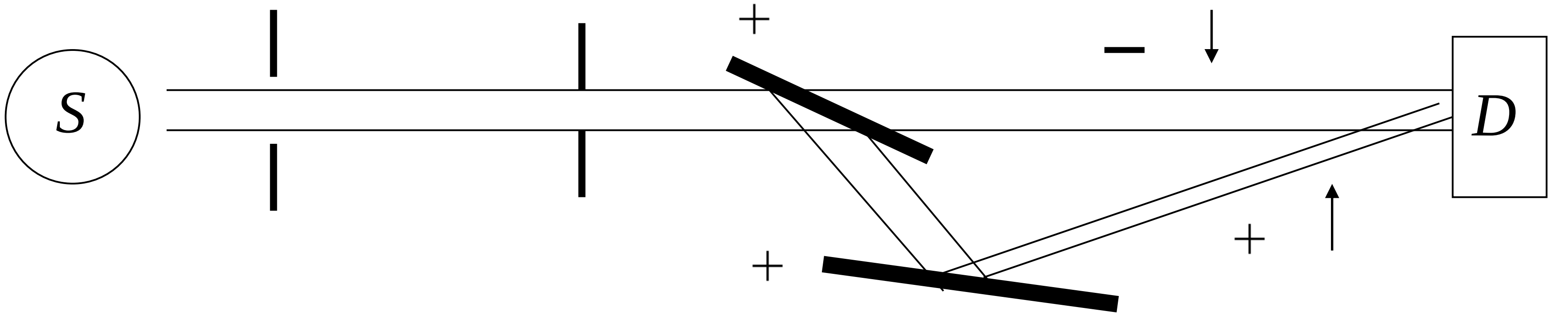
However Bob is unable to send a signal in this way, because particles at Alice's side are not polarized along this axis

$$\rho_A = \frac{1}{2}\left(|\mathbf{b}\rangle\langle\mathbf{b}| + |-\mathbf{b}\rangle\langle-\mathbf{b}|\right)$$

Since Alice is unable to see the quantization axis, she is unable to get a signal from Bob.

I'll show that she is able, so Bob can send a signal with a superluminal speed. Therefore relativity or entanglement is wrong.

An experiment 1



$$N_+ = N_- = N$$

Countrate $N_+ + N_- = 2N$

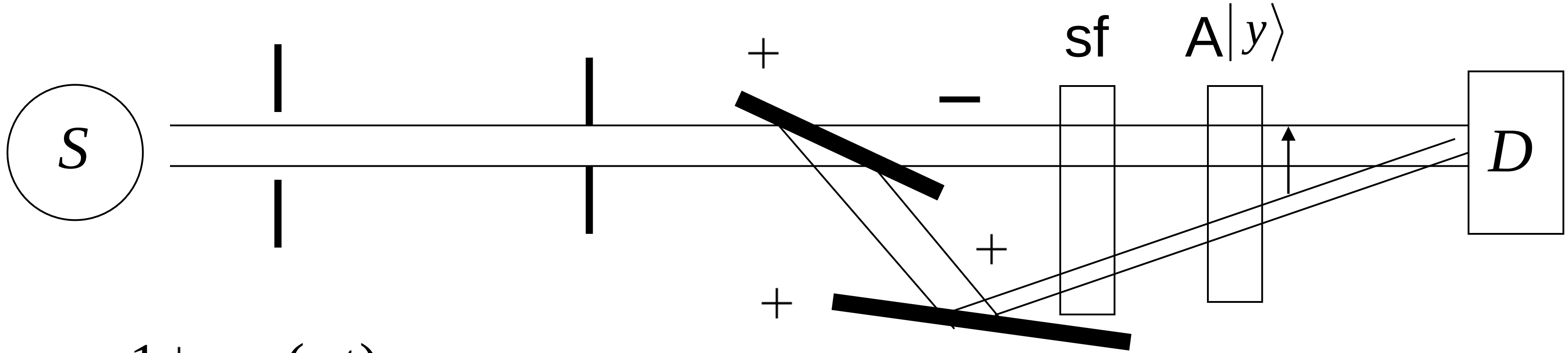
Dispersion

$$\Delta(2N) = \sqrt{\delta N_+^2 + \delta N_-^2} = \sqrt{N_+ + N_-} = \sqrt{2N}$$

Experiment 2

$$N_{\pm} = N\,\frac{1 \pm \cos(\omega t)}{2}$$

countrate $N_{+}+N_{-}=N$



$$\delta N_{\pm} = \delta N\,\frac{1 \pm \cos(\omega t)}{2}$$

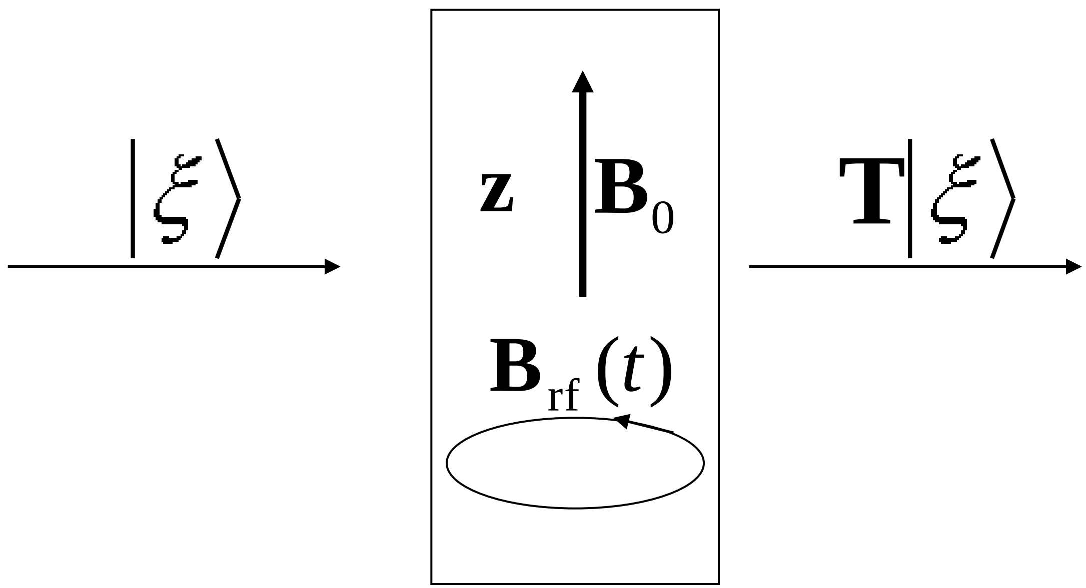
Dispersion

$$\Delta(2N) = \sqrt{\delta N_{+}^{2} + \delta N_{-}^{2}} = \sqrt{\frac{N}{2}\left(1 + \cos^{2}(\omega t)\right)}$$

$$2\left(N_{\text{эксп}} - N\right)^{2} / N = 1 + \cos^{2}(\omega t)$$

Let's check

Radiofrequency spin-flipper



$$\mathbf{B}_{rf} = b\left(\cos(\omega t), \sin(\omega t), 0\right)$$

Quantization axis of the flipper is along $\mathbf{B}_0$

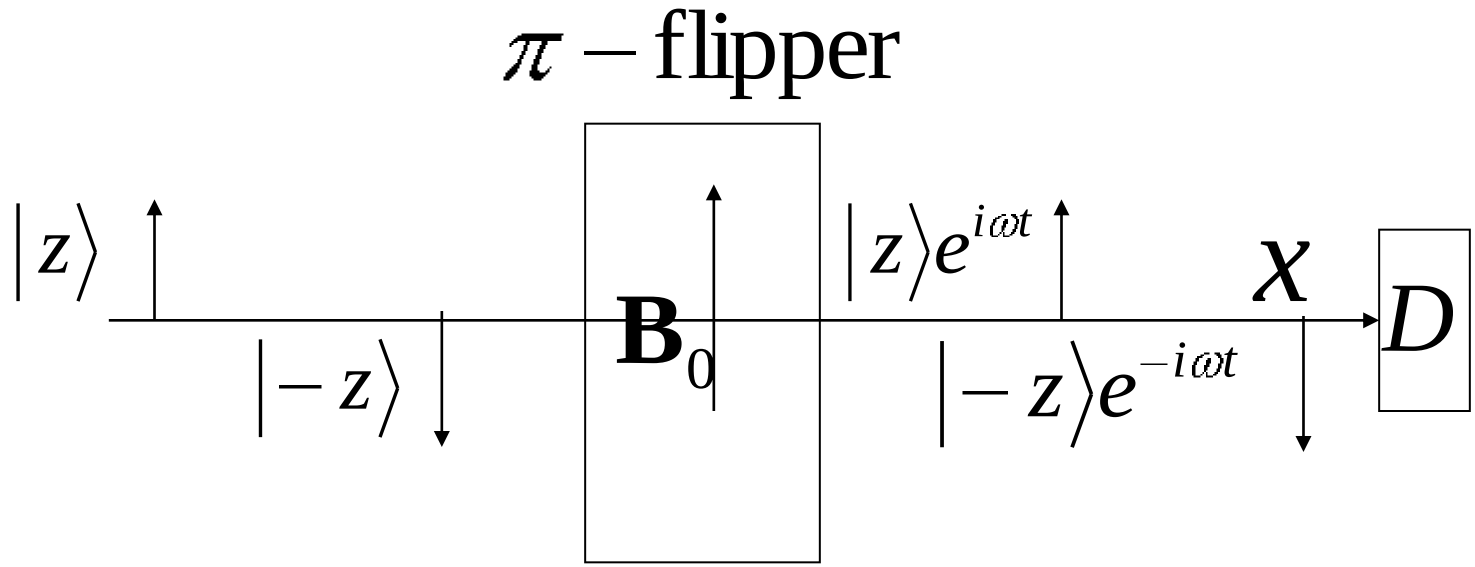
When a neutron with $\boldsymbol{\mu}||\mathbf{B_0}$ enters the field

- It accelerates because of interaction $-\boldsymbol{\mu}\cdot\mathbf{B_0}<0$, which is equivalent to a potential well of the depth μB_0
- R.f. field inside the flipper flips $\boldsymbol{\mu}$ to $-\boldsymbol{\mu}$
- Now $-\boldsymbol{\mu}\cdot\mathbf{B_0}>0$ – becomes a barrier of the height μB_0
- When the neutron exits the barrier it accelerates again.
- The total energy increases by $2\mu B_0$
- Which is equivalent to absorption of a photon of energy $\hbar\omega = 2\mu B_0$

When a neutron with $\boldsymbol{\mu}||-\mathbf{B_0}$ enters the field

- It decelerates because of interaction $-\boldsymbol{\mu}\cdot\mathbf{B_0}<0$, which is equivalent to a potential barrier of the height μB_0
- R.f. field inside the flipper flips $\boldsymbol{\mu}$ to $-\boldsymbol{\mu}$
- Now $-\boldsymbol{\mu}\cdot\mathbf{B_0}>0$ – becomes a well of the depth μB_0
- When the neutron exits the well it decelerates again.
- The total energy decreases by $2\mu B_0$
- Which is equivalent to emission of a photon of energy $\hbar\omega = 2\mu B_0$

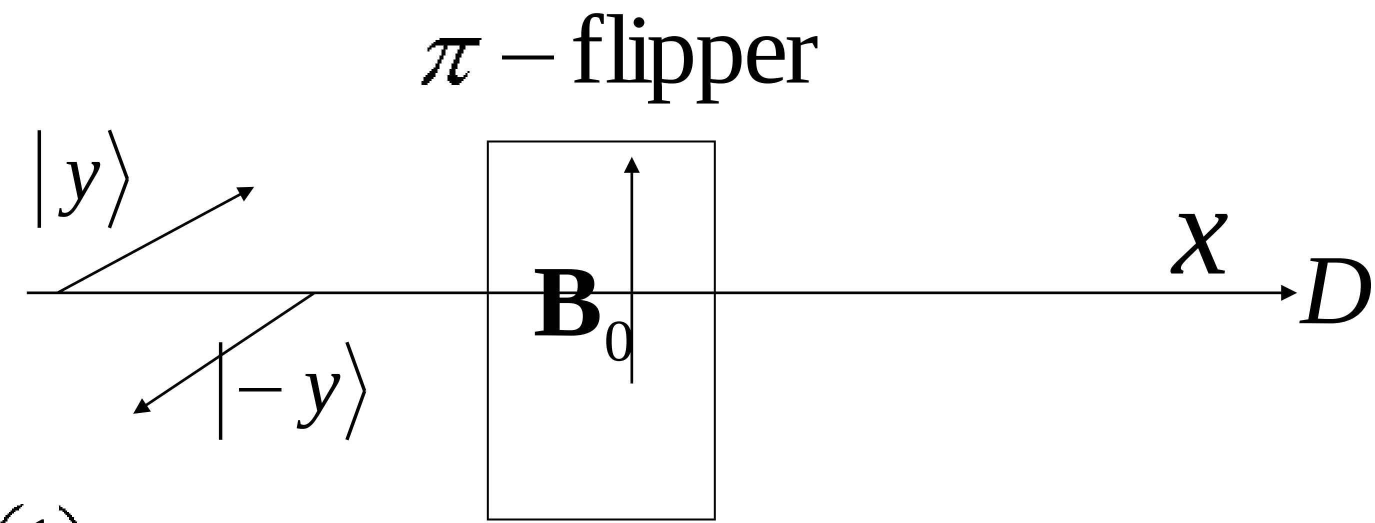
If quantization axis of the incident neutron is along z, then



A spectrometry permits to find polarization of the incident neutron.

But it is not important for us now

If quantization axis of the incident neutron is along y, then



$$|y\rangle = \frac{1}{\sqrt{2}}\begin{pmatrix}1\\ i\end{pmatrix} = \frac{1}{\sqrt{2}}\left(|u\rangle + i|d\rangle\right) \Rightarrow \frac{1}{\sqrt{2}}\left(|d\rangle e^{i\omega t} + i|u\rangle e^{-i\omega t}\right)$$

$$|-y\rangle = \frac{1}{\sqrt{2}}\begin{pmatrix}1\\ -i\end{pmatrix} = \frac{1}{\sqrt{2}}\left(|u\rangle - i|d\rangle\right) \Rightarrow \frac{1}{\sqrt{2}}\left(|d\rangle e^{i\omega t} - i|u\rangle e^{-i\omega t}\right)$$

$$\left(|y\rangle + |-y\rangle\right)/\sqrt{2} = |u\rangle \qquad -i\left(|y\rangle - |-y\rangle\right)/\sqrt{2} = |d\rangle$$

Some trivial algebra

$$|y\rangle = \frac{1}{\sqrt{2}}\begin{pmatrix}1\\ i\end{pmatrix} = \frac{1}{\sqrt{2}}\left(|u\rangle + i|d\rangle\right) \Rightarrow \frac{1}{\sqrt{2}}\left(|d\rangle e^{i\omega t} + i|u\rangle e^{-i\omega t}\right)$$

$$|-y\rangle = \frac{1}{\sqrt{2}}\begin{pmatrix}1\\ -i\end{pmatrix} = \frac{1}{\sqrt{2}}\left(|u\rangle - i|d\rangle\right) \Rightarrow \frac{1}{\sqrt{2}}\left(|d\rangle e^{i\omega t} - i|u\rangle e^{-i\omega t}\right)$$

$$|u\rangle = \left(|y\rangle + |-y\rangle\right)/\sqrt{2} \qquad |d\rangle = -i\left(|y\rangle - |-y\rangle\right)/\sqrt{2}$$

$$\frac{1}{\sqrt{2}}\left(|d\rangle e^{i\omega t} + i|u\rangle e^{-i\omega t}\right) = \frac{-i}{2}\left[\left(|y\rangle - |-y\rangle\right)e^{i\omega t} - \left(|y\rangle + |-y\rangle\right)e^{-i\omega t}\right] =$$

$$= |y\rangle \sin(\omega t) + i|-y\rangle \cos(\omega t)$$

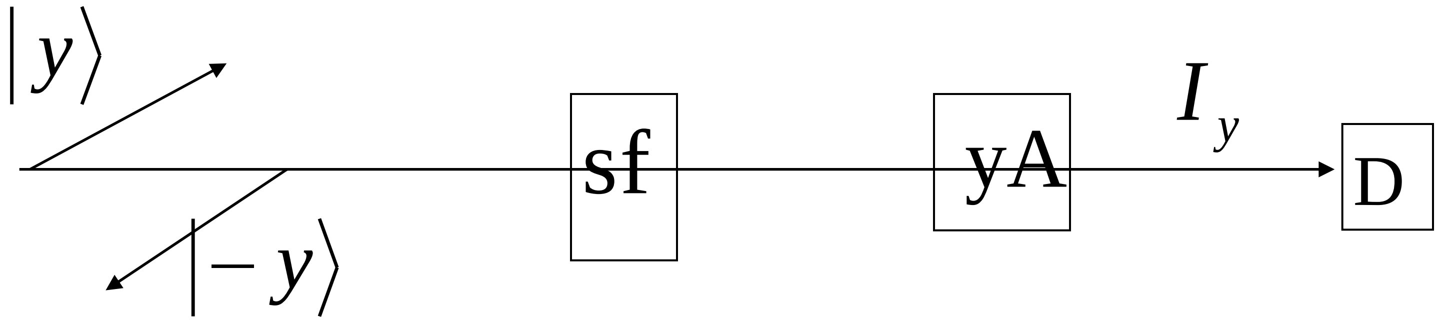
$$\frac{1}{\sqrt{2}}\left(|d\rangle e^{i\omega t} - i|u\rangle e^{-i\omega t}\right) = \frac{-i}{2}\left[\left(|y\rangle - |-y\rangle\right)e^{i\omega t} + \left(|y\rangle + |-y\rangle\right)e^{-i\omega t}\right] =$$

$$= -i|y\rangle \cos(\omega t) + |-y\rangle \sin(\omega t)$$

The result

$$|y\rangle \Rightarrow |y\rangle \sin(\varpi t) + i|-y\rangle \cos(\varpi t)$$

$$|-y\rangle \Rightarrow -i|y\rangle \cos(\varpi t) + |-y\rangle \sin(\varpi t)$$



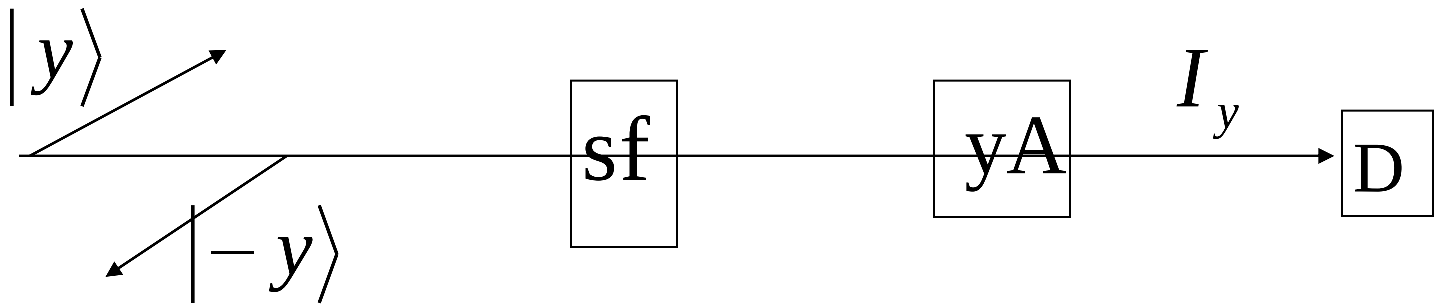
$$|y\rangle \Rightarrow I_y = N\sin^2(\varpi t) = N\frac{1-\cos(2\varpi t)}{2}$$

$$\langle I_y\rangle = I_y(+) + I_y(-) = N$$

$$|-y\rangle \Rightarrow I_y = N\cos^2(\varpi t) = N\frac{1+\cos(2\varpi t)}{2}$$

$$I_0 = 2N$$

We can measure the uncertainty in time channels, then we can find oscillations



$$\langle I_y \rangle = I_y(+) + I_y(-) = N$$

$$\Delta(t) = \frac{\delta I_y^2(t)}{\langle I_y \rangle} = \frac{1+\cos^2(2\omega t)}{2}$$

So quantization axes z and y are not equivalent

The construction **Density matrix** is contradictory

So! Density matrix is an artificial element of QM, which can bring contradictions.

Let's note that in calculations of cross sections we use wave functions. Then we average the obtained cross section over statistical distribution of the initial pure states.

We don't use density matrix.

In fact, we can use it

But be careful.

EPR paradox and the physics around it is a cancer tumor on the splendid bode of science. If the proposed experiment will be successful, we will be able to cut off this tumor.

The statement in the title is evidently wrong at the modern level of knowledge.

The density matrix is not an auxiliary construction but a result of basic concepts of quantum mechanics.

More over, experience with this notion is huge and convincing.

As for the given paper, no doubt it contains an error.

It is in **inexactitude of wordings and reasonings**.

The problem is only how to find this error.

However it is a task for the author.

Referee of JETP Lett.

Thank you