Can Alice influence Bob? A new EPR experiment without correlation measurements.

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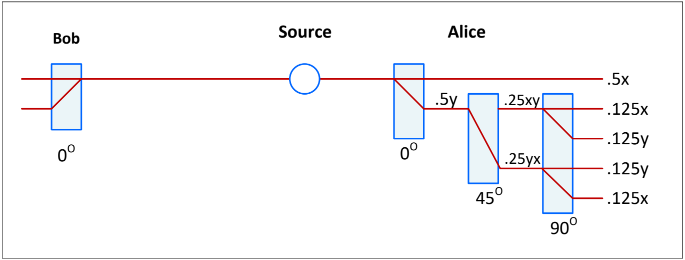
Presentation to the

Harbingers of Neophysics

Slide 2: The Experiment

Consider an EPR experiment, the source emits circular polarised and entangled photon pairs in opposite directions to Alice and Bob. Alice uses an asymmetrical 75:25 polariser.



Question: Are the photons Bob receives skewed 25:75?

Slide 3: What is a wave? (The d'Alembert wave equation)

Towne* states that the requirement for a physical condition to be referred to as a wave, is that its mathematical representation give rise to a partial differential equation of particular form, known as the wave equation. The classical form

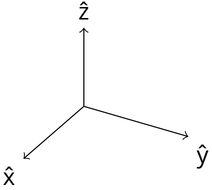
$$\frac{\partial^2 w}{\partial p^2} - \frac{1}{u^2}\frac{\partial^2 w}{\partial t^2} = 0 \qquad \text{or} \qquad \nabla^2 w - \frac{1}{u^2}\frac{\partial^2 w}{\partial t^2} = 0.$$

was proposed in 1748 by d'Alembert for a one-dimensional continuum. A decade later, Euler established the equation for the three-dimensional continuum.

∗ Dudley H. Towne. *Wave phenomena.* New York: Dover Publications, 1988.

Slide 4: A Cartesian reference system

The reference system whose axis are the unit vectors $\hat{x}, \hat{y}$ and $\hat{z}$

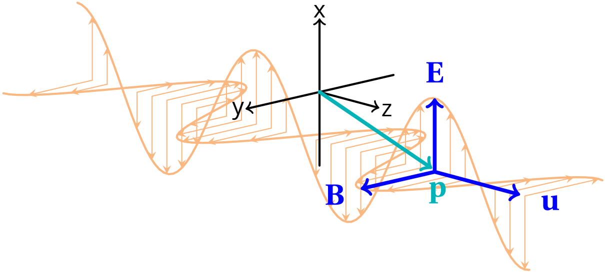


is defined by:

$$\hat{x} \cdot \hat{y} = 0 \qquad \hat{y} \cdot \hat{z} = 0 \qquad \hat{z} \cdot \hat{x} = 0$$

$$\hat{x} \times \hat{y} = \hat{z} \qquad \hat{y} \times \hat{z} = \hat{x} \qquad \hat{z} \times \hat{x} = \hat{y}$$

Slide 5: One Plane of an Electromagnetic Wave



$$\left\{ \mathbf{E} = \mathbf{u} \times \mathbf{B}, \quad \mathbf{u} = \frac{1}{\|\mathbf{B}\|^2} \mathbf{B} \times \mathbf{E}, \quad \mathbf{B} = \frac{1}{\|\mathbf{u}\|^2} \mathbf{E} \times \mathbf{u} \right\}$$

$$\mathbf{p} = \int \mathbf{u} \, \mathrm{d}t$$

Slide 6: Electromagnetic Bimodal Wave Equation & Maxwell

$$\left\{ \mathbf{E} = \mathbf{u} \times \mathbf{B}, \quad \mathbf{u} = \frac{1}{\|\mathbf{B}\|^2} \mathbf{B} \times \mathbf{E}, \quad \mathbf{B} = \frac{1}{\|\mathbf{u}\|^2} \mathbf{E} \times \mathbf{u} \right\}$$

Is a reformulation of the Maxwell equations.

To show this we need to evaluate the triple vector products $\nabla \times (\mathbf{u} \times \mathbf{B})$ and $\nabla \times (\mathbf{E} \times \mathbf{u})$, which we expand using general vector analytic methods.

$$\nabla \times (\mathbf{u} \times \mathbf{B}) = \mathbf{u}(\nabla \cdot \mathbf{B}) - \mathbf{B}(\nabla \cdot \mathbf{u}) - (\mathbf{u} \cdot \nabla)\mathbf{B} + (\mathbf{B} \cdot \nabla)\mathbf{u}$$

$$\nabla \times (\mathbf{E} \times \mathbf{u}) = \mathbf{E}(\nabla \cdot \mathbf{u}) - \mathbf{u}(\nabla \cdot \mathbf{E}) - (\mathbf{E} \cdot \nabla)\mathbf{u} + (\mathbf{u} \cdot \nabla)\mathbf{E}$$

Slide 7: Electromagnetic Bimodal Wave Equation & Maxwell

$\nabla \cdot \mathbf{u} = 0$ because c and $\hat{\mathrm{u}}(t)$ are not functions of x, y, and z

$\nabla \cdot \mathbf{B} = 0$ because B and $\hat{\mathrm{B}}(t)$ are not functions of x, y, and z

$\nabla \cdot \mathbf{E} = 0$ ditto, because $\mathbf{E} = \mathbf{u} \times \mathbf{B}$

$(\mathbf{B} \cdot \nabla)\mathbf{u} = 0$ because $\left(B_x \frac{\partial}{\partial x} + B_y \frac{\partial}{\partial y} + B_z \frac{\partial}{\partial z}\right) c\hat{\mathrm{u}}(t) = 0$

$(\mathbf{E} \cdot \nabla)\mathbf{u} = 0$ ditto

$(\mathbf{u} \cdot \nabla)\mathbf{B} = ?$ What is a convective operator on a velocity vector $\mathbf{u}$

$(\mathbf{u} \cdot \nabla)\mathbf{E} = ?$

Slide 8: Electromagnetic Bimodal Wave Equation & Maxwell

$$\mathbf{u}\cdot\nabla=\frac{\partial}{\partial t}\text{ because }\mathbf{u}\cdot\nabla=\frac{\partial x}{\partial t}\frac{\partial}{\partial x}+\frac{\partial y}{\partial t}\frac{\partial}{\partial y}+\frac{\partial z}{\partial t}\frac{\partial}{\partial z}=\frac{\partial}{\partial t}$$

and that leaves us with

$$\nabla\times(\mathbf{u}\times\mathbf{B})=\cancel{\mathbf{u}(\nabla\cdot\mathbf{B})}-\cancel{\mathbf{B}(\nabla\cdot\mathbf{u})}+\cancel{(\mathbf{B}\cdot\nabla)\mathbf{u}}-(\mathbf{u}\cdot\nabla)\mathbf{B}=-\frac{\partial\mathbf{B}}{\partial t}$$

$$\nabla\times(\mathbf{E}\times\mathbf{u})=\cancel{\mathbf{E}(\nabla\cdot\mathbf{u})}-\cancel{\mathbf{u}(\nabla\cdot\mathbf{E})}+(\mathbf{u}\cdot\nabla)\mathbf{E}-\cancel{(\mathbf{E}\cdot\nabla)\mathbf{u}}=\frac{\partial\mathbf{E}}{\partial t}$$

Slide 9: Electromagnetic Bimodal Wave Equation & Maxwell

Applying a 'left and right side' curl operation on

$$\mathbf{E} = \left(\mathbf{u} \times \mathbf{B}\right) \quad \text{and} \quad \mathbf{B} = \frac{1}{\left\|\mathbf{u}\right\|^2} \mathbf{E} \times \mathbf{u} \quad \text{gives}$$

$$\nabla \times \mathbf{E} = \nabla \times \left(\mathbf{u} \times \mathbf{B}\right) = -\frac{\partial \mathbf{B}}{\partial t}$$

$$\nabla \times \mathbf{B} = \frac{1}{\left\|\mathbf{u}\right\|^2} \nabla \times \left(\mathbf{E} \times \mathbf{u}\right) = \frac{1}{c^2} \frac{\partial \mathbf{E}}{\partial t}$$

and on slide 7 we established $\nabla \cdot \mathbf{B} = 0$ and $\nabla \cdot \mathbf{E} = 0$. That $c^{-2} = \epsilon_0 \mu_0$, see https://neophysics.org/p/1673, thus we have the Maxwell equations

Slide 10: EM-Waves; Hierarchical structure of the wave equation

(1) $$\left\{ \mathbf{E} = \mathbf{u} \times \mathbf{B}, \quad \mathbf{u} = \frac{1}{\|\mathbf{B}\|^2} \mathbf{B} \times \mathbf{E}, \quad \mathbf{B} = \frac{1}{\|\mathbf{u}\|^2} \mathbf{E} \times \mathbf{u} \right\}$$

(2) $$\left\{ \begin{array}{ll} \nabla \times \mathbf{E} = -\dfrac{\partial \mathbf{B}}{\partial t}, & \nabla \cdot \mathbf{E} = 0 \\ \nabla \times \mathbf{B} = \dfrac{1}{c^2} \dfrac{\partial \mathbf{E}}{\partial t}, & \nabla \cdot \mathbf{E} = 0 \end{array} \right\}$$

(3) $$\nabla^2 \mathbf{E} - \frac{1}{c^2} \frac{\partial^2 \mathbf{E}}{\partial t^2} = 0 \quad \text{and} \quad \nabla^2 \mathbf{B} - \frac{1}{c^2} \frac{\partial^2 \mathbf{B}}{\partial t^2} = 0$$

By definition, any solution of (1) is a solution of (3)
But a solution of (3) is not necessarily a solution of (1)

Slide 11: The Rotary Wave (think propeller)

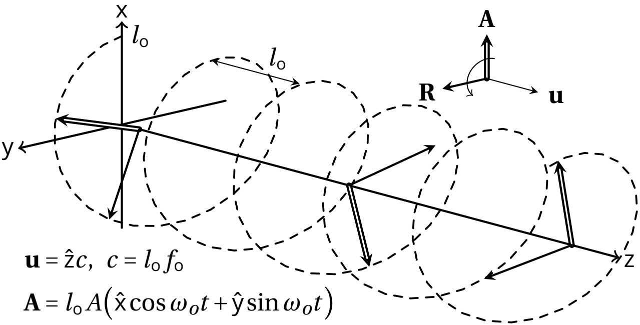
$$\left\{\ \mathbf{R} = \mathbf{u}\times\mathbf{A}, \quad \mathbf{u} = \frac{1}{\|\mathbf{A}\|^2}\mathbf{A}\times\mathbf{R}, \quad \mathbf{A} = \frac{1}{\|\mathbf{u}\|^2}\mathbf{R}\times\mathbf{u}\ \right\}$$

where **A** and **R** are the magnetic and electric flux.

A solution is the quantised rotary wave γ

$$\gamma \xrightarrow[\text{by}]{\text{par}} \begin{cases} \mathbf{u} = \hat{\mathrm{z}}c \\ \mathbf{A} = r l_{\mathrm{o}} A\left(\hat{\mathrm{x}}\cos n\omega_{\mathrm{o}} t + \hat{\mathrm{y}}\sin \grave{n}\omega_{\mathrm{o}} t\right) \\ \mathbf{R} = c r l_{\mathrm{o}} A\left(-\hat{\mathrm{x}}\sin \grave{n}\omega_{\mathrm{o}} t + \hat{\mathrm{y}}\cos \grave{n}\omega_{\mathrm{o}} t\right) \end{cases}$$

Slide 12: The Rotary Wave (think propeller)



$$\mathbf{u} = \hat{z}c, \quad c = l_o f_o$$

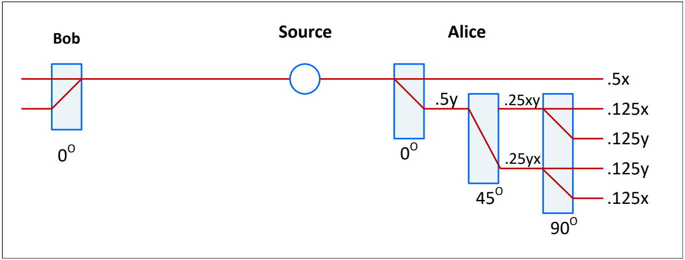
$$\mathbf{A} = l_o A\left(\hat{x}\cos\omega_o t + \hat{y}\sin\omega_o t\right)$$

$$\mathbf{R} = c l_o A\left(-\hat{x}\sin\omega_o t + \hat{y}\cos\omega_o t\right)$$

$$\mathbf{R} = (\mathbf{u}\times\mathbf{A}) \quad \text{and} \quad \mathbf{u} = \frac{1}{A^2}(\mathbf{A}\times\mathbf{R}) \quad \text{and} \quad \mathbf{A} = \frac{1}{c^2}(\mathbf{R}\times\mathbf{u})$$

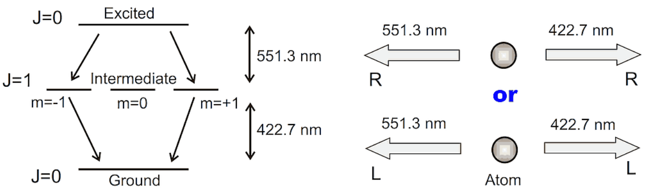
Slide 13: The Experiment

Consider an EPR experiment, the source emits circular polarised and entangled photon pairs in opposite directions to Alice and Bob. Alice uses an asymmetrical 75:25 polariser.



Question: Are the photons Bob receives skewed 25:75?

Slide 14: Calcium light source



Simon, D.S., Jaeger, G. and Sergienko, A.V. *Quantum Metrology, Imaging, and Communication*

The production of entangled photon pairs in calcium cascades. The two-photon decay can occur via an intermediate m=+1 or m=-1 state.

Bohr says: The amplitudes for the possibilities must be added, leading to the polarisation-entangled states $|\psi\rangle = (|LL\rangle + |RR\rangle)/\sqrt{2} = (|HH\rangle + |VV\rangle)/\sqrt{2}$.

The realist says: So that the two-photon decay is nilpotent, requires the production of two circular-polarised photons that underly Maxwellian wave structure $|\psi\rangle = (|L\rangle + |L\rangle)$ or $|\psi\rangle = (|R\rangle + |R\rangle)$

Slide 15: Describing Photons - 1

$$\gamma \xrightarrow[\text{by}]{\text{par}} \begin{cases} \mathbf{u} = \hat{z}c \\ \mathbf{A} = r\,l_o A\left(\hat{x}\cos n\omega_o t + \hat{y}\sin \grave{n}\omega_o t\right) \\ \mathbf{R} = c\,r\,l_o A\left(-\hat{x}\sin \grave{n}\omega_o t + \hat{y}\cos \grave{n}\omega_o t\right) \end{cases}$$

The photons actionable quantities are defined by $\hat{P} = \hat{A} \times \hat{R}$ (Poynting vector).

We are interested only in the photon's characteristics-matrix,

$$\gamma \xrightarrow[\text{by}]{\text{dsc}} \begin{pmatrix} 0 & 0 & 1 \\ \cos\omega t & \sin\omega t & 0 \\ -\sin\omega t & \cos\omega t & 0 \end{pmatrix} \begin{pmatrix} \hat{x} \\ \hat{y} \\ \hat{z} \end{pmatrix}$$

Slide 16: Describing Photons - 2

We must analyse two entangled photons in the same reference frame, defined by a right handed Euclidean space $\mathbb{C}^3$ as $[\![\mathsf{xyz}]\!]$. It is a six dimensional space where each axis, that is the x, y and z axes, are a complex $\mathbb{z}$-plane. In this space we need to define the following:

- Direction of propagation is defined by $\grave{p} = \pm 1$.
- Direction of rotation is referenced to $[\![\mathsf{xyz}]\!]$ as $\grave{r} = \pm 1$.
- The helicity of the photon is given by $\grave{s} = \grave{p}\grave{r}$, or spin $S = \grave{s}\hbar$
- A polarisation direction is x, y, or none (circular).

$$\gamma \xrightarrow[\text{by}]{\text{dsc}} \begin{pmatrix} 0 & 0 & \grave{p} \\ \cos \grave{r}\omega t & \sin \grave{r}\omega t & 0 \\ -\grave{p}\sin \grave{r}\omega t & \grave{p}\cos \grave{r}\omega t & 0 \end{pmatrix} \begin{pmatrix} \hat{\mathsf{x}} \\ \hat{\mathsf{y}} \\ \hat{\mathsf{z}} \end{pmatrix}$$

Slide 17: Nilpotency

⟨1⟩ The superposition of the magnetic flux vectors $\hat{\mathrm{A}}_{\mathsf{A+B}} = \hat{\mathrm{A}}_{\mathsf{A}} + \hat{\mathrm{A}}_{\mathsf{B}}$ must maintain the Maxwellian conditions.

⟨2⟩ Energy conservation requires that $\left|\hat{\mathrm{P}}_{\mathsf{A}}\right| + \left|\hat{\mathrm{P}}_{\mathsf{B}}\right| = 2\left|\hat{\mathrm{A}}_{\mathsf{A+B}} \times \hat{\mathrm{R}}_{\mathsf{A+B}}\right|^{*}$ That is the sum of the energies of the waves γ_{A} and γ_{B} is equal to the energy of the superimposed waves γ_{A} plus γ_{B}.

⟨3⟩ Linear momentum conservation requires $\hat{\mathrm{P}}_{\mathsf{A}} + \hat{\mathrm{P}}_{\mathsf{B}} = 0$

⟨4⟩ Angular momentum conservation requires the helicity $\grave{s}_{\mathsf{A}} = \grave{s}_{\mathsf{B}}$.

⟨5⟩ Magnetic flux conservation requires $\hat{\mathrm{A}}_{\mathsf{A}} + \hat{\mathrm{A}}_{\mathsf{B}} = 0$

∗ The absolute $\left|\hat{\mathrm{P}}\right|$ is calculated with $\grave{p} = 1$, and the factor 2 because of the unit vectors.

Slide 18: Nilpotency

Clarifying $\langle 1 \rangle$: $\hat{A}_{A+B} = \hat{A}_A + \hat{A}_B$ must also be a solution of

$$\left\{ \mathbf{R} = \mathbf{u} \times \mathbf{A}, \quad \mathbf{u} = \frac{1}{\|\mathbf{A}\|^2} \mathbf{A} \times \mathbf{R}, \quad \mathbf{A} = \frac{1}{\|\mathbf{u}\|^2} \mathbf{R} \times \mathbf{u} \right\}$$

that is

$$\left\{ \hat{R}_{A+B} = \hat{u} \times \hat{A}_{A+B}, \quad \hat{u} = \frac{1}{\left\|\hat{A}_{A+B}\right\|^2} \hat{A}_{A+B} \times \hat{R}_{A+B}, \quad \hat{A}_{A+B} = \frac{1}{\|\hat{u}\|^2} \hat{R}_{A+B} \times \hat{u} \right\}$$

Slide 19: Definition of entanglement

Proposition: Two photons γ_A and γ_B are said to be entangled when their superposition $\gamma_\mathsf{A}+\gamma_\mathsf{B}$ is nilpotent. Nilpotency is given when

$$\begin{pmatrix} 0 & 0 & \grave{p}_\mathsf{A} \\ \cos\grave{r}_\mathsf{A}\omega t & \sin\grave{r}_\mathsf{A}\omega t & 0 \\ -\grave{p}_\mathsf{A}\sin\grave{r}_\mathsf{A}\omega t & \grave{p}_\mathsf{A}\cos\grave{r}_\mathsf{A}\omega t & 0 \end{pmatrix} \begin{pmatrix} \hat{\mathsf{x}} \\ \hat{\mathsf{y}} \\ \hat{\mathsf{z}} \end{pmatrix} + \begin{pmatrix} 0 & 0 & \grave{p}_\mathsf{B} \\ \sin\grave{r}_\mathsf{B}\omega t & -\cos\grave{r}_\mathsf{B}\omega t & 0 \\ \grave{p}_\mathsf{B}\cos\grave{r}_\mathsf{B}\omega t & \grave{p}_\mathsf{B}\sin\grave{r}_\mathsf{B}\omega t & 0 \end{pmatrix} \begin{pmatrix} \hat{\mathsf{x}} \\ \hat{\mathsf{y}} \\ \hat{\mathsf{z}} \end{pmatrix}$$

and $\grave{p}_\mathsf{A}+\grave{p}_b=0$ and $\grave{r}_\mathsf{A}+\grave{p}_\mathsf{B}=0$. All four conditions $\langle 1\rangle$ to $\langle 5\rangle$ are fulfilled, also the helicities $\grave{s}_\mathsf{A}=\grave{s}_\mathsf{B}$ are equal.

Slide 20: Introducing polarisation

If γ_A is polarised in the x-orientation by a polarisation angle ϑ then that is described as follows

$$\begin{pmatrix} 0 & 0 & \grave{p}_\mathsf{A} \\ \cos \grave{r}_\mathsf{A}\omega t & \sin \grave{r}_\mathsf{A}\omega t & 0 \\ -\grave{p}_\mathsf{A}\sin \grave{r}_\mathsf{A}\omega t & \grave{p}_\mathsf{A}\cos \grave{r}_\mathsf{A}\omega t & 0 \end{pmatrix} \begin{pmatrix} \hat{\mathsf{x}} \\ \hat{\mathsf{y}}e^{i\vartheta} \\ \hat{\mathsf{z}} \end{pmatrix} + \begin{pmatrix} 0 & 0 & \grave{p}_\mathsf{B} \\ \sin \grave{r}_\mathsf{B}\omega t & -\cos \grave{r}_\mathsf{B}\omega t & 0 \\ \grave{p}_\mathsf{B}\cos \grave{r}_\mathsf{B}\omega t & \grave{p}_\mathsf{B}\sin \grave{r}_\mathsf{B}\omega t & 0 \end{pmatrix} \begin{pmatrix} \hat{\mathsf{x}} \\ \hat{\mathsf{y}} \\ \hat{\mathsf{z}} \end{pmatrix}$$

If $\vartheta = \pi/2$ then γ_A is linearly polarised in the x-axis, but if $0 \le \vartheta \le \pi/2$ then the photon has elliptical polarisation. Here $\hat{\mathsf{y}}e^{i\vartheta}$ is a unit vector defining an axis that is orthogonal to both $\hat{\mathsf{x}}$ and $\hat{\mathsf{z}}$, where the $\hat{\mathsf{y}}$-axis is rotated into the complex plane.

Slide 21: Introducing polarisation

If γ_{A} is polarised in the x-orientation by a polarisation angle ϑ then that is described as follows

$$\begin{pmatrix} 0 & 0 & \grave{p}_{\mathsf{A}} \\ \cos\grave{r}_{\mathsf{A}}\omega t & \sin\grave{r}_{\mathsf{A}}\omega t & 0 \\ -\grave{p}_{\mathsf{A}}\sin\grave{r}_{\mathsf{A}}\omega t & \grave{p}_{\mathsf{A}}\cos\grave{r}_{\mathsf{A}}\omega t & 0 \end{pmatrix} \begin{pmatrix} \hat{\mathsf{x}} \\ \hat{\mathsf{y}} e^{i\vartheta} \\ \hat{\mathsf{z}} \end{pmatrix} + \begin{pmatrix} 0 & 0 & \grave{p}_{\mathsf{B}} \\ \sin\grave{r}_{\mathsf{B}}\omega t & -\cos\grave{r}_{\mathsf{B}}\omega t & 0 \\ \grave{p}_{\mathsf{B}}\cos\grave{r}_{\mathsf{B}}\omega t & \grave{p}_{\mathsf{B}}\sin\grave{r}_{\mathsf{B}}\omega t & 0 \end{pmatrix} \begin{pmatrix} \hat{\mathsf{x}} \\ \hat{\mathsf{y}} \\ \hat{\mathsf{z}} \end{pmatrix}$$

Because of the asymmetry in γ_{A} and γ_{B} we immediately recognise that the entanglement condition $\langle 1 \rangle$ is violated, because $\hat{\mathsf{A}}_{\mathsf{A+B}} = \hat{\mathsf{A}}_{\mathsf{A}} + \hat{\mathsf{A}}_{\mathsf{B}}$ is not a solution of the simultaneous algebraic equations

$$\left\{ \mathbf{R} = \mathbf{u} \times \mathbf{A}, \quad \mathbf{u} = \frac{1}{\|\mathbf{A}\|^2} \mathbf{A} \times \mathbf{R}, \quad \mathbf{A} = \frac{1}{\|\mathbf{u}\|^2} \mathbf{R} \times \mathbf{u} \right\}$$

Slide 22: Entanglement maintains nilpotency

The Maxwellian conditions of entanglement auto-polarise γ_{B}
Yes spooky action at a distance.

$$\begin{pmatrix} 0 & 0 & \grave{p}_{\mathsf{A}} \\ \cos \grave{r}_{\mathsf{A}}\omega t & \sin \grave{r}_{\mathsf{A}}\omega t & 0 \\ -\grave{p}_{\mathsf{A}} \sin \grave{r}_{\mathsf{A}}\omega t & \grave{p}_{\mathsf{A}} \cos \grave{r}_{\mathsf{A}}\omega t & 0 \end{pmatrix} \begin{pmatrix} \hat{\mathsf{x}} \\ \hat{\mathsf{y}} e^{i\vartheta} \\ \hat{\mathsf{z}} \end{pmatrix} + \begin{pmatrix} 0 & 0 & \grave{p}_{\mathsf{B}} \\ \sin \grave{r}_{\mathsf{B}}\omega t & -\cos \grave{r}_{\mathsf{B}}\omega t & 0 \\ \grave{p}_{\mathsf{B}} \cos \grave{r}_{\mathsf{B}}\omega t & \grave{p}_{\mathsf{B}} \sin \grave{r}_{\mathsf{B}}\omega t & 0 \end{pmatrix} \begin{pmatrix} \hat{\mathsf{x}} e^{i\vartheta} \\ \hat{\mathsf{y}} \\ \hat{\mathsf{z}} \end{pmatrix}$$

The superposition $\hat{\mathrm{A}}_{\mathsf{A}_X+\mathsf{B}_Y}$ is given by

$$\chi \hat{\mathrm{A}}_{\mathsf{A}_X+\mathsf{B}_Y} = \begin{pmatrix} \cos \grave{r}_{\mathsf{A}}\omega t & \sin \grave{r}_{\mathsf{A}}\omega t & 0 \end{pmatrix} \begin{pmatrix} \hat{\mathsf{x}} \\ \hat{\mathsf{y}} e^{i\vartheta} \\ \hat{\mathsf{z}} \end{pmatrix} + \begin{pmatrix} \sin \grave{r}_{\mathsf{B}}\omega t & -\cos \grave{r}_{\mathsf{B}}\omega t & 0 \end{pmatrix} \begin{pmatrix} \hat{\mathsf{x}} e^{i\vartheta} \\ \hat{\mathsf{y}} \\ \hat{\mathsf{z}} \end{pmatrix}$$

$$= \begin{pmatrix} \cos \grave{r}_{\mathsf{A}}\omega t + \sin \grave{r}_{\mathsf{B}}\omega t & \sin \grave{r}_{\mathsf{A}}\omega t - \cos \grave{r}_{\mathsf{B}}\omega t & 0 \end{pmatrix} \begin{pmatrix} \hat{\mathsf{x}}(1+e^{i\vartheta}) \\ \hat{\mathsf{y}}(1+e^{i\vartheta}) \\ 2\hat{\mathsf{z}} \end{pmatrix}$$

Slide 23: Entanglement maintains nilpotency

The superposition $\hat{\mathsf{A}}_{\mathsf{A}_X+\mathsf{B}_Y}$ is given by

$$\chi\hat{\mathsf{A}}_{\mathsf{A}_X+\mathsf{B}_Y} = \begin{pmatrix}\cos\grave{r}_{\mathsf{A}}\omega t & \sin\grave{r}_{\mathsf{A}}\omega t & 0\end{pmatrix}\begin{pmatrix}\hat{\mathsf{x}}\\ \hat{\mathsf{y}}e^{i\vartheta}\\ \hat{\mathsf{z}}\end{pmatrix} + \begin{pmatrix}\sin\grave{r}_{\mathsf{B}}\omega t & -\cos\grave{r}_{\mathsf{B}}\omega t & 0\end{pmatrix}\begin{pmatrix}\hat{\mathsf{x}}e^{i\vartheta}\\ \hat{\mathsf{y}}\\ \hat{\mathsf{z}}\end{pmatrix}$$

$$= \begin{pmatrix}\cos\grave{r}_{\mathsf{A}}\omega t+\sin\grave{r}_{\mathsf{B}}\omega t & \sin\grave{r}_{\mathsf{A}}\omega t-\cos\grave{r}_{\mathsf{B}}\omega t & 0\end{pmatrix}\begin{pmatrix}\hat{\mathsf{x}}(1+e^{i\vartheta})\\ \hat{\mathsf{y}}(1+e^{i\vartheta})\\ 2\hat{\mathsf{z}}\end{pmatrix}$$

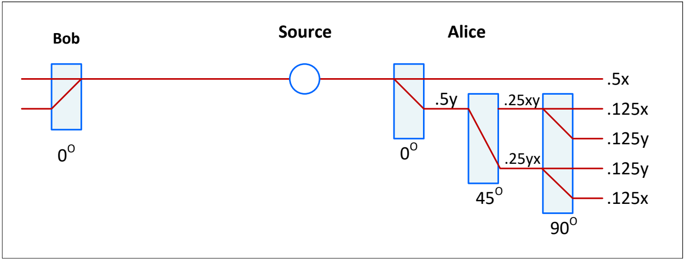
$$\hat{\mathsf{A}}_{\mathsf{A}_X+\mathsf{B}_Y} = \frac{1+e^{i\vartheta}}{\|1+e^{i\vartheta}\|}\frac{1}{\sqrt{2}}\begin{pmatrix}\cos\grave{r}_{\mathsf{A}}\omega t+\sin\grave{r}_{\mathsf{B}}\omega t & \sin\grave{r}_{\mathsf{A}}\omega t-\cos\grave{r}_{\mathsf{B}}\omega t & 0\end{pmatrix}\begin{pmatrix}\hat{\mathsf{x}}\\ \hat{\mathsf{y}}\\ \hat{\mathsf{z}}\end{pmatrix}$$

and provides a solution to

$$\left\{\ \mathbf{R}=\mathbf{u}\times\mathbf{A},\quad \mathbf{u}=\frac{1}{\|\mathbf{A}\|^2}\mathbf{A}\times\mathbf{R},\quad \mathbf{A}=\frac{1}{\|\mathbf{u}\|^2}\mathbf{R}\times\mathbf{u}\ \right\}$$

Slide 24: The Experiment

Consider an EPR experiment, the source emits circular polarised and entangled photon pairs in opposite directions to Alice and Bob. Alice uses an asymmetrical 75:25 polariser.



Question: Are the photons Bob receives skewed 25:75?

Answer: Yes, they are skewed 25:75! And faster than light communication is possible!