Can Alice influence Bob? Yes she can! Maxwell demands it and Noether predicted it: A nonlocal Maxwellian explanation of the EPR experiment.

Anton Lorenz Vrba

Ryde, United Kingdom

February 4, 2023

Abstract: We construct a simple EPR experiment: A source of circular polarised entangled photon pairs are sent to Alice and Bob. Alice intersects her beam with an asymmetrical 75:25 polariser, constructed from a cascade of three polarisers, but does no observation. Question: Are the photons Bob receives skewed 25:75? Using a nonlocal classical construct demonstrates from Maxwellian principles a universal conservation phenomenon, as predicted by Noether's Theorem. The analysis demonstrates the physics underlying the Bell inequality, and predicts the outcome that Bob's observations are skewed 25:75 which contrasts with the expected 50:50 distribution that quantum mechanics predict.

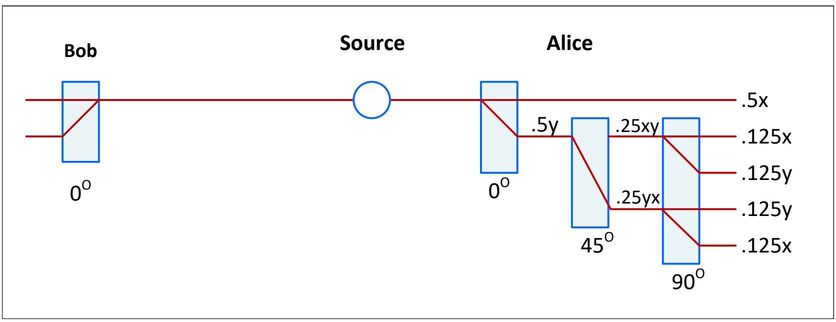

Figure 1: Question: Are the photons Bob receives skewed to a 25:75 distribution?

Figure-1 outlines a very simple EPR-paradox experiment, requiring no statistical analysis but only a simple observation at Bob's station that measures the relative intensities of a photon beam after it is passed through a birefringent polariser. The novelty in this experiment is that Alice uses a 75:25 biased polariser constructed by stacking three birefringent polarisers with each optical axis rotated 45° to the prior. The question that this experiment answers is: Are the photons Bob receives skewed towards a 25:75 distribution?

The photon source is an atomic cascade producing pairs of entangled photons which are emitted simultaneously in opposite directions; angular momentum conservation requires the two photons to have the same circular polarisation (left-handed or right-handed). Quantum mechanics describes this entangled state as follows $|\psi\rangle = (|LL\rangle + |RR\rangle)/\sqrt{2} = (|HH\rangle + |VV\rangle)/\sqrt{2}$.

The experiment is designed so that Alice does not observe her photons; she sets them free into space. What polarisation distribution does Bob observe? There are two possible outcomes:
An equal 50:50 distribution: According to QM Bob observes a 50:50 distribution because Alice does not observe her photons thus they remain in a state of superposition of several eigenstates. Alternatively, if we accept that the act of polarisation is considered as an observation then QM still predicts that Bob would observe a 50:50 distribution, because the eigenstates are defined by the first of Alice's polarisers and any further polarisation by Alice is done on a defined eigenstate.
A skewed 25:75 distribution: This contradicts the QM's expectations!

A nonlocal classical analysis predicts a skewed 25:75 distribution!

To analyse this classically a new classical model for a photon is required. In [1] I show that a photon could be understood by the three simultaneous vector algebraic equations

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

where $\mathbf{A} = A\hat{\mathrm{A}}(t)$ is the magnetic flux vector, $\mathbf{R} = R\hat{\mathrm{R}}(t)$ the electric flux vector, and $\mathbf{u} = c\hat{\mathrm{u}}(t)$ the velocity vector where the scalars A, R and c carry the respective physical units. The unity vectors $\hat{\mathrm{A}}(t), \hat{\mathrm{R}}(t)$, and $\hat{\mathrm{u}}(t)$ are of time only, thus no position dependency. We are interested in solutions of (1) to describe a photon propagating along the z-axis; a simple solution is

$$\gamma \xrightarrow[\text{by}]{\text{dsc}} \left\{ \begin{array}{l} \mathbf{u} = c\hat{\mathrm{z}} \\ \mathbf{A} = A(\hat{\mathrm{x}}\cos\omega t + \hat{\mathrm{y}}\sin\omega t) \\ \mathbf{R} = \mathbf{u} \times \mathbf{A} = cA(-\hat{\mathrm{x}}\sin\omega t + \hat{\mathrm{y}}\cos\omega t) \end{array} \right\}$$

but we are only interested in analysing and developing the unit vectors, thus

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

which we simplify by expressing the photon characteristic-matrix only, using the three axes defining propagation axis and the rotation plane, here in the z direction with rotation on the x–y plane.

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

The above describes a rotary wave; think of a one bladed propeller. The rotary wave is a point-wave. It does not exist before it nor behind it, but it has dimensionality in the plane orthogonal to the propagation vector. The photons actionable quantities are defined by $\hat{\mathrm{P}} = \hat{\mathrm{A}} \times \hat{\mathrm{R}}$ (Poynting vector).

We must analyse two entangled photons in the same reference frame, defined by a right handed Euclidean space $\mathbb{C}^3$ as $[\![\mathrm{xyz}]\!]$. 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 $[\![\mathrm{xyz}]\!]$ 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).

In this analysis we consider two photons γ_{A} and γ_{B}, emitted in an atomic cascade. For the event to be nilpotent requires the following conditions for the entangled photons:

⟨1⟩ To maintain a Maxwellian wave requires the superposition $\hat{\mathrm{A}}_{\mathrm{A+B}} = \hat{\mathrm{A}}_{\mathrm{A}} + \hat{\mathrm{A}}_{\mathrm{B}}$ to be a solution of (1), that is a solution of

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

⟨2⟩ Energy conservation requires that $\left|\hat{\mathrm{P}}_{\mathrm{A}}\right| + \left|\hat{\mathrm{P}}_{\mathrm{B}}\right| = 2\left|\hat{\mathrm{A}}_{\mathrm{A+B}} \times \hat{\mathrm{R}}_{\mathrm{A+B}}\right|^{*}$ 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 $\hat{\mathrm{P}}_{\mathrm{A}} + \hat{\mathrm{P}}_{\mathrm{B}} = 0$

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

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

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

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 $\langle 5 \rangle$ above are fulfilled, also the helicities $\grave{s}_{\mathsf{A}} = \grave{s}_{\mathsf{B}}$ are equal.

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. Because of the asymmetry in γ_{A} and γ_{B} we immediately recognise that the entanglement condition $\langle 1 \rangle$ is violated, because $\hat{\mathrm{A}}_{\mathsf{A+B}} = \hat{\mathrm{A}}_{\mathsf{A}} + \hat{\mathrm{A}}_{\mathsf{B}}$ is not a solution of the simultaneous algebraic equations (1). In ideal conditions, a universal conservation phenomenon, predicted by Noether's theorem, acts on photon γ_{B} that polarises it by the same amount on the orthogonal axis, demonstrated by

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

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

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

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

where χ is a scalar because the right hand part is not a unit vector. Normalising to obtain an expression for a unit vector we obtain:

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

and it is a valid solution of (1).

The above demonstrates classically that the physics of entanglement requires a universal conservation phenomenon, and is predicted in Noether's theorem. Universal conservation is as real as gravity is real. It provides the classical explanation to Bell's theorem, which is confirmed by experience [2] and many others; the 2022 Nobel prize was awarded to honour the researchers in the field of entanglement. However, it is now clear that both the Copenhagen interpretation of quantum mechanics as well as the Einstein, Podolsky, and Rosen challenge [3] were argued on unsound principles; spooky action at a distance is now explained by principles derived only from Maxwell's and Noether's work. Quantum mechanics needs to adapt to the result presented here!

References

[1] Anton Lorenz Vrba. "General Maxwellian Dynamics defined by a novel equation set. Particles are Maxwellian solitons." In: *Proceedings: Harbingers of Neophysics* (2022), Online. URL: `https://neophysics.org/p/1673` (visited on 2023-01-30).

[2] Stuart J. Freedman and John F. Clauser. "Experimental Test of Local Hidden-Variable Theories". In: *Physical Review Letters* 28.14 (1972), pp. 938–941.

[3] A. Einstein, B. Podolsky, and N. Rosen. "Can Quantum-Mechanical Description of Physical Reality Be Considered Complete?" In: *Physical Review* 47.10 (1935), pp. 777–780.

Biblatex for citing this article:

```
@Article{Vrba-2023-1767,
   author    = {Vrba, Anton Lorenz},
   title     = {Can Alice influence Bob? Yes she can, Noether demands it;
                A classical approach proves the Bell inequality},
   year      = {2023},
   pages     = {Online},
   journal   = {Proceedings: Harbingers of Neophysics},
   publisher = {PhysNew Ltd},
   address   = {Ryde, UK},
   issn      = {2753-5770},
   url       = {https://neophysics.org/p/1767},
   urldate   = {2023-02-2},
}
```