Disproof of Bell's Theorem

Illuminating the Illusion of Entanglement

Second Edition

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Appendix 9: Simulation of EPR-Bohm Correlation

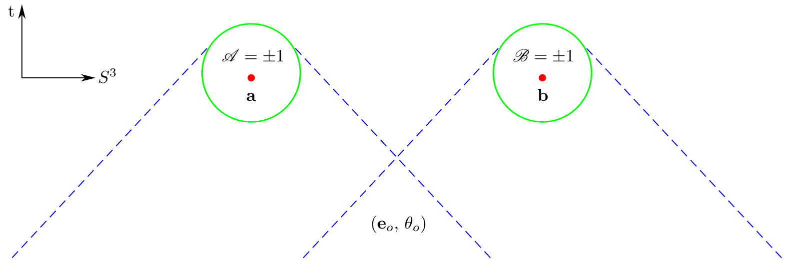

Figure 9.1: The measurement results $\mathscr{A}(\mathbf{a};\, \mathbf{e}_o,\, \theta_o)$ and $\mathscr{B}(\mathbf{b};\, \mathbf{e}_o,\, \theta_o)$ are deterministically brought about by the common cause $(\mathbf{e}_o,\, \theta_o)$.

The set of ***complete*** states $(\mathbf{e}_o,\, \theta_o)$ of the system is defined by

$$\Lambda := \left\{ (\mathbf{e}_o,\, \theta_o) \;\middle|\; |\cos(\,\eta_{\mathbf{x}\mathbf{e}_o})| \,\geq\, \frac{1}{2}\,\sin^2(\,\theta_o\,) \;\;\; \forall\; \mathbf{x} \in T_p S^3 \right\}, \quad \text{(A.9.1)}$$

where $\mathbf{e}_o \in \mathrm{I\!R}^3$ is a random vector, $\theta_o \in [0,\, \pi/2]$ is a random scalar, and each vector $\mathbf{x}$ specifies a *different* 2-sphere within the 3-sphere. Note that there exist no states for which $|\cos(\,\eta_{\mathbf{x}\mathbf{e}_o})| < \frac{1}{2}\,\sin^2(\,\theta_o\,)$ for any $\mathbf{x} \in T_p S^3$. The two measurement results are then defined by

$$\mathscr{A}(\mathbf{a};\, \mathbf{e}_o,\, \theta_o) \;=\; \begin{cases} sign\{-\cos(\,\eta_{\mathbf{a}\mathbf{e}_o}\,)\} & \text{if } |\cos(\,\eta_{\mathbf{a}\mathbf{e}_o})| \,\geq\, \frac{1}{2}\,\sin^2(\,\theta_o\,) \\ 0 & \text{if } |\cos(\,\eta_{\mathbf{a}\mathbf{e}_o})| \,<\, \frac{1}{2}\,\sin^2(\,\theta_o\,) \end{cases} \quad \text{(A.9.2)}$$

and

$$\mathscr{B}(\mathbf{b};\, \mathbf{e}_o,\, \theta_o) = \begin{cases} sign\{+\cos(\,\eta_{\mathbf{b}\mathbf{e}_o}\,)\} & \text{if } |\cos(\,\eta_{\mathbf{b}\mathbf{e}_o})| \,\geq\, \frac{1}{2}\,\sin^2(\,\theta_o\,) \\ 0 & \text{if } |\cos(\,\eta_{\mathbf{b}\mathbf{e}_o})| \,<\, \frac{1}{2}\,\sin^2(\,\theta_o\,), \end{cases} \quad \text{(A.9.3)}$$

with *freely chosen* $\mathbf{a}$ and $\mathbf{b}$. Evidently, the averages of the results $\mathscr{A}$ and $\mathscr{B}$ vanish, but the probabilities of their joint detections do not:

$$P^{++} = P\{\mathscr{A} = +1,\; \mathscr{B} = +1 \mid \eta_{\mathbf{ab}}\,\} = \frac{1}{2}\sin^2\left(\frac{\eta_{\mathbf{ab}}}{2}\right), \quad \text{(A.9.4)}$$

$$P^{--} = P\{\mathscr{A} = -1,\; \mathscr{B} = -1 \mid \eta_{\mathbf{ab}}\,\} = \frac{1}{2}\sin^2\left(\frac{\eta_{\mathbf{ab}}}{2}\right), \quad \text{(A.9.5)}$$

$$P^{-+} = P\{\mathscr{A} = -1,\; \mathscr{B} = +1 \mid \eta_{\mathbf{ab}}\,\} = \frac{1}{2}\cos^2\left(\frac{\eta_{\mathbf{ab}}}{2}\right), \quad \text{(A.9.6)}$$

$$P^{+-} = P\{\mathscr{A} = +1,\; \mathscr{B} = -1 \mid \eta_{\mathbf{ab}}\,\} = \frac{1}{2}\cos^2\left(\frac{\eta_{\mathbf{ab}}}{2}\right). \quad \text{(A.9.7)}$$

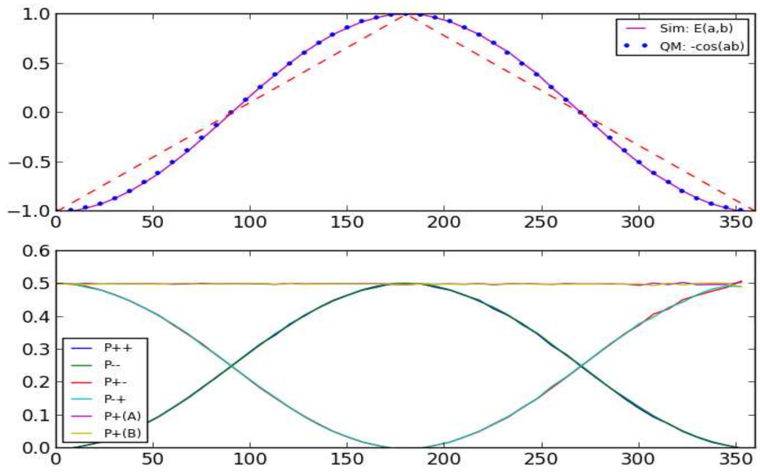

Figure 9.2: An event-by-event simulation of the correlation between simultaneously occurring measurement events $\mathscr{A} = \pm 1$ and $\mathscr{B} = \pm 1$ within a parallelized 3-sphere. The code for this simulation is written by Michel Fodje, in Python. Along with other relevant information, it can be downloaded from https://github.com/minkwe/epr-simple/.

From these joint probabilities (which are exactly those predicted by quantum mechanics) the correlation can now be computed as follows:

$$\begin{aligned}
\mathcal{E}(\mathbf{a},\,\mathbf{b}) \;&=\; \lim_{n\,\gg\,1}\left[\frac{1}{n}\sum_{i\,=\,1}^{n}\,\mathscr{A}(\mathbf{a};\,\mathbf{e}_o^i,\,\theta_o^i)\;\mathscr{B}(\mathbf{b};\,\mathbf{e}_o^i,\,\theta_o^i)\right] \\
&=\; \frac{P^{++}\,+\,P^{--}\,-\,P^{-+}\,-\,P^{+-}}{P^{++}\,+\,P^{--}\,+\,P^{-+}\,+\,P^{+-}} \\
&=\; \frac{1}{2}\sin^2\left(\frac{\eta_{\mathbf{ab}}}{2}\right)\,+\,\frac{1}{2}\sin^2\left(\frac{\eta_{\mathbf{ab}}}{2}\right) \\
&\qquad\qquad -\,\frac{1}{2}\cos^2\left(\frac{\eta_{\mathbf{ab}}}{2}\right)\,-\,\frac{1}{2}\cos^2\left(\frac{\eta_{\mathbf{ab}}}{2}\right) \\
&=\; -\,\cos\eta_{\mathbf{ab}}\,. \qquad\qquad (A.9.8)
\end{aligned}$$

These are then the strong correlations predicted by our local model[1].

[1] The original simulation by Michel Fodje confirming the above results has been translated by John Reed from Python to Mathematica. It can be found in PDF format at this page: http://libertesphilosophica.info/Minkwe_Sim_J_Reed.pdf.