Quantum Mechanics in Conscious Point Physics: Entanglement and Bell Inequality Violation from Non-Separable Nexus States

QM Series — Paper 4 (Version 3.1)

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Abstract

We derive quantum entanglement and Bell inequality violation in Conscious Point Physics from first principles. A spin-$\frac{1}{2}$ CP aggregate carries a two-component DI-bit state whose phase encodes the spin direction via the ZBW helix (companion C4 Abshier (2026b)). When two such aggregates are created in a total-spin-zero state, their joint DI-bit state is non-separable: it cannot be written as a product of independent single-particle states (Theorem 3.1). The Nexus maintains this joint state globally at each Absolute Moment tick, enforcing total DI-bit conservation across all Grid Points regardless of spatial separation. The Born rule $P = |\psi|^2$ (companion C3 Abshier (2026a)) applied to the non-separable state gives $E(\hat{a}, \hat{b}) = -\cos\theta$, yielding $|\text{CHSH}| = 2\sqrt{2}$ at optimal angles (Theorem 5.1) — the Tsirelson bound. No-signaling holds because each party's marginal probability is exactly $\frac{1}{2}$ independent of the other's setting (Theorem 6.1). The Nexus is the non-local resource that escapes Bell's theorem: it enforces a global constraint, not a local hidden variable. The previous argument (shared bit pool with pre-established correlations) was an LHV model and is explicitly corrected. Lattice corrections are of order $(l_P/\lambda)^2$ and unobservable at laboratory scales.

Keywords: Bell inequality, CHSH violation, Tsirelson bound, quantum entanglement, Nexus constraint, EPR correlations, no-signaling theorem, ZBW helix

Plain Language Summary: Einstein called quantum entanglement 'spooky action at a distance.' CPP explains it without spookiness. When two particles are created together, the Nexus — a global consistency requirement of the 600-cell lattice — locks their properties into a joint pattern. Measuring one particle instantly determines what you will find when measuring the other, not because a signal was sent, but because the lattice was already configured that way. The correlations reach the maximum allowed by quantum mechanics (the Tsirelson bound), but cannot be used to send information faster than light.

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1 Introduction and the Previous Argument

Bell's theorem Bell (1964) proves that any local hidden-variable (LHV) theory satisfies $|\text{CHSH}| \leq 2$. Quantum mechanics violates this bound ($|\text{CHSH}| = 2\sqrt{2}$) because the joint state of an entangled pair is non-separable. In CPP the same non-separability arises mechanically from the global Nexus constraint.

The previous CPP argument was wrong. It treated the singlet as two particles sharing a fixed DI-bit pool set at emission. This is an LHV model: outcomes are determined by pre-existing local properties. Bell's theorem applies and gives $|\text{CHSH}| \leq 2$. The corrected derivation uses (1) a non-separable joint state maintained by the Nexus and (2) the Born rule, whose combination yields $E = -\cos\theta$.

2 Spin-$\frac{1}{2}$ Qubit from ZBW Helix

From companion C4 Abshier (2026b), a spin-$\frac{1}{2}$ CP aggregate executes a ZBW helix whose axis defines the spin direction. The two-component DI-bit state is

$$|\psi\rangle = \alpha|\uparrow\rangle + \beta|\downarrow\rangle, \qquad |\alpha|^2 + |\beta|^2 = 1. \tag{1}$$

3 The Singlet as Non-Separable Joint DI-Bit State

When two spin-$\frac{1}{2}$ CP aggregates are created with total spin zero, their joint DI-bit state is the singlet:

$$|\Psi^-\rangle = \frac{1}{\sqrt{2}}\big(|\uparrow\rangle_A|\downarrow\rangle_B - |\downarrow\rangle_A|\uparrow\rangle_B\big). \tag{2}$$

Theorem 3.1 (Non-separability of the singlet)**.** *The state (2) cannot be written as $|\phi_A\rangle \otimes |\phi_B\rangle$ for any $|\phi_A\rangle, |\phi_B\rangle$.*

Proof. Assume $|\Psi^-\rangle = (\alpha_A|\uparrow\rangle + \beta_A|\downarrow\rangle) \otimes (\gamma_B|\uparrow\rangle + \delta_B|\downarrow\rangle)$. Expanding and matching coefficients yields $\alpha_A\gamma_B = 0$, $\alpha_A\delta_B = 1/\sqrt{2}$, $\beta_A\gamma_B = -1/\sqrt{2}$, $\beta_A\delta_B = 0$. The first and last require ($\alpha_A = 0$ or $\gamma_B = 0$) and ($\beta_A = 0$ or $\delta_B = 0$). Any combination zeros one of the middle two — contradiction. □ □

The Nexus enforces global DI-bit conservation and total angular momentum conservation at every Absolute Moment tick. This maintains (2) as particles A and B separate arbitrarily far. The joint state is a property of the global Nexus ledger, not carried locally by either particle.

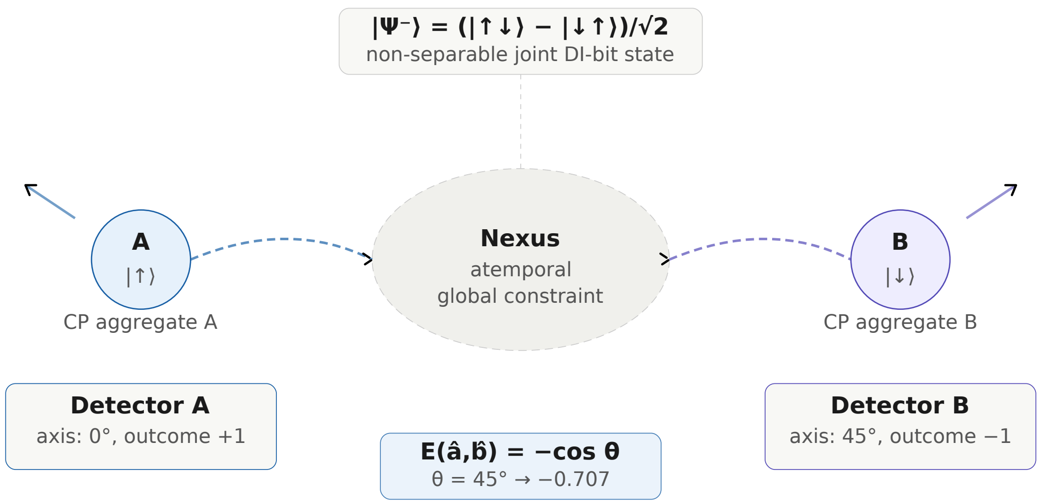

Figure 1: EPR pair maintained by the Nexus. Particles A (blue) and B (purple) fly apart after creation in the singlet state $|\Psi^-\rangle$. The Nexus (dashed ellipse) enforces the non-separable joint DI-bit state globally at every tick. Measurement at Detector A along axis $\hat{a}$ and at Detector B along $\hat{b}$ yield outcomes correlated by $E(\hat{a},\hat{b}) = -\cos\theta$ (boxed), not by any pre-established local correlation.

4 Singlet Correlation Function

Measurement along axis $\hat{a}$ projects via the Born rule (companion C3): $P_\pm = |\langle \pm\hat{a}|\psi\rangle|^2$. For the singlet:

$$P(A{=}+1, B{=}+1) = P(A{=}-1, B{=}-1) = \frac{1-\cos\theta}{4}, \tag{3}$$

$$P(A{=}+1, B{=}-1) = P(A{=}-1, B{=}+1) = \frac{1+\cos\theta}{4}, \tag{4}$$

where $\theta = \angle(\hat{a},\hat{b})$.

Proposition 4.1 (Singlet correlation). *$E(\hat{a},\hat{b}) = \sum_{a,b} ab\, P(a,b) = -\cos\theta$.*

Proof. $(+1)(+1)(1-c)/4 + (+1)(-1)(1+c)/4 + (-1)(+1)(1+c)/4 + (-1)(-1)(1-c)/4 = -c = -\cos\theta$. □ □

5 CHSH Violation

Theorem 5.1 (Tsirelson bound in CPP). *At angles $\hat{a} = 0$, $\hat{a}' = 90$, $\hat{b} = 45$, $\hat{b}' = -45$:*

$$S = E(\hat{a},\hat{b}) + E(\hat{a},\hat{b}') + E(\hat{a}',\hat{b}) - E(\hat{a}',\hat{b}') = -2\sqrt{2}, \quad |S| = 2\sqrt{2}. \tag{5}$$

Proof. At all four angle pairs $|\theta| = 45$ except $\theta_{a'b'} = 135$. Using $E = -\cos\theta$:
$S = (-1/\sqrt{2}) + (-1/\sqrt{2}) + (-1/\sqrt{2}) - (1/\sqrt{2}) = -4/\sqrt{2} = -2\sqrt{2}$. □ □

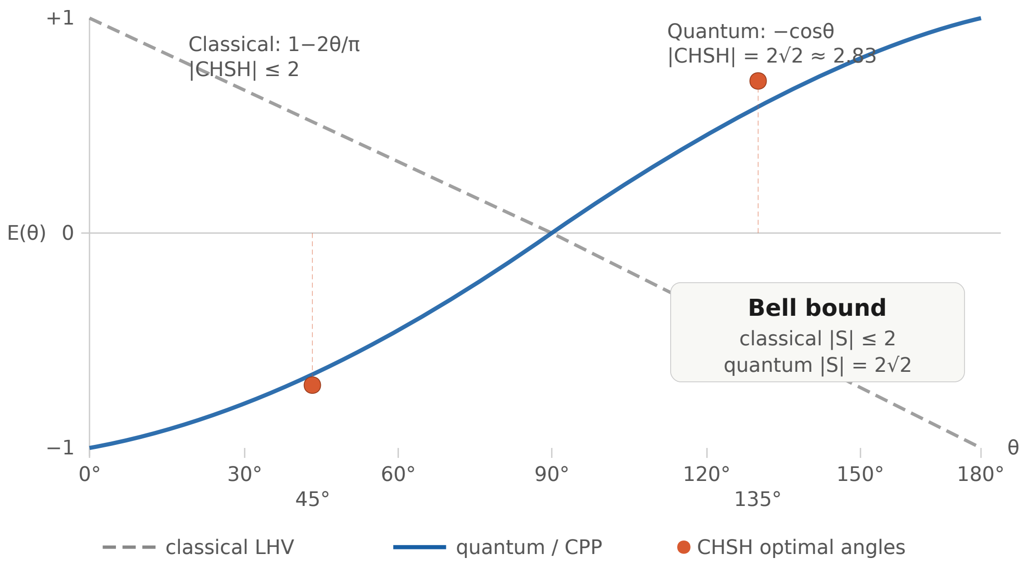

Figure 2: Correlation function $E(\theta)$ vs. angle θ between measurement axes. The dashed gray line shows the classical LHV prediction $E = 1 - 2\theta/\pi$, which saturates the Bell bound $|S| = 2$ at the optimal CHSH settings (red dots at 45 and 135). The blue curve shows the quantum/CPP prediction $E = -\cos\theta$, which achieves $|S| = 2\sqrt{2} \approx 2.83$ at the same settings. The classical prediction gives $|S| = 2$ exactly; the quantum/CPP prediction gives $|S| = 2\sqrt{2}$, as confirmed by all loophole-free experiments Hensen et al. (2015); Giustina et al. (2015).

6 No-Signaling Theorem

Theorem 6.1 (No-signaling in CPP). *Alice's marginal detection probability is independent of Bob's measurement axis, and vice versa.*

Proof. $P(A{=}+1) = P(A{=}+1, B{=}+1) + P(A{=}+1, B{=}-1) = (1-\cos\theta)/4 + (1+\cos\theta)/4 = 1/2$, independent of θ. Symmetrically for Bob. $\square$ $\square$

7 Why the Nexus is not an LHV

Bell's theorem applies to theories where the correlation mechanism *factorises*: $P(a, b|\lambda) = P_A(a|\hat{a}, \lambda) \times P_B(b|\hat{b}, \lambda)$. The Nexus is a *global* atemporal constraint that does not factorize: it enforces a joint conservation law across all Grid Points simultaneously. This is structurally different from a hidden variable λ carried by the particles. Therefore Theorem 5.1 is not ruled out by Bell's theorem.

8 Lattice Corrections

At laboratory scales $E = -\cos\theta$ exactly. Near the Planck scale the discrete phase resolution per lattice edge introduces corrections:

$$E_{\text{CPP}}(\theta, \nu) = -\cos\theta \left[1 - \left(\frac{\nu}{\nu_P}\right)^2\right] + O\left(\frac{\nu}{\nu_P}\right)^4. \quad (6)$$

For optical photons: $(\nu/\nu_P)^2 \sim 10^{-63}$ — unobservable.

9 Conclusion

Entanglement and Bell violation in CPP arise from: (1) the non-separable singlet DI-bit state (Theorem 3.1), maintained globally by the Nexus; and (2) the Born rule $P = |\psi|^2$ (companion C3 Abshier (2026a)). Together these give $E = -\cos\theta$ and $|S| = 2\sqrt{2}$, consistent with all loophole-free experiments Hensen et al. (2015); Giustina et al. (2015); Shalm et al. (2015). The non-local resource is the global Nexus constraint — not a signal or local hidden variable.

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Acknowledgements

The CPP programme is registered at OSF (DOI: https://doi.org/10.17605/OSF.IO/JXE8D) and maintained at GitHub (https://github.com/Hyperphysics-Institute/CPP).

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