Bell’s 1964 correlation argument

J. S. Bell, On the Einstein Podolsky Rosen paradox. Original six-page scan, Physics 1, pp. 195-200.

Bell’s exact inequality and finite-angle approximation argument are supported under the stated local-response model. The illustrative examples need small corrections. The higher-dimensional extension has a short checked repair. The final claims about instantaneous propagation and Lorentz invariance are not established by the supplied mathematics; this is a local limit of the interpretation, not a refutation of Bell’s theorem.

Reviewed component	Source-adjudicated result
Model and assumptions	Coherent conditional model; one setting-independent distribution is encoded in (2).
Illustrative constructions	Repairable angle-direction wording and a function-label typo.
Exact inequality	Supported; finite-setting null sets and singlet violation checked.
Approximation bound	Supported after restoring the missing integral sign in (21).
Higher-dimensional extension	Literal joint extensions leave locality unproved; local representatives provide a checked repair.
Physical interpretation	Temporal/relativistic implications remain unproved; no operational-communication assertion is attributed.

Each of six targets received independent Sol and Fable 5.2 assessments at high effort. Dependent waves opened only after source checks. Astra at max effort adjudicated the selected remaining issues using all six original page images. Model labels, original failures and costs are preserved separately from the conclusions below.

This is an identified, familiar development paper, with possible training-set exposure. No human expert grade, blind benchmark, experimental validation or formal proof certificate is claimed. Only the scopes listed here were audited; the neutral reading index and panel decision map are separate artifacts.

The mathematical contradiction

The model being excluded

The calculation uses deterministic ±1 response functions $A(a,\lambda)$, $B(b,\lambda)$, each independent of the distant setting, and one normalized nonnegative distribution $\rho(\lambda)$ common to the settings. It asks these to reproduce the singlet correlation $-a\cdot b$. The common distribution is a substantive premise of the representation. A rejection of this conjunction does not select which premise a different physical theory must abandon.

Exact correlations

Perfect equal-setting anticorrelation forces $A(b,\lambda) = -B(b,\lambda)$ almost everywhere for each setting used. A finite union of exceptional null sets suffices for the finite-setting contradiction; no common exceptional set over every possible direction is needed. Equations (12)-(15) give:

$$|P(a,b) - P(a,c)| \leq 1 + P(b,c).$$

Choose $a\cdot c = 0$ and $a\cdot b = b\cdot c = 1/\mathrm{sqrt}(2)$. The singlet values would require $1/\mathrm{sqrt}(2) \leq 1 - 1/\mathrm{sqrt}(2)$, which is false. This directly verifies incompatibility without treating the paper's informal local-regularity remark as a theorem about every correlation function.

Finite-angle approximation

Independent local angular averages yield response values in $[-1,1]$. The two-term decomposition after (21), its nonnegative brackets and the stated error bounds lead to:

$$4(\varepsilon + \delta) \geq \mathrm{sqrt}(2) - 1.$$

Thus $\varepsilon \geq 0.103553\ldots - \delta$, with δ tending to zero for narrowing angular caps. The asserted obstruction is uniform over settings after the stated independent averaging. It is not a claim about every possible approximation norm or about empirical error rates. The source omits an integral sign in (21); inserting it follows immediately from (18), (19) and normalization.

Illustrative examples: local corrections

The angle prescribed in Section III is $\theta' = (\pi/2)(1 - \cos\theta)$. At $\theta = 2\pi/3$ it is $3\pi/4$, so an instruction always to rotate toward the reference direction is inaccurate. Choosing the specified separation in the same plane repairs the example. Equation (9) also mislabels B's arguments; its right-hand side supplies the intended function. The isotropic product-mixture comparison needs the stated antiparallel interpretation. These issues do not enter the core inequality proof.

Extension and physical interpretation

Astra confirms that the literal zero-extension from the whole product subspace does not by itself provide measurements on separate subsystems. It classifies this as a substantive missing link in that local argument, while independently checking the short local-operator repair. The existential conclusion survives under the original observability and separated-system assumptions. The third eigenvalue, zero, creates no additional obstruction for the chosen state.

For Section VI, Astra confirms an unsupported transition from distant-setting dependence to instantaneous propagation, and then to the asserted exclusion of Lorentz-invariant underlying laws. The stronger statements remain unresolved here, rather than refuted. The algebraic incompatibility result is unaffected.

Astra also rejects two overbroad criticisms. The common distribution is already encoded in equation (2), even without a separately named prose assumption. The original text discusses dependence of individual results at fixed hidden variables; it does not thereby assert controllable operational communication. An absent proof of such communication is therefore not an additional error in the paper. The cited experimental proposal remains unchecked rather than proven defective.

A checkable local realization

Choose two-dimensional subspaces K_1, K_2 and let X_i be a Pauli observable on K_i, zero on its orthogonal complement. Use $X_1 \otimes I$ and $I \otimes X_2$, with the matched-basis singlet supported in $K_1 \otimes K_2$. They are local and have correlation $-a \cdot b$. The extra eigenvalue 0 has zero probability in this state. Literal joint extensions $X_1 \otimes P_2$ and $P_1 \otimes X_2$ agree on this state but do not establish subsystem locality on the whole space. This clarification retains the explicit premise that the required state and local observables are available.

What the inequality alone does not determine

The equations have no event times, propagation law or transformation rule for the hidden-variable dynamics. Dependence of a response on a distant setting at fixed λ is different from controllable communication in the observable marginal distributions. A claim about instantaneous propagation or Lorentz invariance therefore needs additional physical premises and definitions. Changing settings during flight also needs timing and geometry to establish the relevant causal separation. The source itself presents limited validity of quantum predictions as a possibility, not a proved alternative theory.

The report assesses what is established in the supplied 1964 argument. It uses no later experiment or later proof to justify that argument. Later knowledge in model weights cannot be excluded. A missing derivation of an interpretive assertion is not a refutation of Bell’s mathematical inequality or an empirical verdict about quantum mechanics.

Evidence, coverage and service cost

Source and imported assumptions

The retained six-page original scan is a mirror, not the publisher. Its printed receipt date is 4 November 1964; conflicting nominal publication metadata was not substituted for that cutoff. The scan and page images are authoritative. OCR is only a locator and drops most displayed equations. Dirac's cited page and Bohm-Aharonov's experimental paper were not supplied or fully audited. The generalization is conditional on observability and preparation assumptions; it does not apply to every state or every experimentally restricted system merely because its dimension is large.

Verification and packet coverage

Original pages were inspected. Finite checks include all eight deterministic response triples, 625 bounded-response quadruples with rational arithmetic, and the exact radical coefficients in the example violation. Nine embedded Pauli-axis correlations, commuting local operators and zero-outcome probabilities were checked with exactly representable small matrix operations. These are checks of algebra and conventions, not experimental validation or substitutes for the general argument.

The initial embedding packets supplied pages 195 and 197-200, omitting the transitive definition page 196. Both reviewers disclosed that limit. The model formulation was separately reviewed earlier, and both final Astra cases received all six pages. The expanded neutral map now records the direct formulation dependency. Frozen initial packets remain unchanged.

Of 14 native responses, 7 passed the automatic gates; 7 needed explicit editorial reconciliation. These concerned OCR quotation tokens, metadata citations, an image-visible date omitted from text snippets, or background-reference associations in a field reserved for proof use. Mathematical judgments were unchanged, and the original failed responses and costs remain retained. Differences between "defective" and "needs context" labels were resolved by examining each inference, not by voting.

Accounted API use	USD
12 independent Sol/Fable assessments	1.514563
2 Astra max adjudication(s)	1.388420
Total for this paper	2.902983
Allocated ceiling within shared $25	12.500000

Provider-reported usage at frozen rates, rounded upward per durable attempt; includes invalid responses. These figures are not provider invoices or total service costs. First submission to final collection: 37.6 minutes, including staged waiting and operator work; not an SLA or labor-cost measurement. No retries or synchronous fallback were used.

Qualification judgment: useful evidence for supervised review of mathematical arguments in theoretical physics. This foundational correlation proof does not qualify experimental review, phenomenological modeling, numerical simulation, data analysis or all of theoretical physics. No public advertising expansion is made by this trial.