Bell's theorem refuted: Bell's 1964:(15) is false

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Abstract: Generalizing Bell 1964:(15) to realizable experiments, CHSH (1969) coined the term "Bell's theorem". Since the results of such experiments (eg, see Aspect 2002) contradict Bell's theorem: at least one step in his supposedly commonsense analysis must be false. Using undergraduate maths and logic, we find a mathematical error, a false equality, in Bell (1964). Uncorrected, and therefore continuing, this error undermines all of Bell's EPR-based analysis and many later variants, rendering them false. We can therefore predict with certainty that all loophole-free EPRB-style experiments will also give the lie to Bell's theorem.

"It is a matter of indifference ... whether λ denotes a single variable or a set, or even a set of functions, and whether the variables are discrete or continuous. However, [Bell writes] as if λ were a single continuous parameter," Bell (1964:195). λ may denote "any number of hypothetical additional complementary variables needed to complete quantum mechanics in the way envisaged by EPR," Bell (2004:242); from his final essay.

#**1.** Re Bell (1964) (which, like other key essays here, is available online; see References): Let the unnumbered equations between Bell's (14)-(15) be (14a)-(14c). Let $\mathbf{a}, \mathbf{b}, \mathbf{c}$ replace his $\vec{a}, \vec{b}, \vec{c}$. Given Bell's (2004:242) λ specification above (from his final essay), let $A(\mathbf{a}, \lambda_i)$ and $B(\mathbf{b}, \lambda'_i)$ denote the respective outcomes (± 1) when Alice and Bob test the i-th particle-pair.

#**2.** NB: Primes ($'$) distinguish λs in Bob's domain from those in others. With $i = 1, 2, .., N$ (and j similarly), there is no requirement here that any two particle-pairs should be the same.

#**3.** Let expectation $\langle A(\mathbf{a})B(\mathbf{b})\rangle$ replace Bell's equivalent term $P(\vec{a}, \vec{b})$; etc. Let $P(. \mid Z)$ denote a probability conditioned on Z: where Z is shorthand for EPRB, the experiment based on EPR (1935), Bohm (1951:611-623), Bohm & Aharonov (1957), that Bell (1964) considers.

#**4.** Finally, for use when convenient; typically to reveal the source of errors in CHSH-style inequalities: Let $A(\mathbf{a}, \lambda_i)B(\mathbf{b}, \lambda'_i) = A_iB_i = \pm 1$; $B(\mathbf{b}, \lambda_j)C(\mathbf{c}, \lambda'_j) = B_jC_j = \pm 1$; etc.

#**5.** Then, from Bell's 1964:(1)-(2), (12)-(13); in the limit as $N \to \infty$:

$$B(\mathbf{b}, \lambda'_i) = -A(\mathbf{b}, \lambda_i) = \pm 1; B(\mathbf{c}, \lambda'_j) = -A(\mathbf{c}, \lambda_j) = \pm 1; \text{ etc.} \tag{1}$$

$$\langle A(\mathbf{a})B(\mathbf{b})\rangle = \sum_{i=1}^{N} P(\lambda_i \mid Z)A(\mathbf{a}, \lambda_i)B(\mathbf{b}, \lambda'_i) = -\sum_{i=1}^{N} P(\lambda_i \mid Z)A(\mathbf{a}, \lambda_i)A(\mathbf{b}, \lambda_i); \tag{2}$$

$$\langle A(\mathbf{a})B(\mathbf{c})\rangle = \sum_{j=1}^{N} P(\lambda_j \mid Z)A(\mathbf{a}, \lambda_j)B(\mathbf{c}, \lambda'_j) = -\sum_{j=1}^{N} P(\lambda_j \mid Z)A(\mathbf{a}, \lambda_j)A(\mathbf{c}, \lambda_j). \tag{3}$$

#**6.** Then, since each particle-pair is uniquely numbered: $P(\lambda_i \mid Z) = P(\lambda_j \mid Z) = 1/N$. So, commencing with Bell's (14a) in our terms, we find:

$$\text{Bell's (14a)} = \langle A(\mathbf{a})B(\mathbf{b})\rangle - \langle A(\mathbf{a})B(\mathbf{c})\rangle = -\frac{1}{N}\sum_{i=1,j=1}^{N} [A(\mathbf{a}, \lambda_i)A(\mathbf{b}, \lambda_i) - A(\mathbf{a}, \lambda_j)A(\mathbf{c}, \lambda_j)] \tag{4}$$

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$$= \frac{1}{N}\sum_{i=1,j=1,}^{N} A(\mathbf{a},\lambda_i)A(\mathbf{b},\lambda_i)[A(\mathbf{a},\lambda_i)A(\mathbf{b},\lambda_i)A(\mathbf{a},\lambda_j)A(\mathbf{c},\lambda_j)-1]; \tag{5}$$

$$\because A(\mathbf{a},\lambda_i)A(\mathbf{b},\lambda_i)A(\mathbf{a},\lambda_i)A(\mathbf{b},\lambda_i) = 1 \text{ since } A(\mathbf{a},\lambda_i)A(\mathbf{b},\lambda_i) = \pm 1. \tag{6}$$

#**7.** (5) is a physically significant and mathematically precise representation of Bell's (14a). So Bell's (14b) should agree with (5): but it does not; and here's why:

#**8.** To move from (14a) to (14b): Bell uses $A(\mathbf{a},\lambda) = \pm 1$ from his (1) to (supposedly) yield

$$\text{Bell's (14b)} = \int d\lambda\rho(\lambda)A(\mathbf{a},\lambda)A(\mathbf{b},\lambda)[A(\mathbf{b},\lambda)A(\mathbf{c},\lambda)-1]. \quad (?) \tag{7}$$

#**9.** Comparing (7) with (5) term-by-term, the validity of Bell's (14b) rests (at least) on this:

$$A(\mathbf{a},\lambda_i)A(\mathbf{a},\lambda_j) = 1 \text{ in general.} \quad (?) \tag{8}$$

#**10.** But under EPRB-based experiments, (8) is impossible:

$$\because \frac{1}{N}\sum_{i=1,\,j=1}^{N} A(\mathbf{a},\lambda_i)A(\mathbf{a},\lambda_j) = 0 \neq 1; \therefore\ A(\mathbf{a},\lambda_i)A(\mathbf{a},\lambda_j) \neq 1 \text{ in general;} \tag{9}$$

ie, the average over N random outcomes of ± 1 is zero, not one; so (8) is false in general. Therefore (7) – Bell's (14b) – is false in general. So (14a) = (14b) is equally false in general.

#**11.** We therefore record the first *valid* EPRB-based Bell-inequality and its consequence.

$$\text{Bell's blunder: } \rightarrow \text{ Bell 1964:(14a)} \neq \text{Bell 1964:(14b):} \tag{10}$$

then, since no compensating errors intervene, Bell 1964:(15) — first termed "Bell's theorem" by CHSH (1969:880) — is false; refuted. Bell's theorem is refuted. QED.

#**12.** Here's Bell's problem: in his move (14a) to (14b), Bell subtly uses $A(\mathbf{a},\lambda) = \pm 1$ to yield $A(\mathbf{a},\lambda)A(\mathbf{a},\lambda) = 1$. In other words, for the generality of Bell's analysis to go through, Bell requires λ_i in (2) above to equal λ_j in (3) above.

#**13.** However, under EPRB-based tests, that's a readily-proven impossibility: for we can run the experiment for (2) in Peru, that for (3) in Paris. Erroneous (8) thus leads to factual (10) and (in our terms and from our analysis) to EPRB's crucial fact.

$$\text{EPRB's fact: } \rightarrow \text{ in general: } \lambda_i \neq \lambda j; \tag{11}$$

in full accord with Bell's own λ-licence: see our opening quotation above, from Bell's final essay.

#**14.** (11) thus corrects fallacies like CHSH (1969) and Clauser & Shimony (1978); mistakes like Bell 1980:(14), in *Bertlmann's socks and the nature of reality*; Mandel & Wolf 1995:(12.14-12)-(12.14-13); Ballentine 1998:(20.5)-(20.6); Aspect 2002:(17); Bell 2004:(244, (10)).

#**15.** To be clear: Using our compact notation (see #4 above), here's an example of the easy corrective power of (11) — ie, of EPRB's fact. Compare Peres 1995:(6.29)

$$A_jB_j + B_jC_j + C_jD_j - D_jA_j \equiv \pm 2\,(?) \text{ with } -4 \leq A_iB_i + B_jC_j + C_kD_k - D_lA_l \leq +4: \tag{12}$$

ie, Bell-Peres (with eight subscripted js) and the Bell-CHSH bounds of ± 2 are false: exceeded experimentally and theoretically. Our bounds of ± 4 are true: and never exceeded. QED.

#**16.** So, thanks to the team acknowledged below, the story that began with Mermin (1988) continues. And thanks to viXra.org, there's http://vixra.org/abs/1405.0020: a rough draft that delivers Bell's (1990:10) expectation that relativity and quantum mechanics would be reconciled; ie, Bell's hope (2004: 167) for a simple constructive locally-causal model of reality.

#**17.** With our work already confirmed experimentally (and Bell's theorem disconfirmed), we again predict with certainty that loophole-free EPRB-style experiments will continue to support our theory. And again: that such experiments will also give the lie to Bell's theorem.

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> On one supposition we absolutely hold fast; that of local-causality, often called Einstein-locality: "The real *factual* situation of the system S_2 is independent of what is done with the system S_1, which is spatially separated from the former," after Einstein (1949:85).

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