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". Despite loopholes, but as expected, the results of such experiments contradict Bell's theorem to our total satisfaction. Thus, for us, at least one step in Bell's supposedly commonsense analysis must be false. Using undergraduate maths and logic, we find a mathematical error in Bell (1964) — a false equality, uncorrected and thus continuing, undermines all Bell-style EPRB-based analyses, rendering them false. We again 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).

#**1.** Re Bell (1964) (pdf online; see References): Let the 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), let $A(\mathbf{a}, \lambda_i)$ and $B(\mathbf{b}, \lambda'_i)$ denote the i-th outcomes (± 1) when Alice and Bob respectively test a set I of N particle-pairs at settings $\mathbf{a}$, $\mathbf{b}$ (say). Primes ($'$) denote λs in Bob's domain.

#**2.** Like $i = 1, 2, .., N$, let $j = 1, 2, .., N$ be the j-th test at settings $\mathbf{a}$, $\mathbf{c}$ (say) on a set J of N new pristine particle-pairs. If tested over identical settings, sets I, J, K, etc, yield differing sequences but the same expectation in the limit as $N \to \infty$. With no requirement here that any two particle-pairs should be the same, #15-16 below show the impact of such caution.

#**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 Bell-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.** Thus, 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, with each particle-pair uniquely identified and with no requirement that $I \ni \lambda = \lambda \in J$: $P(\lambda_i \mid Z) = P(\lambda_j \mid Z) = 1/N$. So, expressing Bell's 1964:(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:

$$\text{Bell's false implication} : \rightarrow \quad A(\mathbf{a},\lambda_i)A(\mathbf{a},\lambda_j) = 1 \text{ in general.} \quad (?) \tag{8}$$

#**10.** Bell's implication is false since, 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.

$$\text{Our correction to Bell (1964)} : \rightarrow \text{ Bell 1964:(14a)} \neq \text{Bell 1964:(14b).} \tag{10}$$

#**12.** Then, since no compensating errors intervene, Bell 1964:(15) — first termed "Bell's theorem" by CHSH (1969:880) — is false. In our terms, Bell's first theorem is refuted. QED.

#**13.** 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.

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

$$\text{EPRB's fact} : \rightarrow \lambda_i \neq \lambda j \text{ in general; since, per \#2 above, } P((\lambda_i, \lambda_i') = (\lambda_j, \lambda_j') \mid Z) \approx 0; \tag{11}$$

in full accord with Bell's (ie, EPR's) λ-licence: see our opening quotations above.

#**15.** (11) thus corrects fallacies like CHSH 1969:(1a); Clauser & Shimony 1978:(3.7); Bell 1980:(14); Mandel & Wolf 1995:(12.14-12)-(12.14-13); Ballentine 1998:(20.5)-(20.6); Aspect 2002:(17); Bell 2004:(244, (10)); Mermin 2005:(2)-(3); 't Hooft 2014:(8.22)-(8.23).

#**16.** To be clear, using our compact notation from #4 above: here's an example of the easy corrective power of (11) — ie, of EPRB's fact. Compare CHSH-influenced Peres 1995:(6.29)

$$A_iB_i + B_iC_i + C_iD_i - D_iA_i \equiv \pm 2\ (?) \text{ with } -4 \leq A_iB_i + B_jC_j + C_kD_k - D_lA_l \leq +4 : \tag{12}$$

ie, Bell/CHSH/Peres' eight subscripted is and the ensuing bounds of ± 2 are false: exceeded experimentally and theoretically. Our bounds of ± 4 are true, and cannot be exceeded. QED.

#**17.** 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.

#**18.** 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 thus, 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/Einstein causality: "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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