Review of "A Diagrammatic Formulation of Local Realism", by James Fullwood (*Foundations of Physics* 55:40, 2025)

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For *Mathematical Reviews*

It's quite common to find in the literature on the foundations of quantum mechanics the claim that Bell's theorem rules out 'local realism'. As put forcefully by Myrvold *et al.* [1], however, it's not always clear what's meant by 'local realism', or whether the term is in fact deployed in a univocal way. As Myrvold *et al.* go on to explain, 'local realism' in the hands of Mermin [2] (this by now being the most prevalent sense in which the term is used) amounts to the conjunction of two theses: Parameter Independence (PI) and *Outcome Determinism* (OD), the latter of which states that "one can assign a definite value to the result of an impending measurement of any component of the spin of either of the two correlated particles, whether or not that measurement is actually performed" [2, p. 356]. But Outcome Determinism is strictly stronger than Outcome Independence (OI), and Bell's theorem in fact rules out any theories which combine Parameter Independence and Outcome Independence [1]. (Parameter Independence and Outcome Independence are standard in the literature and I will not repeat here their definitions, which can be found in [1].)

These observations are pertinent to the article under consideration here, which indeed seems to follow Mermin's lead in understanding 'local realism' in the above sense (although the author does not use the terminology of PI or OD). The upshot is that certain claims made by the author—for example, that Bell's theorem "unequivocally established the fact that any theory which satisfies local realism cannot be consistent with the predictions of quantum theory" (p. 2)—are, in the words of Myrvold *et al.*, "true but misleading". One of the most notable questions with which one is confronted when reading this article is then whether (and how) its results and diagrams could be transferred over to the more general case.

But I get ahead of myself, because of course I have not yet discussed the content and purpose of this article. In brief, the article aims to give clean, diagrammatic statements of local realism in terms of commuting diagrams, where arrows are projections and nodes are probability spaces. On this front the arti-

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cle is a success: the diagrams are clean, the prose is clear, and the mathematics is correct. Those unfamiliar with Bell setups will likely get a lot out of reading it, and as such the article has my recommendation.

But—in addition to my main comment about local realism above—I do have some other gripes. The main one which I'd like to mention here is that the author proposes to elucidate Bell setups, measurements schemes, local realism, etc., using tools from category theory. But the article never uses any substantial category-theoretic resources beyond communing diagrams—even functors (though defined in the article) do not play any substantial role. In my view, this chimes with a number of other attempts in the foundations of physics to use category theory to 'illuminate' the subject matter, in the sense that what one actually gets out of the *bona fide* category theory is in fact rather thin and arguably trivial (and even, one might say, just as likely to obscure the subject matter as to illuminate it). In my view, not much would have been lost in this article from eschewing all category-theoretic terminology.

References

[1] Myrvold, W., Genovese, M., & Shimony, A. (2024). Bell's Theorem. In E. N. Zalta & U. Nodelman (Eds.), *The Stanford Encyclopedia of Philosophy* (Spring 2024 Edition). Metaphysics Research Lab, Stanford University. Available at: https://plato.stanford.edu/archives/spr2024/entries/bell-theorem/

[2] Mermin, N. D. (1980). Quantum mechanics vs local realism near the classical limit: A Bell inequality for spin s. *Physical Review D*, 22(2), 356–361.