A possibilistic no-go theorem on the Wigner's friend paradox

Marwan Haddara[a] and Eric G. Cavalcanti[a]

[a] *Centre for Quantum Dynamics, Griffith University, Gold Coast, Queensland 4222, Australia*

A recent no-go theorem [1] shows that the assumptions of Absoluteness of Observed Events (AOE) and Local Agency (LA) are not consistent with quantum phenomena in general. The compound condition of these two assumptions is called Local Friendliness (LF), as the no-go theorem is demonstrated in a modified version of the Wigner's friend scenario. The LF no-go result is comparable to Bell's theorem [2] in the sense that the assumptions underlying it can be phrased in a manner largely independent of any details of a particular physical theory. The fact that in comparable scenarios the LF assumptions lead to weaker constraints on the observable behaviour than Bell inequalities implies however, that the metaphysical implications of the LF no-go result are strictly stronger than those suggested by Bell's theorem.

In this work, we demonstrate a probability free analogue of the LF no-go theorem, in the same spirit as the famous theorems by Hardy [3] and Greenberger, Horne and Zeilinger (GHZ) [4] in the case of Bell's theorem. We do this by replacing any reference to probabilities by possibilities, and show by the means of a logical argument on an explicit example scenario, that the compound condition made of AOE and a possibilistic version of Local Agency, which we call Possibilistic Local Agency (PLA), leads to contradictions with the type of possibilities allowed for by quantum mechanics. Our formulation strengthens the original LF no-go result because any critique on the use of probability theory does not apply to it, and also because the assumption of PLA is technically even weaker than the assumption of LA.

Possibilities, necessities etc. are the topic of a branch of modal logic known as *alethic modal logic*. We formalize our argument by using such modal logical language and the result thus opens up new interesting research questions to consider on the interface of quantum foundations and modal logic.

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[2] J. S. Bell, *Physics Physique Fizika* **1**, 195 (1964).

[3] L. Hardy, *Phys. Rev. Lett.* **68**, 2981 (1992).

[4] D. M. Greenberger, M. A. Horne and A. Zeilinger, in *Bell's theorem, Quantum Theory and Conceptions of the Universe* (M. Kafatos ed.) pp. 69-72 Dordrecht: Springer Netherlands (1989).