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Quantum nonlocality: Novel construction, improved bounds and upcoming experiments

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Abstract

Quantum correlations are unique. On the one hand, they are stronger than those produced by any local hidden variables model. On the other hand, stronger-than-quantum correlations exist which are nevertheless non-signaling. It is therefore customarily believed that Nature is not more nonlocal than predicted by quantum mechanics due to some principle other than relativistic causality.

In this talk I will prove that in an inherently indeterministic theory, relativistic causality does lead to strict bounds on quantum mechanical correlations. Without assuming quantum mechanics, I will discuss a general consequence of relativistic causality under indeterminism, named relativistic independence [1]. I will show that it induces a particular statistical structure, which gives rise to the state-of-the-art bounds on bipartite quantum correlations, as well as to a few tighter bounds. Moreover, relativistic independence holds in general multipartite scenarios which leads to further bounds. These results show that theories with correlations stronger than quantum do not satisfy the relativistic independence property and are therefore incompatible with either indeterminism (in the sense of this work) or relativistic causality. Quantum mechanics employs specific uncertainty relations for preventing a clash between causality and nonlocality [2]. I will then characterize and restrict all possible models for nonlocal hidden variables [3]. Finally, I will describe an upcoming series of experiments in Ottawa which I designed for testing the above results. These experiments are based on my previous demonstration of sequential and protective measurements with the Turin group [4,5].

References

- [1] A. Carmi, E. Cohen, Relativistic causality limits nonlocality via indeterminism, under review in Nature Communications.
- [2] Y. Aharonov, E. Cohen, F. Colombo, T. Landsberger, I. Sabadini, D.C. Struppa, J. Tollaksen, Proc. Natl. Acad. Sci. USA 114, 6480-6485 (2017).
- [3] A. Carmi, E. Cohen, P. Skrzypczyk, S. Popescu, Nonlocal hidden variables are either pseudolocal or quasilocal, forthcoming.
- [4] F. Piacentini, A. Avella, M.P. Levi, M. Gramegna, G. Brida, I.P. Degiovanni, E. Cohen, R. Lussana, F. Villa, A. Tosi, F. Zappa, M. Genovese, Phys. Rev. Lett. 117, 170402 (2016).
- [5] F. Piacentini, A. Avella, E. Rebufello, R. Lussana, F. Villa, A. Tosi, M. Gramegna, G. Brida, E. Cohen, L. Vaidman, I.P. Degiovanni, M. Genovese, Nat. Phys., doi:10.1038/nphys4223 (2017).

ההרצאה תתקיים ביום רביעי, ה - 10.1.2018 בשעה 12:30

באודיטוריום המכון למחצב מוצק, קומת כניסה

**The lecture will take place on Wednesday, 10.1.2018 at 12:30
at the Solid State Institute auditorium, entrance floor**

Host: Assistant Professor Yoav Sagi