Contribution ID: **66** Type: **talk**

Pseudodensity Matrix of a quatum optical system as a tool for visualizing open timelike curves.

Wednesday, September 25, 2019 3:00 PM (30 minutes)

Quantum optical systems present several interesting properties that allow using them as a tool for visualizing physical phenomena otherwise subject of theoretical speculation only, as Bose Einstein condensation for Hawking radiation [1] or Page Wootters model [2-5].

Closed Time-like Curves (CTC), one of the most striking predictions of general relativity, are notorious for generating paradoxes, such as the grandfather's paradox, but these paradoxes can be solved in a quantum network model [6], where a qubit travels back in time and interacts with its past copy. However, there is a price to pay. The resolution of the causality paradoxes requires to break quantum theory's linearity. This leads to the possibility of quantum cloning, violation of the uncertainty principle and solving NP-complete problems in polynomial time. Interestingly, violations of linearity occur even in an open time-like curve (OTC), when the qubit does not interact with its past copy, but it is initially entangled with another, chronology-respecting, qubit. The non-linearity is needed here to avoid violation of the monogamy of entanglement. To preserve linearity and avoid all other drastic consequences, we discuss how the state of the qubit in the OTC is not a density operator, but a pseudo-density operator (PDO) - a recently proposed generalisation of density operators, unifying the description of temporal and spatial quantum correlations. Here I present an experimental simulation of the OTC using polarization-entangled photons, also providing the first full quantum state tomography of the PDO describing the OTC, verifying the violation of the monogamy of entanglement induced by the chronology-violating qubit. At the same time the linearity is preserved since the PDO already contains both the spatial degrees of freedom and the linear temporal quantum evolution. These arguments also offer a possible solution to black hole entropy problem.

[1] J.Steinahauer et al., Nature Physics volume12, 959–965 (2016)

[2] D.N. Page and W.K. Wootters, Phys. Rev. D 27, 2885 (1983); W.K. Wootters, Int. J. Theor. Phys. 23, 701 (1984).

[3] E.Moreva,M.Gramegna,G.Brida,L.Maccone,M.Genovese, Phys. Rev. A 89, 052122 (2014).

[4] V.Giovannetti, S.Lloyd, L.Maccone, Phys. Rev. D, 92, 045033 (2015).

[5] E.Moreva,M.Gramegna,G.Brida,L.Maccone,M.Genovese, Phys. Rev.D in press. arXiv:1710.00707

[6] D. Deutsch, Phys. Rev. D 44, 10, 1991.

[7] C. Marletto, V. Vedral, S. Virzì, E.Rebufello,A.Avella,M.Gramegna, I.P. Degiovanni,M.Genovese, in press.

Presenter: Dr GENOVESE, Marco (INRiM)

Session Classification: Investigating the fundamental properties of physics