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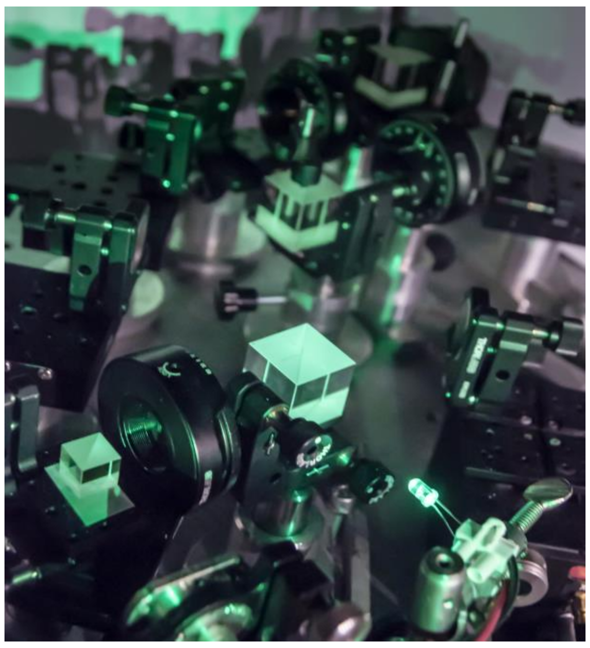

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Revealing new facets in experimental quantum information processing with photons

March 15, 2023 – h 10.30 a.m.

Aula B108 – Povo 2 – Via Sommarive n. 9

Abstract:

In this talk, we present new facets in the domain of photonic quantum information processing.
In the first part, we present the first loophole-free experiment wherein both the LGI and the WLGI inequalities have been decisively violated using single photons[1], thus providing a comprehensive refutation of the classical realist worldview along with measurements ensured to be non-invasive. Our results also demonstrate perfect matching of these observed violations with quantum-mechanical predictions incorporating experimental nonidealities, again not analysed in earlier such experiments. Our carefully designed strategies make this setup a powerful platform for harnessing this most general unambiguous signature of nonclassicality of single photon states towards various information theoretic applications wherein the single photon is a ubiquitous workhorse.
The second part of the talk focuses on our recent works in higher dimensional quantum information processing.
We provide a novel scheme for direct determination of different entanglement monotones used to quantify entanglement in arbitrary system dimensions using only one pair of complementary observables, as opposed to the standard d^2 measurements needed in d dimensions. Our experiment [2] is the first direct empirical determination of the standard entanglement monotones in higher dimensions, that uses only one set of joint local measurements. This naturally motivates the question as regards the extent to which this scheme can be extended for two-qudit mixed states and what would be its ramifications. This is thoroughly studied in [3] for different types of mixed entangled states, showing that the efficacy of this scheme is restricted to not only distillable entangled states, but extends to bound entangled states as well.
We end with our novel approach to higher dimensional quantum state estimation, using interference as a tool [4]. Here we present an interferometric method, in which any qubit state, whether mixed or pure, can be inferred from the visibility, phase shift, and average intensity of an interference pattern using a single-shot measurement—hence, we call it Quantum State Interferography [4]. This provides us with a "black box" approach to quantum state estimation, wherein, between the incidence and extraction of state information, we are not changing any conditions within the setup, thus giving us a true single shot estimation of the quantum state. An extension of the scheme to pure states involving d−1 interferograms for d-dimensional systems (qudits) is also presented. The scaling gain is even more dramatic in the qudit scenario for our method, where, in contrast, standard QST, scales roughly as d2.

[1] Loophole free interferometric test of macrorealism using heralded single photons, K.Joarder, D.Saha, D.Home, U.Sinha, PRX Quantum, 3, 010307, 2022.
[2] Direct determination of entanglement monotones for arbitrary dimensional bipartite states using statistical correlators and one set of complementary measurements, D. Ghosh, T.Jennewein, U.Sinha, Quantum Science and Technology, 7, 045037, 2022.
[3] Relating an entanglement measure with statistical correlators for two-qudit mixed states using only a pair of complementary observables, S. Sadana, S. Kanjilal, D.Home, U.Sinha, arXiv: 2201.06188, 2022.
[4] Quantum State Interferography, S.Sahoo, S. Chakraborti, A.K.Pati, U.Sinha, Phys. Rev. Lett. 125 123601, 2020.

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