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Photonic quantum feedback as a way towards generating higher dimensionality cluster states of entangled photons

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Abstract

The ability to produce in a controlled manner quantum entanglement between many photons is a key to many quantum information processing protocols in general and for quantum communication protocols, in particular. Our group demonstrated such an ability, for the first time, using a device based on a semiconductor quantum dot in which a confined hole spin functions as a needle in a quantum knitting machine. The device deterministically generates single, indistinguishable photons at a sub-Gigahertz repetition rate, and the photons are all entangled in polarization, forming a one-dimensional cluster state with the hole spin [1].

Quantum protocols, in general, however, require higher entanglement dimensionality (or entanglement connectivity). One way to increase the dimensionality of the one-dimensional cluster that our group produces for generating a two-dimensional cluster state, which is a key resource for universal measurement-based quantum computation is to use delayed quantum feedback [2]. This feedback can in principle be implemented using a partial mirror that returns the emitted photons back into the device.

In my talk, I will present theoretical considerations of this quantum feedback. I will provide an analytical solution for the time evolution of such a system, which includes the precessing hole spin and its interaction with the feedbacked photon's polarization.

I will use my model to discuss a detailed proposal for generating a 2D photonic cluster state using the heavy hole spin and single photons' quantum feedback and will suggest a particular experimental setup for its demonstration.

References

[1] Cogan, D., Su, Z. E., Kenneth, O., & Gershoni, D. (2023). Deterministic generation of indistinguishable photons in a cluster state. *Nature Photonics*, *17*(4), 324-329.

[2] Pichler, H., Choi, S., Zoller, P., & Lukin, M. D. (2017). Universal photonic quantum computation via time-delayed feedback. *Proceedings of the National Academy of Sciences*, *114*(43), 11362-11367.

ההרצאה תתקיים ביום רביעי, ה-10.1.24 בשעה 12:30
באודיטוריום המכון למצב מוצק, קומת כניסה
The lecture will take place on Wednesday, 10.1.24 at 12:30
at the Solid State Institute auditorium, entrance floor

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