QSS29 - Charles Adams - Questions & Answers

Charles Adams

Bill Phillips: The high sensitivity of Ry states is great, but does it present a problem in achieving the high fidelity one will need for quantum computation? Are you confident that 10^{-4} fidelity can be achieved, for example.

CHARLES: The ultimate limit is the lifetime of the Rydberg states. There are ways to make this extremely long, e.g. > 10 ms using circular Rydberg states, see https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.124.123201 As we can execute say pi pulses in 10 ns, the challenges are technical rather than fundamental.

Cuprates: What limits the max. visible state in the cuprate spectroscopy (main qn, here 12d)?

CHARLES: Inhomogeneity due to strain and impurities. See e.g. https://arxiv.org/pdf/2010.11117.pdf

Why is the EIT efficiency low?

CHARLES: It's a question of optical depth. You need very high optical depth to slow and capture a photon with unit efficiency, and it is hard to achieve a high OD in a small volume. The solution is to use patterned atom arrays see e.g. https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.116.103602 and for recent experiment see https://www.nature.com/articles/s41586-020-2463-x

Pei-Wen Tsai: what's the number of Rydberg atoms in the science MOT?

CHARLES: Typically, we work with one or two Rydberg excitations shared amongst 1000 atoms, and map those into one and two photons. The number of Rydberg excitations is roughly equal to the atomic ensemble volume divided by the Rydberg blockade volume.

Bill Phillips: Microwave control has the advantage and the disadvantage that the microwaves talk to all the atoms in a sample. Would it be useful to use an MRI-like, gradient-field technique to control where in space one addresses the atoms?

CHARLES: The problem is the spatial extent of the stored photon, so a field gradient will impose a phase gradient on the photon which may lead to deflection and distortion of retrieved mode. It could also be useful if applied in the right way.

Bill Phillips: In the continuous monitoring experiment, it seems that this would be a good scenario for a quantum Zeno effect. Why isn't it?

CHARLES: Good question. It could be that the stabilisation into the dark state could be interpreted as a quantum Zeno steering.

Bill Phillips: Concerning the idea of using different photonic modes to store different bits of quantum information—is this essentially a holographic storage scenario? What is the limit to how many different qubits can be stored? Is it as large as the number of atoms?

CHARLES: Limit is diffraction I think. In practice, I think we can never approach number of modes equals the number of atoms as it takes many atoms separated by more than a wavelength to make a well-defined spatial photonic mode.

Concerning the qutrit: can you go beyond it, can you have qudit?

CHARLES: Yes, just need more microwave sources.

Can you explain again the mapping between different Rydberg levels and the photonic state? How you distinguish between different Rydberg levels?

CHARLES: We map state-encoding into time-bin encoding, i.e. using a sequence of microwave pulses we can decide when in time we read out each state.

Pau Farrera: What ingredients are you missing in order to implement the microwave mediated photon-photon quantum gate that you mentioned at the beginning of the talk?

CHARLES: We need another laser to couple to a Rydberg state that differs in principal quantum number, n, by Delta n >= 5, so that they do not interact, and then a high frequency microwave/THz source to couple the two Rydberg states and hence turn on the interaction.