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Quantum Control of Hybrid Atom-Plasmonic Systems

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Miniaturization of quantum technologies have led to physics that require the marriage of atomic physics and nanomaterials science. Some of the resulting areas of research are hybrid quantum devices, single-molecule spectroscopies, table-top intense field generators, etc. I will present an exciting way of controlling light and nanomatter - the control of hybrid atom-plasmonic systems. By combining the electromagnetic enhancement properties of plasmonic nanomaterials with the modification of the atomic properties, we can achieve an unprecedented level of control over quantum dynamics.

The practical implementation of quantum computers places two specific requirements on the lifetime of a qubit, namely, long relevant decoherence times, and rapid state initialization times. There is a need for protocols wherein the spontaneous emission rate of a quantum system can be selectively increased so that long state lifetimes can be maintained during operation, and upon demand, selectively decreased so that the cooling time can be drastically shortened in duration when qubit purity needs to be restored.

Chris DiLoreto and I propose an efficient method to selectively enhance the spontaneous emission rate of a quantum system by changing the polarization of an incident control field, and exploiting the polarization dependence of the system's spontaneous emission rate. This differs from the usual Purcell enhancement of spontaneous emission rates as it can be selectively turned on and off. Using a three-level "Lambda" system in a quantum dot placed in between two silver nanoparticles and a linearly-polarized, monochromatic driving field, we present a protocol for rapid quantum state initialization; while maintaining long coherence times for control operations. This process increases the overall amount of time that a quantum system can be effectively utilized for quantum operations.

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