Two-Qubit Atomic Entanglement in Metallic Carbon Nanotubes\textsuperscript{1} 

MISTY GREEN, IGOR BONDAREV, North Carolina Central University — Recent progress in the growth techniques of centimeter-long single-walled carbon nanotubes (CNs) \cite{1}, as well as the experiments on the controlled encapsulation of single atoms into CNs \cite{2}, stimulate theoretical studies of the potential applications of hybrid atomically doped CN systems in quantum information science. We analyze the conditions for two spatially separated atomic qubits (two-level atoms, or ions) encapsulated in a CN, or located close to the CN surface, to be strongly coupled to a common high-finesse surface photonic mode of the nanotube, and thus to be entangled via the virtual surface photon exchange \cite{3}. We show that metallic CNs of $\sim$1 nm diameter can be very efficient, even at room temperatures, to entangle a pair of the spatially separated atomic qubits. We discuss how to employ the rear-earth Eu$^{3+}$ ions to test our predictions as they are known to be excellent probes to study quantum optical effects in spatially confined systems \cite{4}, owing to the dominant 5D$0$--$7F2$ electric dipole transition that essentially creates a qubit system.

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