Nuclear spin - photon entanglement on NV center for Quantum Repeater applications

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Quantum communication lines have many different applications such as Quantum Key Distribution [1], Cloud Quantum Computing [2] or Telescope baseline extension. For their practical implementation, quantum repeaters are required, the operation of which is based on the effect of spin-photon entanglement [3]. Among the many platforms for the implementation of quantum repeaters, NV centers have proven themselves very well - this is due to their outstanding coherent properties, along with high state readout efficiency [4]. Moreover, the available adjacent nuclear spins could serve as memory qubits, expanding possible applications.
We demonstrated quantum repeater link, which is the building block for quantum network. In the current work, we implement an experimentally robust "spin-photon time bin" type of entanglement [5], demonstrating high fidelities (around 90%) of the entangled state and discussing the problems limiting it. To estimate the Fidelity of entangled state, we performed measurements in different bases. To control the phase of the photonic qubit, we used an unbalanced Mach-Zehnder interferometer, which allows us to replace temporal modes with spatial ones, and then adding a phase is straightforward. It is worth noting here, that spectral diffusion becomes a big problem with this change of basis, however, a quick control using FPGA allows this effect to be reduced.
We also discuss possible solutions for increasing the rate of entanglement generation (directing the light to the desired branch of the interferometer) and fidelity value, as long as the ideas of two-node realization.

References

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