Adaptive quantum manipulation over geometrical spin qubits under a zero field

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Manipulating an integrated quantum system is a challenging task. We have succeeded in storing photon polarization into a nuclear spin in an NV center in diamond [1]. The storage scheme is based on generation of entanglement between an electron and a ^{14}N nuclear spin and detection of entanglement between a photon and an electron [2], which consists of a geometrical spin under a zero field [3]. However, it is hard to increase the number of memory qubits due to complex time evolution of mutually interacting many-body system.

We experimentally demonstrate faithful manipulation of an electron spin interacting with two nuclear spins on ^{14}N and ^{13}C with optimized microwave pulses based on the gradient ascent pulse engineering (GRAPE) algorithm [4]. We achieved adaptive quantum manipulation of an electron spin state from $|m_s = 0\rangle$ to $|+\rangle = |m_s = +1\rangle + |m_s = -1\rangle$ with the fidelity of 95% (Fig.1). We also demonstrate dynamical simultaneous initialization of ^{13}C and ^{14}N nuclear spins under an oscillating magnetic field by applying the above scheme with the fidelity of 78% (Fig. 2). These demonstrations indicate that "exclusive" entanglement generation between an electron and a selected nuclear spin keeping the others unchanged could be realized to build an integrated quantum memory.

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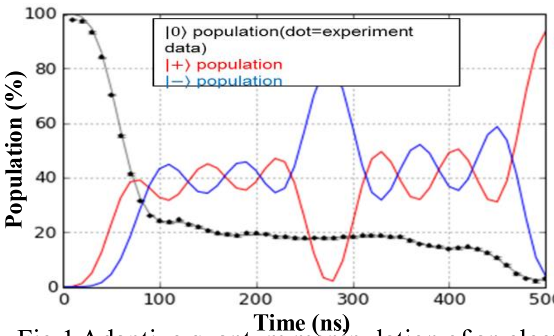

Fig.1 Adaptive quantum manipulation of an electron spin with the GRAPE pulse to prepare the $|+\rangle$ state.

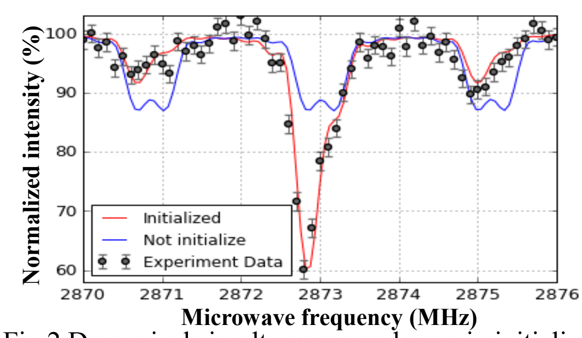

Fig.2 Dynamical simultaneous nuclear spin initialization of ^{13}C and ^{14}N atoms with the GRAPE pulse under a zero field.