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CPHASE gate for two distant NV center spins using optical cavity QED GUIDO BURKARD, University of Konstanz, DAVID D. AWSCHALOM, Institute for Molecular Engineering, University of Chicago — We propose and analyze a controlled-phase (CPHASE) gate for the spins of two nitrogen-vacancy (NV) centers in diamond embedded in a common optical cavity and driven by two off-resonant lasers. In combination with previously shown single-qubit gates, CPHASE allows for arbitrary quantum computations with the NV $|m_s = 0\rangle$ and $|m_s = -1\rangle$ ground states. The coupling of the NV center spin to the cavity mode is based upon Raman transitions via the excited states of the NV center and can be controlled with the intensity or the relative phase of the lasers. We find a characteristic laser frequency at which a laser photon is only scattered into the cavity mode if the NV center spin is $|m_s = 0\rangle$, and not in the case $|m_s = -1\rangle$. The scattered photon can then be reabsorbed by another selectively driven NV center and give rise to the conditional phase shift required for the CPHASE gate. Selectivity of NV centers within a larger array could be achieved using electrical control of the zero-field splittings or strain engineering in the crystal. We estimate a gate time of below 10 ns, several orders of magnitude shorter than typical NV electron spin coherence times. The separation between the two NV centers is only limited by the extension of the cavity.

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