Optical non-adiabatic geometric rotation with a degenerate spin under a zero field

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Although an optical field, which is especially useful for individually addressing integrated spins, cannot interact with a spin directly, a spin-orbit interaction mediates between the optical field and the spin, allowing to interact with each other. Recent work has demonstrated an optical adiabatic geometric rotation of an electron spin [1]. Here we show a detailed study of an optical "non-adiabatic" geometric rotation of a degenerate subspace of a spin-1 electronic system under a zero field, with a nitrogen vacancy center in diamond [2]. Degeneracy of the spin states allows faithful non-adiabatic arbitrary axis rotations by any angle defined by the light polarization and detuning. We demonstrate a complete set of Pauli quantum gates (Fig. 1) using the geometric spin preparation and readout techniques [3]. The new scheme is not only allow quick and local access but also immune to driving and environmental error [4], thus opening the way to fast quantum RAMs and quantum processors.

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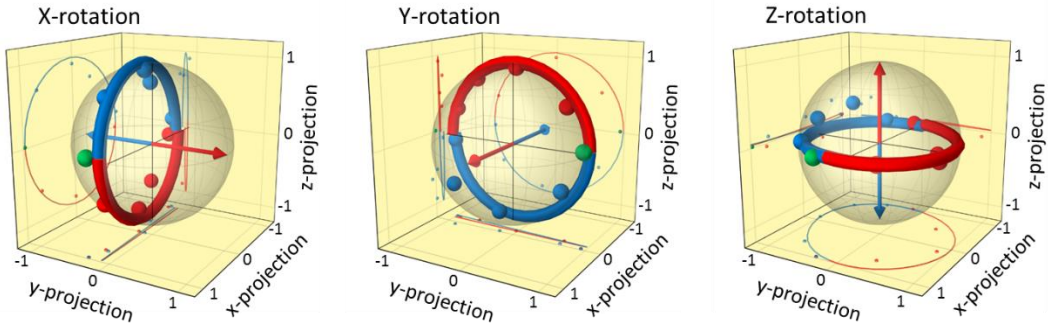

Fig.1 Optical holonomic quantum gates. The degenerate spin states beginning at the $|+i\rangle$, $|+\rangle$ and $|+\rangle$ states (green dots), are rotated about the X-, Y- and Z-axes. Red (blue) dots show positive (negative) rotation.