SCIENCE ADVANCES | RESEARCH ARTICLE

APPLIED PHYSICS

Electrically driven optical interferometry with spins in silicon carbide

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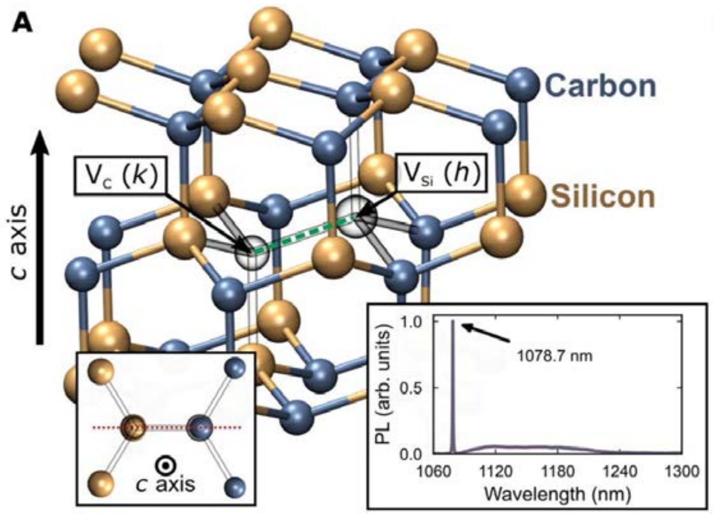
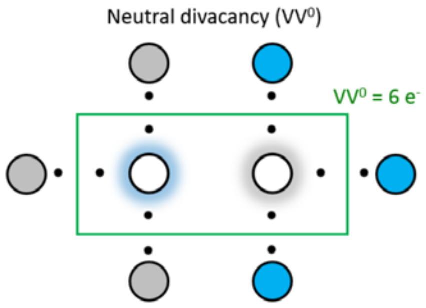
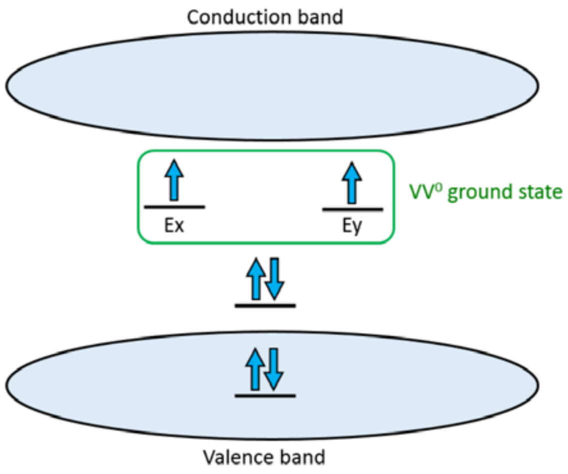
Ground state spins: weak coupling to environment, good coherence

Excited-state orbitals: stronger coupling to photonic & E fields

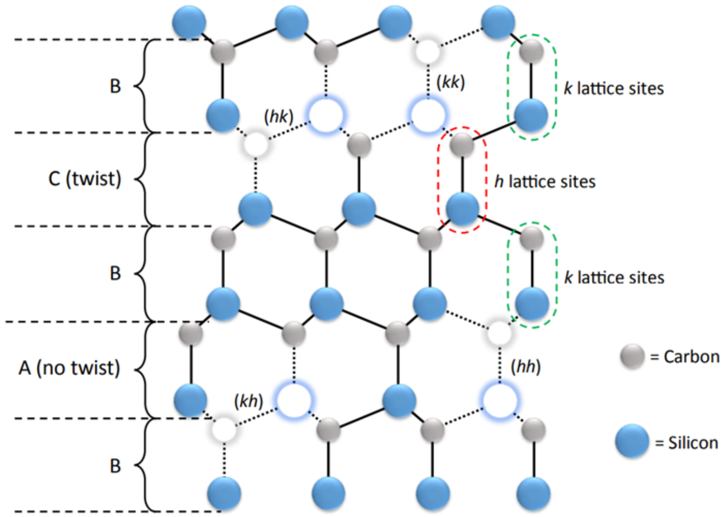
Neutral divacancy in silicon carbide



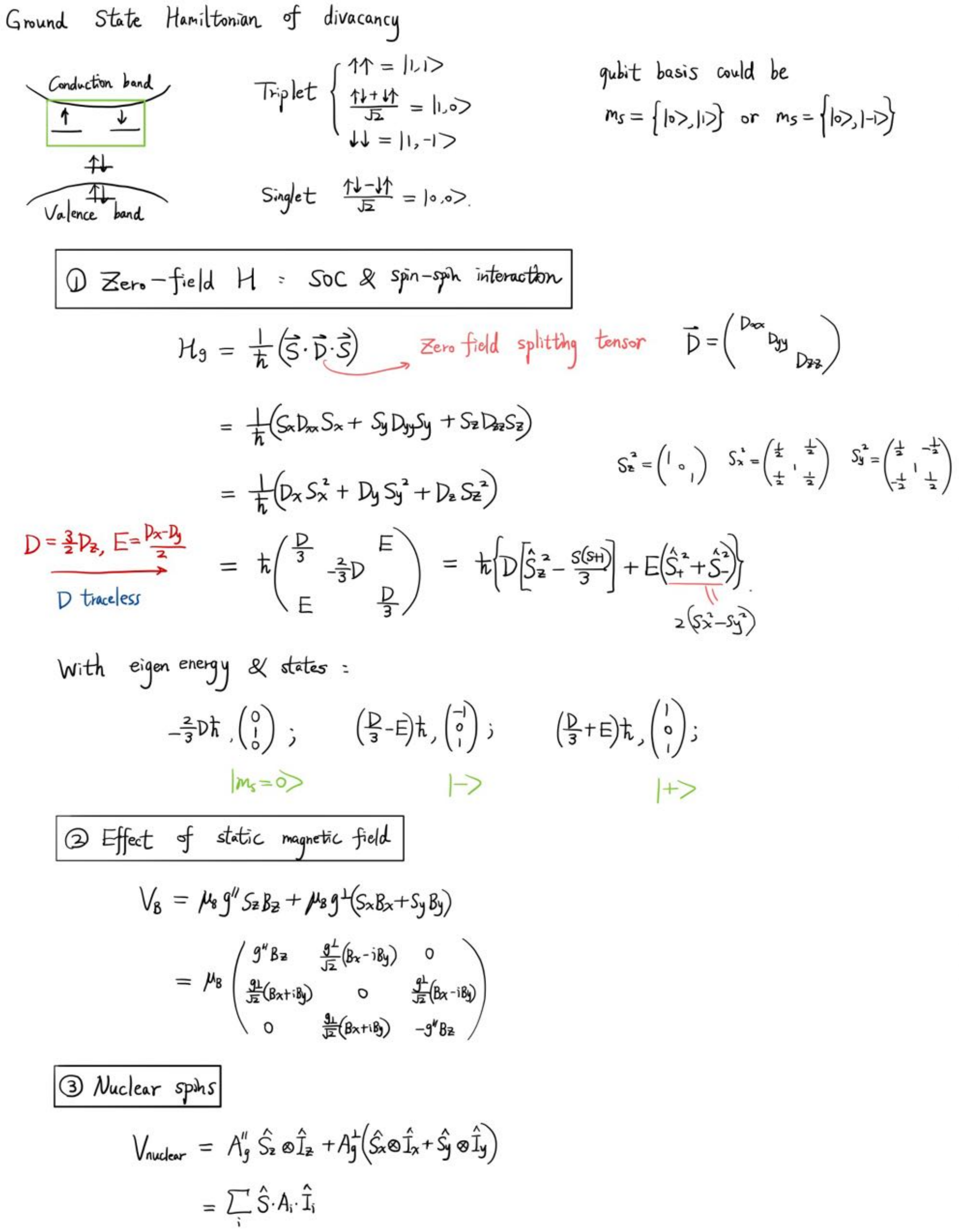




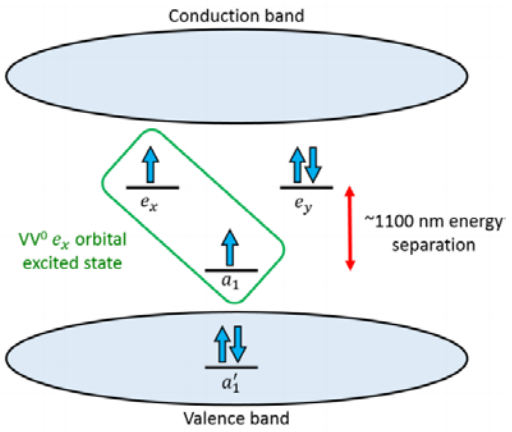
a localized C_{1h}
symmetry system

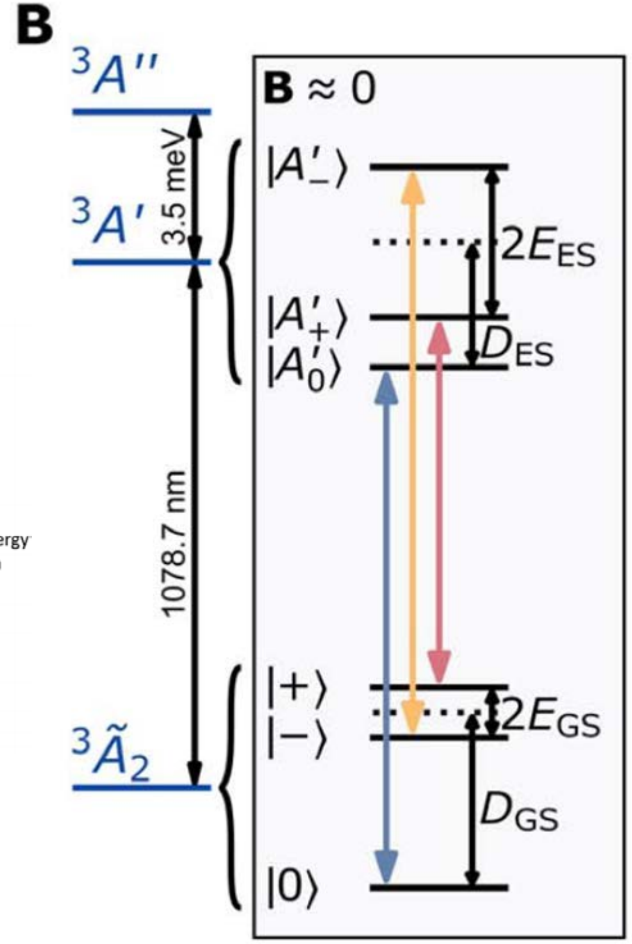


Hamiltonian of divacancy

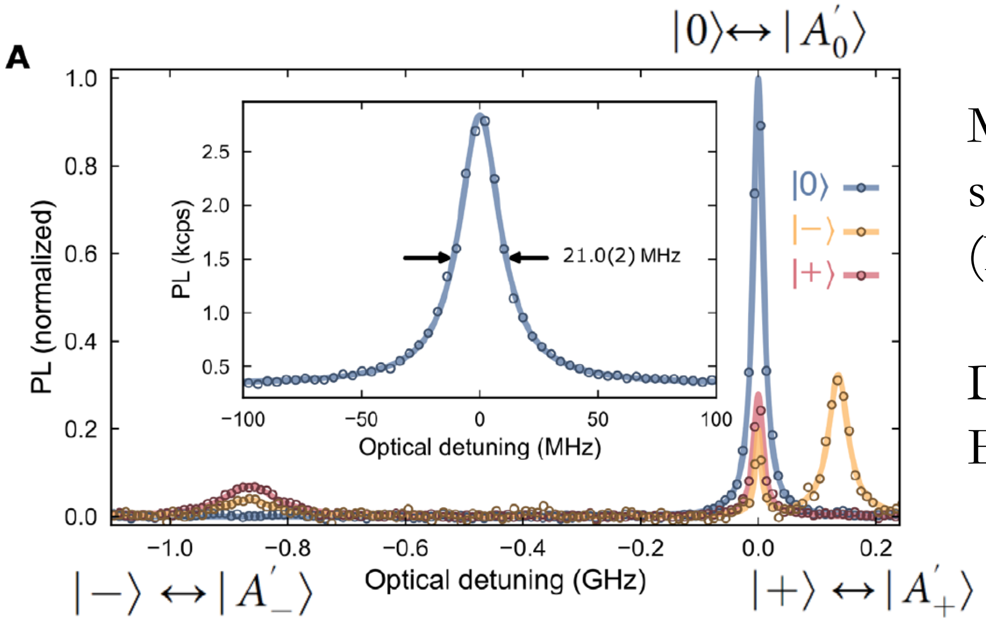


Excitated state longitudinal and transverse zero-field splittings D_{ES} and E_{ES}



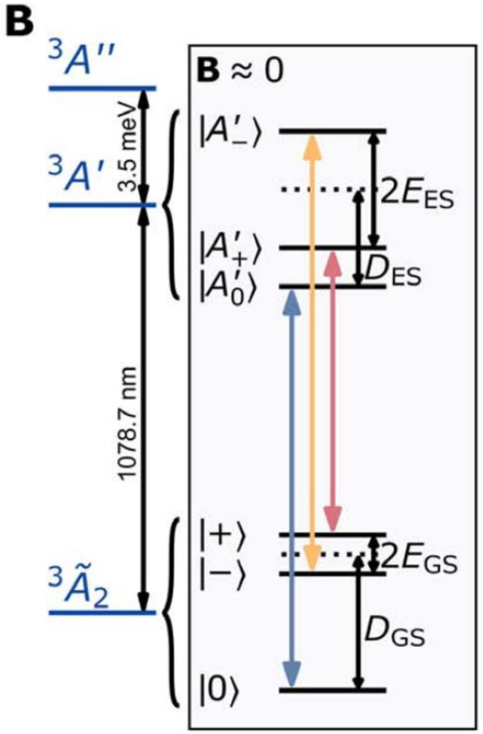


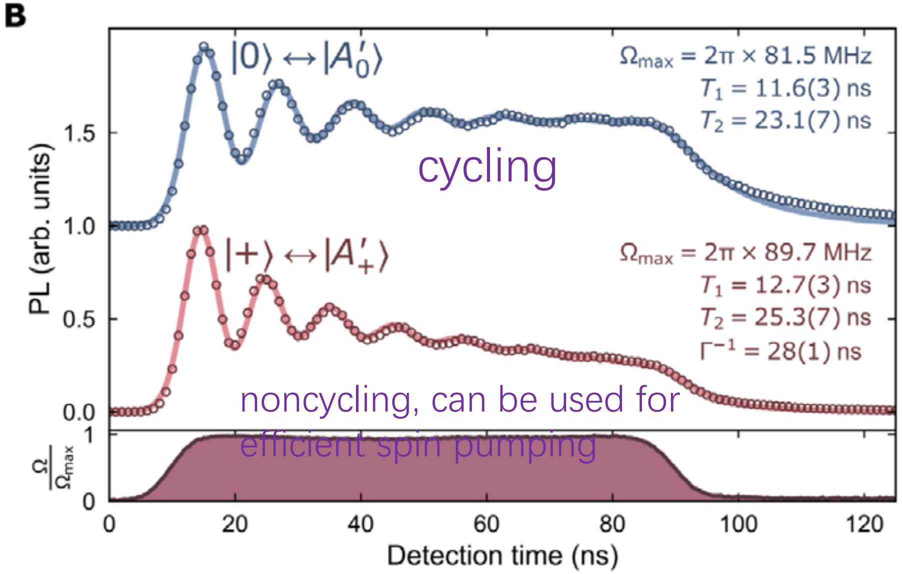
optical properties characterization



Map the fine structure of 3A'
spin-dependent PL excitation
(PLE) spectroscopy

D_{ES} : +970 MHz
E_{ES} : −483 MHz





Probe the excited-state dynamics
time-correlated fluorescence measurements

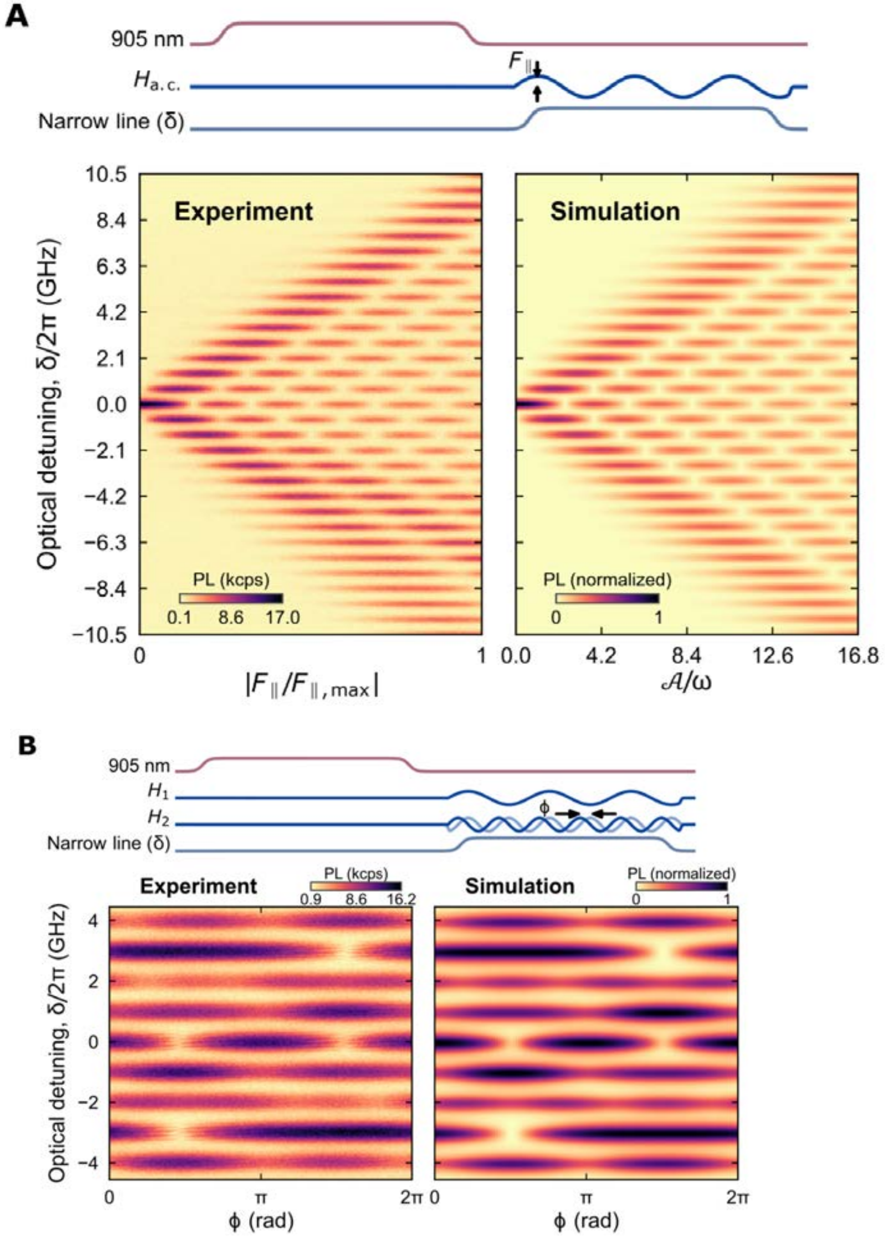
Optical TLS has near-lifetime-limited coherence

$$H(t)/\hbar = \frac{\Omega\cos(\omega_{opt}t)}{2}\sigma_x + \frac{\omega_0}{2}\sigma_z$$

Ω: optical Rabi frequency
δ : laser detuning

$$\dot{\rho}(t) = -\frac{i}{\hbar}[H(t),\rho(t)] + \frac{1}{2}\sum_n \left(2C_n\rho C_n^\dagger - \{C_n^\dagger C_n,\rho\}\right)$$

LZS interference



$$|0\rangle \leftrightarrow |A_0'\rangle$$

Arises when the TLS is repeatedly brought through an avoided crossing diabatically, Stückelberg phase between each crossing

Optical driving

Stark effect

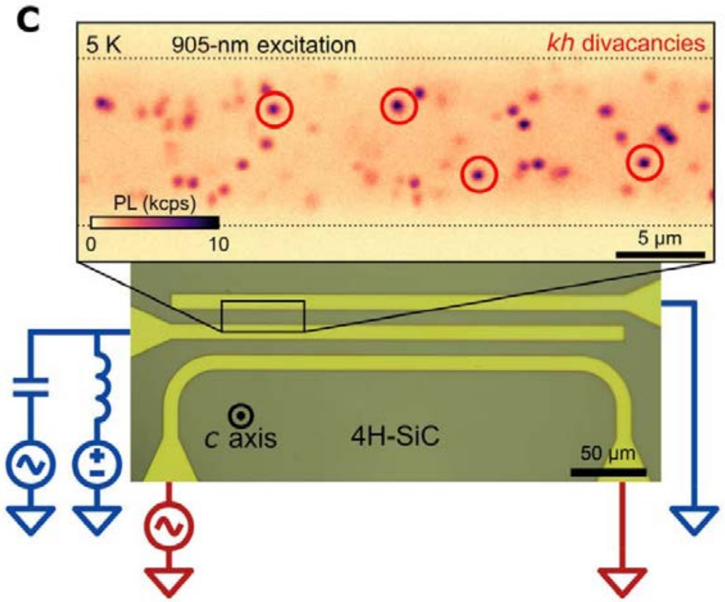
Multiphoton(15) resonances at detunings equal to integer multiples of drive frequency

F: Amplitude of E drive

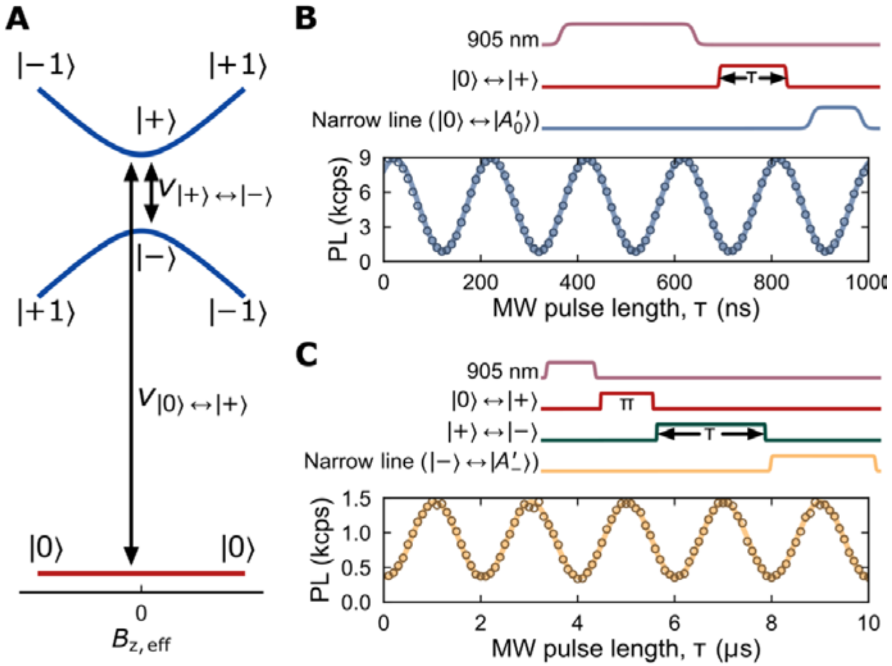
$\mathcal{A}$: induced Stark shift amp

dc Stark shifts of excited-state orbital levels

GHz ac electric field drive concurrently with the resonant excitation



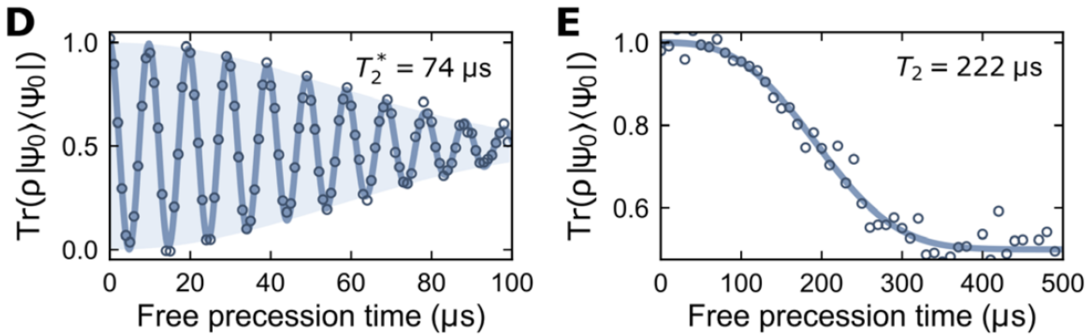
ground-state spin system in single kh VVs



magnetically driven transitions between all three spin states

Rabi oscillations marked by high PL contrast

Ramsey interferometry $\frac{1}{\sqrt{2}}(|0\rangle + |+\rangle)$



ZEFOZ

$$\mathrm{eigvec}(H/h) = \begin{cases} \frac{E}{C_+ + \sqrt{C_+^2 + E^2}}\,|+1\uparrow\rangle + |-1\uparrow\rangle, & |1\rangle \\ \frac{E}{C_- + \sqrt{C_-^2 + E^2}}\,|+1\downarrow\rangle + |-1\downarrow\rangle, & |2\rangle \\ \frac{E}{C_+ - \sqrt{C_+^2 + E^2}}\,|+1\uparrow\rangle + |-1\uparrow\rangle, & |3\rangle \\ \frac{E}{C_- - \sqrt{C_-^2 + E^2}}\,|+1\downarrow\rangle + |-1\downarrow\rangle, & |4\rangle \\ |0\uparrow\rangle, & |5\rangle \\ |0\downarrow\rangle, & |6\rangle \end{cases}$$

When a nonzero nuclear spin couples to the VV0

$$H/h = D\left(\hat{S}_z^2 - \frac{S(S+1)}{3}\right) + E(\hat{S}_+^2 + \hat{S}_-^2) + g\mu_B \mathbf{B}\cdot\hat{\mathbf{S}} + \sum_i \hat{\mathbf{S}}\cdot\mathbf{A}_i\cdot\hat{\mathbf{I}}_i$$