Magnetic Field Insensitive Radio-Frequency Dressed Qubit

Yiluo Li, Mingyu Fan, Andrew Jayich
Physics Department, University of California, Santa Barbara, California 93106, USA

College of Creative Studies

Trapped Ions

Representation of qubits

- Electron/nuclear spin are good representation of qubits
- Spin states live inherently in a finite space
- Other inifinite Hilbert space systems needs to be truncated artificially to represent qubits

Quantum computer

- Qubit: electron and nuclear spin states
- Unitary gates: external manipulation through laser pulses
- Initial state: cooling atom so its kinetic energy is much less than ΔE between hyperfine state

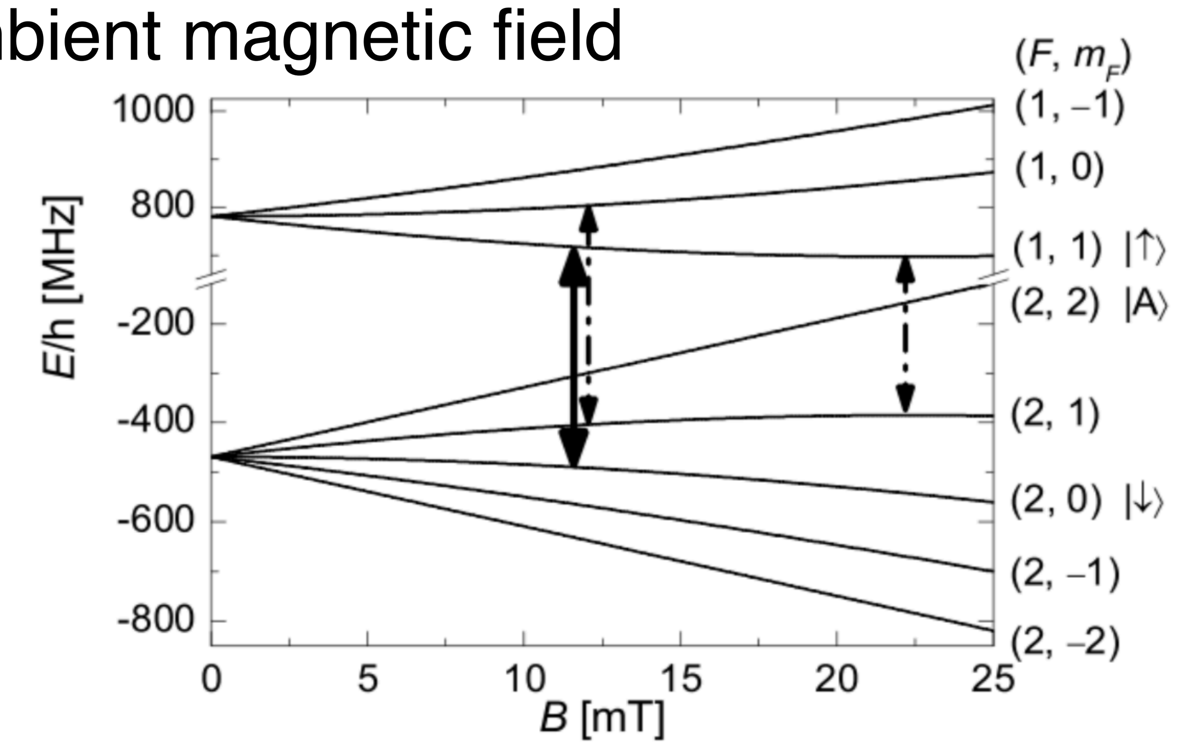
$$k_B T << \hbar\omega_z$$

- Readout: photon count of each hyperfine state

Static Magnetic Field

$$H_0 = \frac{A_{hfs}}{\hbar^2}\vec{I}\cdot\vec{J} + \frac{\mu_B}{\hbar}(g_I\vec{I} + g_J\vec{J})\cdot\vec{B}_{DC}$$

- Decoherence caused by fluctuation in ambient magnetic field



Zeeman Effect

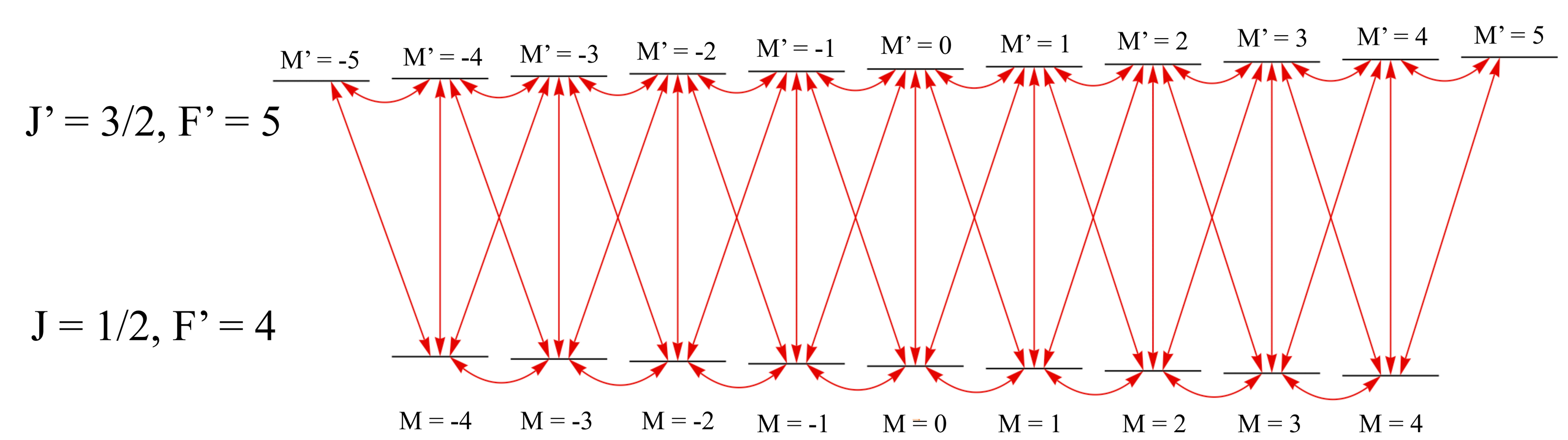
C. Langer et al., Phys. Rev. Lett. 95, 060502 (2005).

Rotating Wave Approximation

- Static and time dependent (RF) Hamiltonian

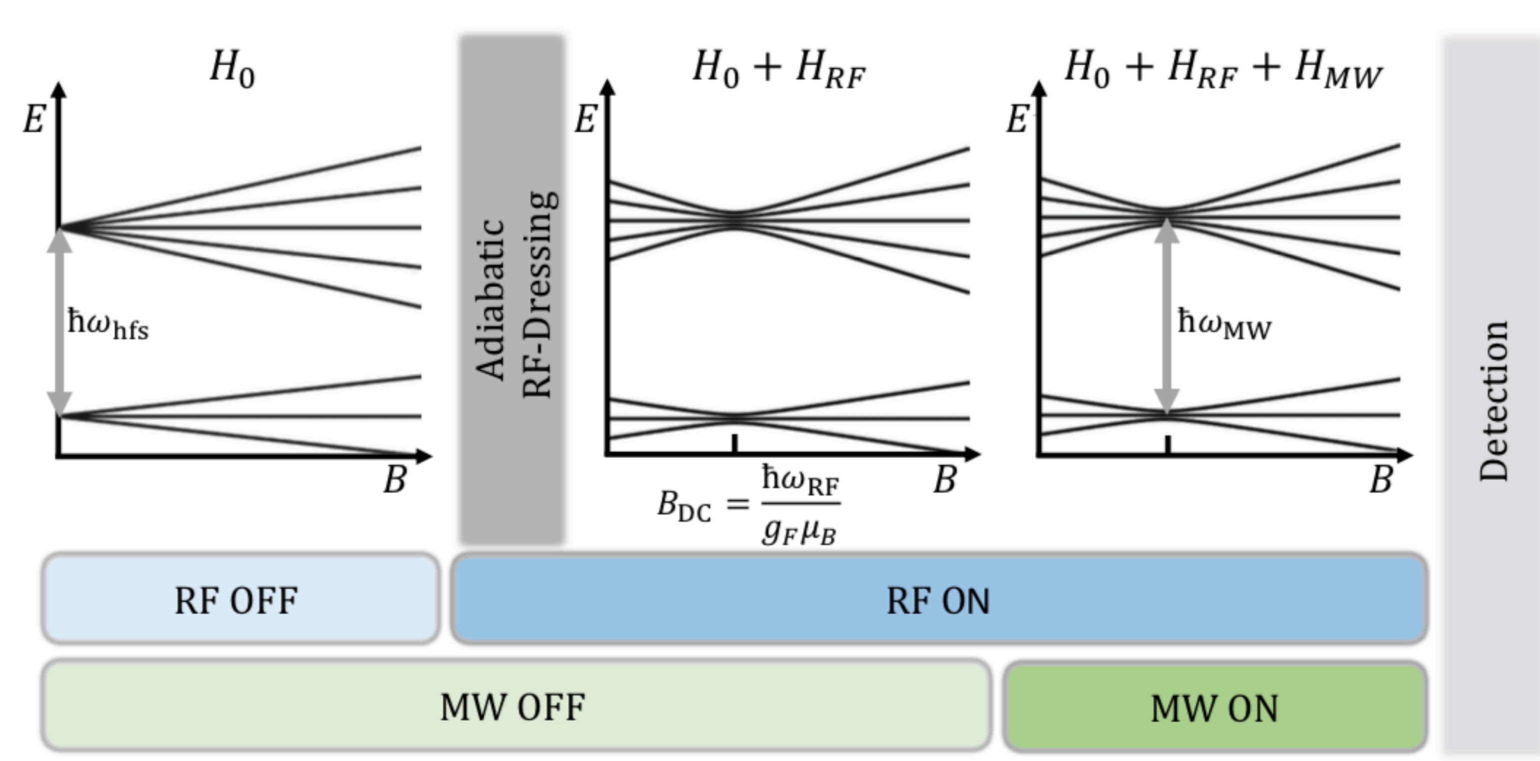
$$H_0 + H_{RF} = \frac{A_{hfs}}{\hbar^2}\vec{I}\cdot\vec{J} + \frac{\mu_B}{\hbar}(g_I\vec{I} + g_J\vec{J})\cdot(\vec{B}_{DC} + \vec{B}_{RF}(t))$$

- Use rotating wave approximation to simplify the Hamiltonian
- Magnetic field near resonance of a transition
- Fast oscillating term in Hamiltonian is dropped



Allowed transitions for the ground lower and upper manifolds of Sr87+

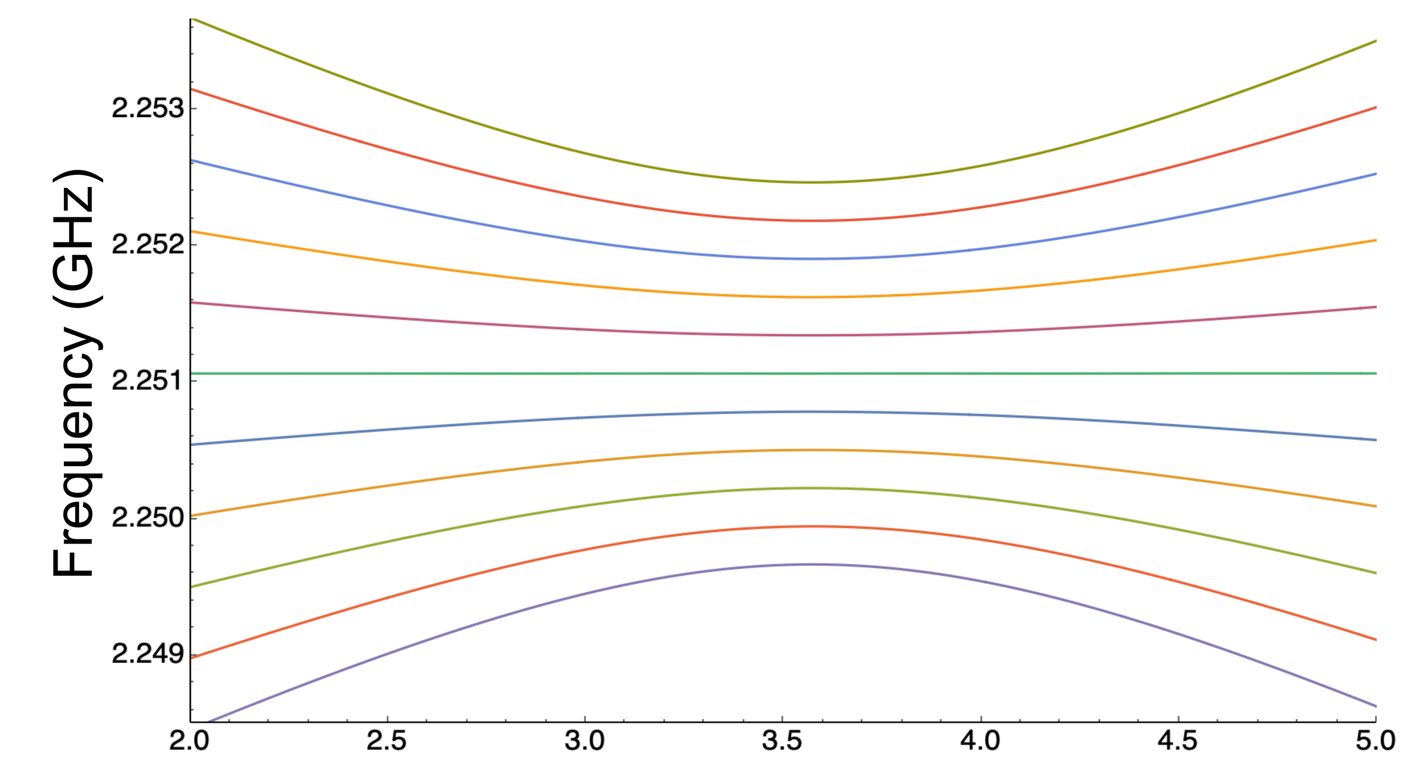
- Find allowed transitions and use RF magnetic wave to engineer a first order magnetic field insensitive regime



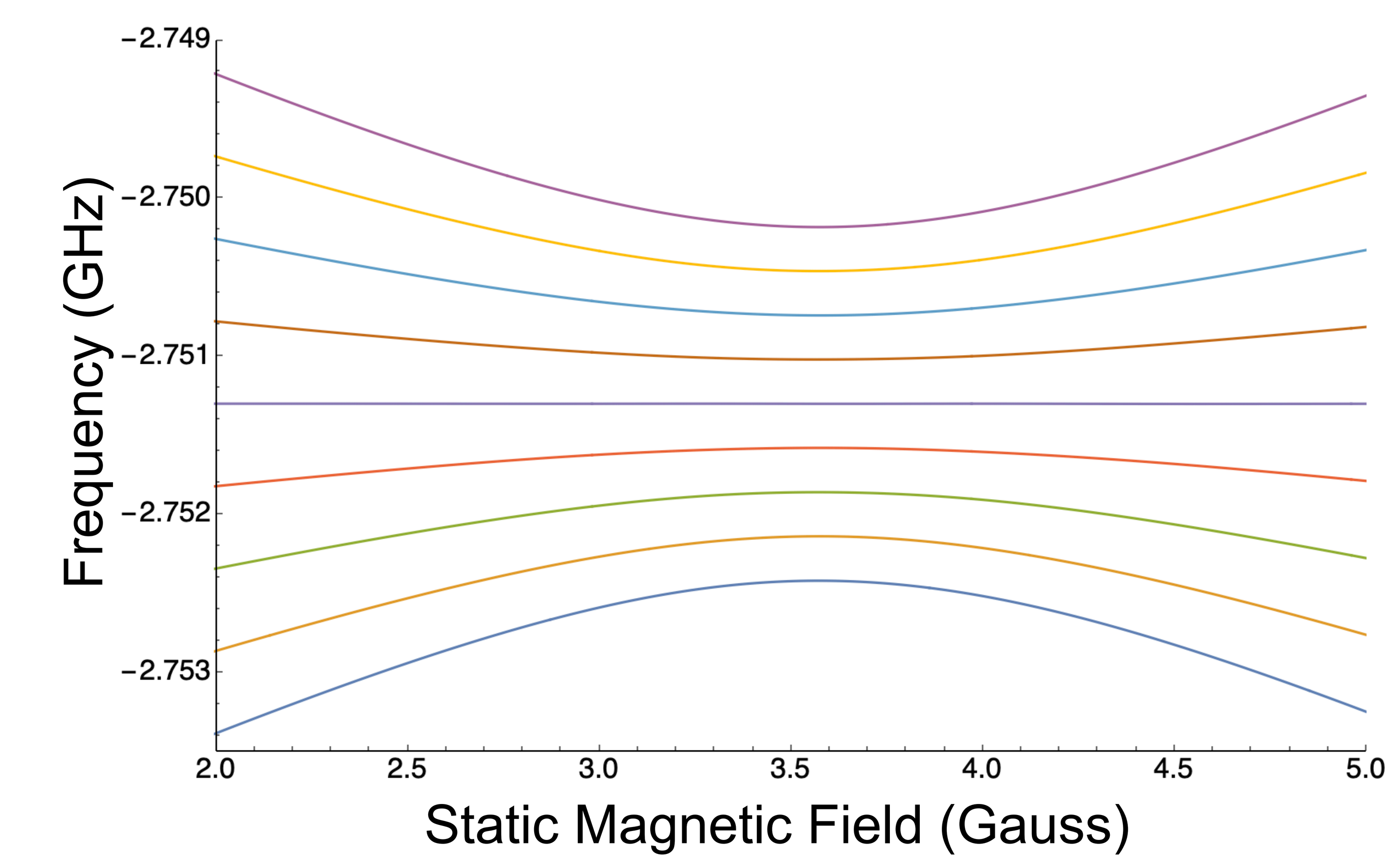
Using RF magnetic field to engineer a first order magnetic field insensitive area for transitions within and between different hyperfine manifolds

G. A. Sinuco-Leon et al., arXiv:1904.12073v2 (2019).

Monochromatic Dressing



Ground upper manifold dressed states for Sr87+, ω_{RF} = 1 MHz, B_{RF} = 2 Gauss



Ground lower manifold dressed states for Sr87+, ω_{RF} = 1 MHz, B_{RF} = 2 Gauss

Next Step

- Bichromatic RF dressing
- Opposite circular polarization
- Driving transitions using microwave magnetic field

$$\vec{B}_{RF}(t) = \frac{1}{\sqrt{2}}\Big[((B_x\cos(\omega_{RF}t+\phi_x) + iB_y\sin(\omega_{RF}t+\phi_y))\hat{e}_+ + ((B_x\cos(\omega_{RF}t+\phi_x) - iB_y\sin(\omega_{RF}t+\phi_y))\hat{e}_-\Big]$$

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