ABSTRACT: The viability of quantum computers depends on the development of scalable platforms with low error rates. Our "Oregon Ions" group has studied one such scalable architecture proposal including the limitations placed on logic gate fidelity by photon scattering. We studied spontaneous Raman scattering-induced errors in stimulated Raman laser beam-driven logic gates in metastable- and ground-manifold-encoded qubits. For certain parameter regimes, we found that previous, simplified models of the process significantly overestimated the gate error rate due to spontaneous photon scattering. We developed an improved model, which shows that there is no fundamental lower limit on gate error due to spontaneous photon scattering for electronic ground state qubits in commonly-used trapped-ion species when the Raman laser beams are red detuned from the main optical transition.

Additionally, spontaneous photon scattering errors are studied for qubits encoded in a metastable $D_{5/2}$ manifold, showing that gate errors below $10^{-4}$ are achievable for all commonly used trapped ions. Furthermore, we extended this theory from hyperfine to Zeeman qubits and we measured scattering rates from far-detuned Raman beams in a metastable $D_{5/2}$ Zeeman qubits in $^{40}\text{Ca}^+$, obtaining results that matched theoretical expectations. Finally, we present progress towards implementing a two-qubit Mølmer-Sørensen gate with these Raman beams in trapped $^{40}\text{Ca}^+$ ions.