Hybrid Quantum System with Polar Molecules in Cryogenic Crystals

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Polar molecules are compelling candidates for hybrid quantum architectures as their large electric dipole moments facilitate strong coupling to microwave circuits, while their dense hyperfine structures afford long-lived internal states for information storage [1]. Despite this potential, widespread adoption is constrained by the technical overhead of traditional trapping schemes. Here, we integrate polar molecules within cryogenic, magnetically quiet, predominantly spin-zero neon crystals grown directly atop superconducting resonators. These cryo-crystals provide robust trapping at submicron distances without degrading superconducting performance [2] or compromising the favorable properties of the embedded dopants [3]. Using a multimode resonator, we observed dispersive coupling to a molecular ensemble of ammonia at approximately 17 GHz. Moving forward, we aim to employ a frequency-tunable resonator to observe vacuum Rabi splitting, a definitive signature of coupling between the molecular electric dipole and the resonator electric field.

References

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Figures

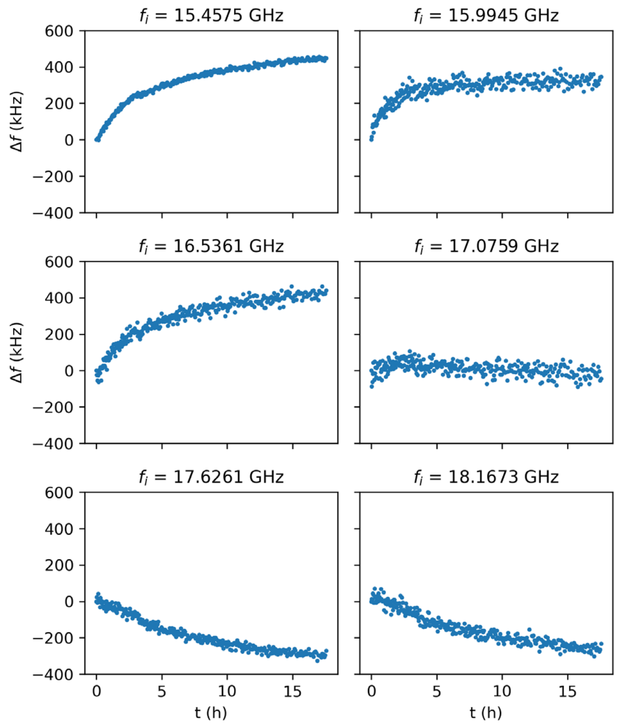

Figure 1: Resonance frequency of different resonator modes tracked as a function of time after populating the ∣J, K⟩ = ∣1,1⟩ molecule level by crystal annealing. The positive and negative frequency drift reveals dispersive coupling to a molecular transition at ~ 17GHz.