# Decoherence of Superposition States in Trapped Ions

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**Abstract:** We investigate the decoherence of superpositions of hyperfine states of $^{9}Be^{+}$ ions due to spontaneous scattering of off-resonant light. We find that, contrary to conventional wisdom, elastic Rayleigh scattering can have majour contributions to decoherence when compared to the effect of inelastic Raman scattering.

## 1. Summary

Minimizing the effects of decoherence is a central challenge in many quantum physics experiments. In the case of ion trap quantum computing [1] a majour contribution to decoherence comes from the off-resonant scattering of the controlling light beams. It is often assumed that the decoherence process is dominated by in-elastic Raman scattering, since in that case the scattered photon has a different frequency from the incoming photon, and consequently carries with it information regarding the internal state of the ion [2, 3]. This leads to decoherence of that internal state. On the otherhand since Rayleigh scattering does not carry this information it is assumed to not lead to comparable decoherence.

Here we show that under certain circumstances the Rayleigh scattering can dominate the ecoherence process even at large detunings from the excited state levels. We find excellent agreement between a masters theory approach and experimental measurements.

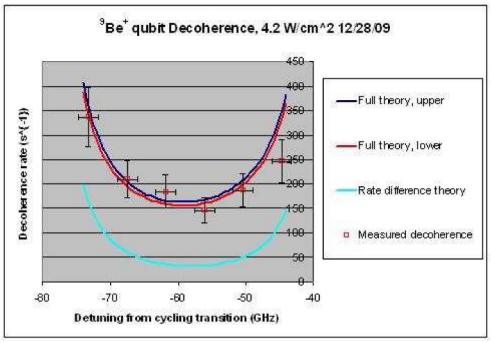


Figure 1: Comparison of decoherence rates as a function of detuning from the $^{9}Be^{+}$ cycling transition.
Squares - experiment, Blue/Red line - full masters equation theory, Cyan line - incomplete model sometimes used in literature.

## 2. References

[1] D.J. Wineland, *et al.*, Phil. Trans. R. Soc. Lond. A 361, 1349 (2003).
[2] R. Ozeri, *et al.*, Phys. Rev. A 75, 042329 (2007).
[3] R. Ozeri, *et al.*, Phys. Rev. Lett. 95, 030402 (2005).