Decoherence-Assisted Spectroscopy: Demonstrated with a Single Mg^+ Ion

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We describe a spectroscopy method that takes advantage of decoherence, typically thought of as detrimental when controlling quantum systems. The occurrence of a single excitation event is detected by enhancing its impact via a complete loss of coherence of a superposition of two ground states [1].
Thereby, transitions of a single isolated atom nearly at rest are recorded efficiently with high signal-to-noise ratios. The Spectra display symmetric line shapes without stray-light background from spectroscopy probes. We demonstrated this method on a ^{25}Mg ion to measure one-, two-, and three-photon transition frequencies from the 3S ground state to the 3P, 3D, and 4P excited states, respectively.
In combination with an additional logic ion [2], and incorporating the motional degrees of freedom, our method may also be applicable to species without cooling and detection transitions as well as molecular ions.

Please note that also other techniques based on the detection of momentum kicks altering the occupation of motional states from few absorbed photons have been developed recently [3–4].

References

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