Photon Recoil Heating Spectroscopy of Metal Ions

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Many atoms and molecules with interesting spectroscopic properties can not be laser cooled owing to their complex internal level structure. We present a universal spectroscopy system based on sympathetic cooling of a spectroscopy ion through a co-trapped logic ion which is laser cooled [1]. Spectroscopy is performed by monitoring the change of the motional state of the two-ion crystal due to photon recoil. Starting from the motional ground state, scattering of photons near the resonance of a spectroscopy transition leads to photon recoil heating. The motional excitation can be measured through coupling the motional state to the internal state of the logic ion, which can be determined with high fidelity [2]. This allows us to detect the scattering of only 60 photons using a Ca^+ spectroscopy and a Mg^+ logic ion. The use of non-classical motional states to further enhance the sensitivity will be discussed.

This spectroscopy technique is an extension of the quantum logic spectroscopy technique [3] to short-lived excited states. It is particularly useful if either the number of scattered photons or the number of atoms (e.g. rare isotopes) is a valuable resource. We plan to use this highly sensitive technique to perform precision measurements of the isotope shifts in Ti^+ and Fe^+, relevant to the search for a possible variation of the fine-structure constant using quasar absorption spectroscopy [4, 5].

References:

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