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Detection of Single Ion Spectra by Coulomb Crystal Heating

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— Sympathetic Heating Spectroscopy (SHS) takes advantage of the Coulombic interaction between two trapped ions. SHS maps the information of the back action of the interrogating laser on the spectroscopy ion onto the control ion for measurement. SHS only requires Doppler cooling of the ions and measurement of the fluorescence. In this work, we use two individual isotopes of calcium: $^{40}Ca^{+}$ to cool the Coulomb crystal (control ion) and $^{44}Ca^{+}$ as the target spectroscopy ion. We demonstrate that it is possible to get spectroscopic information by heating the crystal through the spectroscopy ion and observing the changes in the fluorescence of the control ion as we re-cool the system .The resolution of the spectrum is limited by the accumulative stochastic heating mechanism. The main advantage of the SHS technique is that the read out is done on the control ion and not on the spectroscopy (heating) ion. Very low laser intensities are required to have a significant stochastic optical force that builds up very fast with the laser interaction time and affects dramatically the ions' trajectory. This results in a large Doppler shift of the control ion which can be observed in the re-cooling process. Potentially, SHS can become an effective tool to study dipole transitions that are weak or fall in regions of the electromagnetic spectrum where the sensitivity of detectors is marginal or non-existent.

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