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# Sideband Thermometry on Ion Crystals

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Being a prospective platform for quantum computing and metrology, Coulomb crystals of ultracold trapped ions currently reach sizes of hundreds of individual particles. Such systems require high level of control over their motional temperature in order to account for the second-order Doppler shift in atomic clocks and implement high-fidelity entangling gates in quantum computers. However, the existing ion crystal thermometry tools struggle to provide an accurate temperature estimation for large ground-state cooled Coulomb crystals, either focusing only on the symmetric center-of-mass vibrational mode of motion or neglecting the involved spin-spin correlations between the trapped ions. To resolve the arising thermometry bottleneck, we consider the many-body dynamics of an ion crystal, arising when motional sideband transitions are driven in a near ground-state regime. In the single ion case, thermometry methods based on the motional sidebands are widely used and are thus of interest in the ion crystal case. The conducted study of the single-ion case from the Fisher Information prospective gives us some valuable insights for extending the approach further towards ion crystals. In our work we account for entanglement created between the ions in a Coulomb crystal to derive a new reliable temperature estimator, insensitive to the number of ions, and field-test in experiments with 4- and 19-ion crystals done by our colleagues from PTB Braunschweig and University of Innsbruck.

**Primary authors:** VYBORNYI, Ivan (Leibniz Universität Hannover); HAMMERER, Klemens (Leibniz University Hannover); ROOS, Christian (University of Innsbruck); MEHLSTÄUBLER, Tanja (PTB Braunschweig, Leibniz University Hannover); DREISSEN, Laura (Vrije Universiteit Amsterdam, PTB Braunschweig); KIESENHOFER, Dominik (University of Innsbruck); HAINZER, Helene (University of Innsbruck); BOCK, Matthias (University of Innsbruck); TUOMAS, Ollikainen (University of Innsbruck); VADLEJCH, Daniel (PTB Braunschweig)

**Presenter:** VYBORNYI, Ivan (Leibniz Universität Hannover)

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