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**Using Entanglement to Measure Temperatures and Frequencies
of Individual Normal Modes in a Strongly Coupled 2D Plasma of Be^{+1}**

BRIAN SAWYER, NIST- Boulder, JOSEPH BRITTON, ADAM KEITH, NIST-
Boulder, C.-C. JOSEPH WANG, Los Alamos National Laboratory, JAMES FRE-
ERICKS, Georgetown University, JOHN BOLLINGER, NIST-Boulder — Confined
non-neutral plasmas of ions in the regime of strong coupling serve as a platform for
studying a diverse range of phenomena including: dense astrophysical matter, quan-
tum computation/simulation, dynamical decoupling, and precision measurements.
We describe a method of simultaneously detecting and measuring the temperature
of transverse plasma modes in two-dimensional crystals of cold $^9\text{Be}^+$ confined within
a Penning trap. ² We employ a spin-dependent optical dipole force (ODF) gener-
ated from off-resonant laser beams to directly excite plasma modes transverse to the
crystal plane of ~ 100 ions. Extremely small mode excitations (~ 1 nm) may be
detected through spin-motion entanglement induced by an ODF as small as 10 yN ,
and even the shortest-wavelength ($\sim 20 \mu\text{m}$) modes are excited and detected through
the spin dependence of the force. This mode-specific thermometry has facilitated
characterization and mitigation of ion heating sources in this system. Future work
may include sub-yN force detection, spectroscopy/thermometry of the more complex
in-plane oscillations, and implementation/confirmation of sub-Doppler cooling.

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²B. C. Sawyer et al., Phys. Rev. Lett. **108**, 213003 (2012).

Brian Sawyer
NIST-Boulder

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