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Cavity probe for single-shot detection of atom dynamics in an optical lattice ROBERT NIEDERRITER, CHANDLER SCHLUPF, PAUL HAMILTON, University of California, Los Angeles — We propose and demonstrate a technique for real-time sub-wavelength cavity QED measurements of atom spatial distributions within the lattice sites of an optical cavity. Atoms are trapped in a red-detuned standing wave formed within an optical cavity and probed with an adjacent longitudinal cavity mode near atomic resonance. The atoms in $\sim 10^4$ lattice sites are uniformly coupled to the probe wave, enabling global measurements to provide single-site spatial information about the atom distribution. As a demonstration of the proposed technique, we perform single-shot axial and radial temperature measurements of 20-70 μK ensembles. Axial temperature measurements are based on detecting 100-nm-scale expansion of the atom cloud from each lattice site simultaneously on a time scale of $<$10 μs after extinguishing the trapping lattice. As the cloud expands, the atom-cavity coupling changes, shifting the cavity resonance frequency. The atom dynamics are therefore imprinted on the probe beam transmission through the cavity. The continuous observation of single-site spatial dynamics enables a range of applications in optomechanics and quantum sensing.

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