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Theory of Clock-Shift Density-Profile Measurements and Applications KADEN HAZZARD, ERICH MUELLER, Cornell University — "Clock shifts" – shifts in spectroscopic line energies proportional to the local density – provide a spectroscopic way of measuring spatial density profiles. By measuring the absorption of a probe laser at various frequencies, one can obtain a histogram of the number of particles with the associated local densities. Campbell *et al.* (*Science* **313**, 649 (2006)) have recently imaged the "wedding-cake structure" of the Mott insulator phase in trapped ultracold bosons in optical lattices, using this technique. We develop a theory of clock-shifts for these systems, making comparisons with experiment. We find qualitative agreement with experiment using the simplest strong-coupling mean-field theory with a local density approximation, and a harmonic, isotropic trap model. We show which embellishments to these approximations are best at accounting for the experimental data. We propose applications of this technique to cooling, thermometry, and measurement of correlations, giving an elementary theory of each. Finally, we highlight a *superfluid* shell structure that can be particularly apparent in these experiments.

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