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Probing many-body physics with an optical lattice clock

MICHAEL BISHOF, MICHAEL J. MARTIN, MATTHEW D. SWALLOWS, CRAIG BENKO, JAVIER VON STECHER, JILA, NIST, and University of Colorado at Boulder, ALEXEY V. GORSHKOV, Institute for Quantum Information, California Institute of Technology, ANA MARIA REY, JUN YE, JILA, NIST, and University of Colorado at Boulder — Advances in ultra-stable lasers now permit sub-Hz resolution of optical atomic transitions. At this level, interactions can dominate dynamics of the interrogated atoms, even for ultracold spin-polarized fermions. Density dependent frequency shifts of the $^1S_0$ to $^3P_0$ clock transition were first observed in ^{87}Sr [1]. Originally, this effect was attributed to s-wave interactions enabled by inhomogeneous excitations [2,3]. More recently, evidence for p-wave interactions was reported in ^{171}Yb [4]. Understanding interactions in theses systems is necessary to improve clock accuracy and stability. Moreover, such an understanding will enable optical lattice clock systems to serve as quantum simulators for open, driven, strongly-interacting quantum systems at the mesoscopic scale. We present a comprehensive evaluation and understanding of the interactions present in a ^{87}Sr optical lattice clock system under various conditions using a mean-field theory. The regime in which only a genuine many-body treatment can properly describe our system is within immediate experimental reach.

[1] G. Campbell et al., Science 324, 360 (2009). [2] A. M. Rey et al., PRL 103, 260402 (2009). [3] K. Gibble, PRL 103, 113202 (2009). [4] N. D. Lemke et al., PRL 107, 103902 (2011).

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