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Abstract for an Invited Paper
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Direct Observation of Atomic Number Squeezing in a Degenerate Bose Gas

MARK RAIZEN, The University of Texas at Austin

I will discuss recent work in my group on many-body quantum control towards the creation of atomic Fock states. In our rubidium experiment, a single Bose-Einstein condensate is optically trapped in crossed TEM01 modes, and we achieve confinement in two dimensions that is comparable to an optical lattice, but with single-atom addressability and detection. Using this system we have directly observed sub-Poissonian atom number statistics for a degenerate Bose gas with numbers as small as 20 atoms. The number squeezing was produced by starting with a Bose-Einstein condensate in an optical box trap and slowly lowering the walls in one dimension, a process we call quantum evaporation. The final atom number is determined by the energy of the N-body state in the box and can be precisely controlled. The observed squeezing is nearly a factor of two below the Poissonian (shot noise) limit. More importantly, known sources of noise can account for the residual fluctuations, so our results are consistent with the production of N-body Fock states. I will discuss the current limit to Fock state creation for even smaller numbers which we believe is due to many-body quantum tunneling. This effect can be controlled by the use of carefully tailored optical potentials and experiments are in progress. I will also discuss applications of our system to quantum computing and to the study of quantum critical phenomena.