Robust Atomic Fountain Interferometry

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Atomic Fountain Interferometry (AFI) is the disruptive technology for the measurement of gravitational gradients and accelerations with remarkable precision. AFI is based on the manipulation of atom cloud in a free-fall-tower using laser pulses to create a superposition of two momentum space pathways. The interferometric signal contrast is limited by variations in the initial velocity of the atoms in the cloud and variations in the laser amplitude over the cross-section of the cloud. A robust pulse scheme must provide separation, mirroring, and recombination of the atoms to high precision over a realistic range of these variations. In this work, we analyze the robustness of analytic pulse schemes, starting with the predominantly used sequence of Rabi pulses. We show that using rapid adiabatic passage as an alternative analytical pulse scheme leads to a significant improvement in robustness. In addition, we explore numerical optimal control theory to generate robust pulse schemes and formulate the most general control conditions for the implementation of an interferometer. Efficient generation of N-atom not-classical states and their use for robust AFI are also discussed.