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Optimal Robust Pulses for Atomic Fountain Interferometry

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— Atomic Fountain interferometers allow for unprecedented precision in the measurement of accelerations and gravitational gradients. They enable advances in fundamental research such as tests of the equivalence principle and gravitational wave detection, as well as technological applications such as inertial navigation. The signal contrast of large area interferometers depends on the precision and robustness of the laser pulses that implement the effective atomic beamsplitter and mirrors. We numerically map the robustness of the full atom interferometer with respect to variations both in the laser intensity and in the initial velocity of the atoms in the atomic cloud, comparing the relative merits of pulse schemes based on a train of Rabi pulses, respectively on rapid adiabatic passage (RAP) with linearly chirped pulses. Building on the RAP scheme, we further use optimal control theory to modulate the laser amplitude with the goal of making the interferometer insensitive to deviations in the pulse intensity and the initial velocity distribution, demonstrating an order of magnitude improvement in the interferometer's robustness.

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