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A Robust Ramsey Interferometer for Atomic Timekeeping in Dynamic Environments KRISH KOTRU, MIT Department of Aeronautics and Astronautics, JUSTIN BROWN, DAVID BUTTS, JENNIFER CHOY, Draper Laboratory, MARISSA GALFOND, MIT Department of Aeronautics and Astronautics, DAVID M. JOHNSON, JOSEPH KINAST, BRIAN TIMMONS, RICHARD STONER, Draper Laboratory — We present a laser-based approach to atomic timekeeping, in which atomic phase information is extracted using modified Raman pulses in a Ramsey sequence. We overcome systematic effects associated with differential AC Stark shifts and variations in laser beam intensity by employing atom optics derived from Raman adiabatic rapid passage (ARP). This technique drives coherent transfer between two hyperfine ground states by sweeping the frequency difference of two optical fields and maintaining a large single-photon detuning. Compared to a Raman-pulse Ramsey interferometer, we show a $\sim$100x reduction in sensitivity to differential AC Stark shifts. We also demonstrate that ARP preserves fringe contrast in Ramsey interferometers for cloud displacements reaching the $1/e^2$ intensity radius of the laser beam. Deviations of the phase in response to changes in duration, rate, and range of the ARP frequency sweep are bounded to <7 mrad, implying a per-shot fractional frequency stability of $1e^{-11}$ for an interrogation time of 10 ms. These characteristics are expected to improve the robustness of clock interferometers operating in dynamic environments.

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