Analysis and compensation of the fringe contrast loss in an atomic gravimeter caused by carrier motion

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Fringe contrast loss is a prominent problem for atomic gravimetry applications on moving platforms. The non-inertial carrier motion leads to the change in the relative position between the atomic cloud and the Raman laser cross section. Along with the Inhomogeneous distribution of the Raman laser intensity distribution, this results in a modulated laser intensity and effective Rabi frequency felt by the atoms, which causes reduction in Raman pulse fidelity, additional parasitic paths and fringe contrast loss in the atom interferometer.
In this work, the effects on both single Raman pulse fidelity and final fringe contrast due to transverse accelerations and attitude rotations have been investigated. The coupling between different motion components is analysed. Fixed motion rates as well as random motion noises are studied. The quantitative results show a strong correlation with the gravimeter parameters. The compensation method is then proposed. By monitoring the carrier motion in real time, the pulse-to-pulse effective Rabi frequency fluctuation is dynamically estimated, which is thus corrected via quickly adjusting the Raman intensity or pulse duration. Fine compensation strategies considering the integration within the atomic cloud are comparatively discussed.
A significant improvement of 18% in fringe contrast is achieved.

References

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[3] C.D. Panda, Applied Physics Letters 123 (2023), 064001.
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Figures

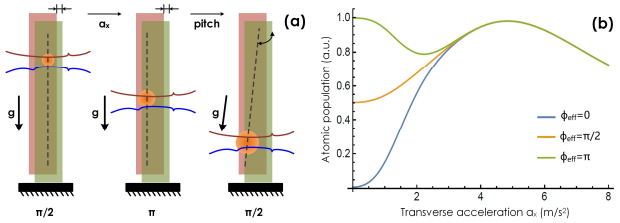

Figure 1: Influence mechanism of carrier motion and its influence on single pulse fidelity

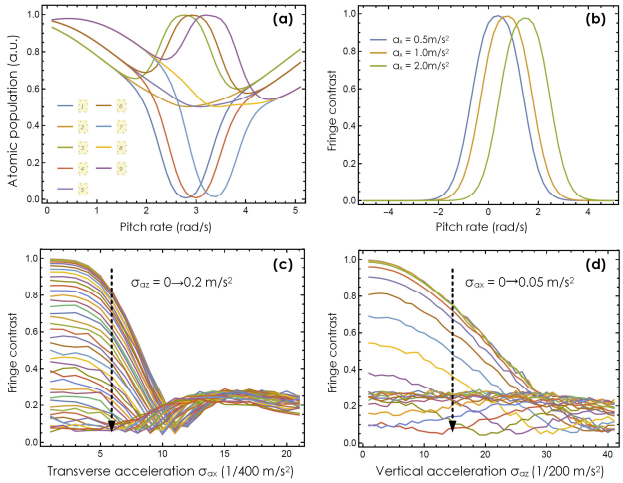

Figure 2: Coupling effect of carrier transverse acceleration and attitude rotation on fringe contrast

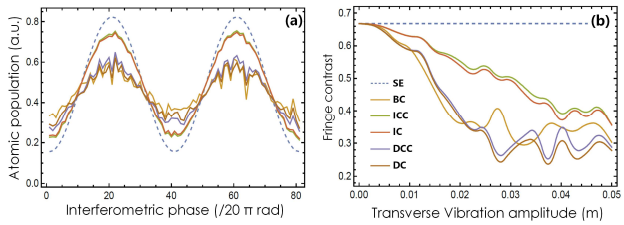

Figure 3: Fringe contrast compensation effect