Proof-of-principle demonstration of direct gravity gradient measurement using a single cloud double-loop atom interferometer

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Cold atoms gravity gradiometers (measuring the gravity gradient i.e. the gravity difference between two different places) have a wide area of application in metrology, geophysics and fundamental physics. The states-of-the-art gravity gradiometers use two clouds of cold atoms, separated by a certain distance, each measuring the gravity at the same time at a different place. We demonstrate a proof-of-principle of direct Earth gravity gradient measurement with an atom interferometer-based gravity gradiometer using a single source of cold ^{87}Rb atoms as proof mass. The atomic gradiometer is implemented in the so-called double-loop configuration showed in Figure 1(b), hence providing a direct gravity gradient dependent phase shift insensitive to DC acceleration and constant rotation rate [1]. The atom interferometer (AI) can be either operated as a gravimeter or a gradiometer by simply adding an extra Raman π-pulse.

We demonstrate gravity gradient measurements with and without vibration isolation. The simplicity of the experimental setup (one atomic source, one detection) and the immunity of the AI to rotation-induced contrast loss, make it compatible for onboard gravity and/or gravity gradient measurements in noisy environments.

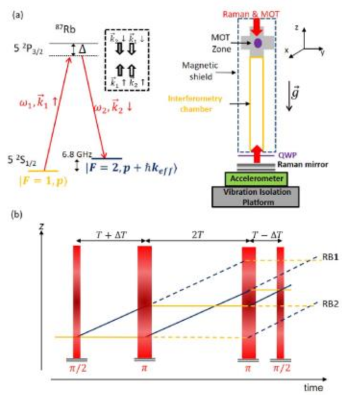

Figure – (a) Left: Energy levels scheme of rubidium D2-line. Two-photon Raman transitions performed on a single cloud in vertical configuration. Δ is the one photon detuning from the electronic transition. Right: Scheme of the experimental setup, the Raman laser beams are aligned along g. (b) Space-time recoil diagram in the absence of gravity of the four pulse double-loop AI baser gravity gradiometer. A time asymmetry ΔT is implemented to suppress parasitic Ramsey-Bordé interferometers (RB1 and RB2) due to imperfect mirror pulses.

Keywords: gravity gradiometer, cold atoms, interferometer, double loop

References

[1] M. Cadoret, N. Zahzam, Y. Bidel, C. Diboune, A. Bonnin, F. Théron, and A. Bresson, J. Opt. Soc. Am. B **33**, 1777 (2016).