Light-pulse atom interferometry with ultracold thermal clouds and realistic laser pulses

J. U. Jenewein, A. Roura, and W. P. Schleich

Institut für Quantenphysik
Universität Ulm
89069 Ulm
e-mail: jens.jenewein@uni-ulm.de.

We present a simulation of light-pulse atom interferometry with realistic laser pulses and ultracold thermal clouds. With our path-based approach we are able to study in detail the coherent evolution of the individual wave packets following each path and compare with experimental outcomes.

Our simulation of an atom interferometer uses imperfect beam splitters and mirrors according to Ref. [1]. In particular, we include an incomplete transfer of population from one resonant momentum to another, but also additional higher orders. We are also able to describe Doppler-induced velocity selectivity taking non-resonant momenta into account. This feature is especially relevant when we incorporate broad momentum distributions of ultracold thermal states. These are momentum distributions with width larger than that of a BEC but smaller than the recoil momentum of the two-photon process of Bragg diffraction. Experimentally, those states are created by evaporative cooling to a certain effective temperature followed by a magnetic lense in order to collimate the distribution even further [2,3]. Our interferometer approach is based on Ref. [4] and enables us to follow individual paths through the interferometer and identify spurious exit ports. This property is especially useful for thermal clouds, because there is a large overlap of the individual exit ports.

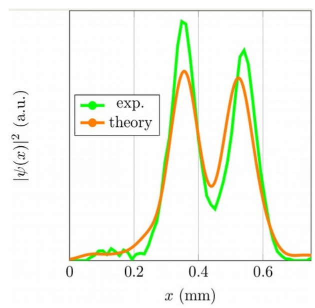

Figure 1: Density profile at the detection time of a Mach-Zehnder light-pulse atom interferometer with a laser phase difference of π/2. The green and orange lines represent the experimental and simulated data, respectively.

In Figure 1 we compare and contrast experimental data of atom interferometry experiments performed by the QUANTUS collaboration led by Prof. E. M. Rasel. They employ ultracold thermal states evaporated to an effective temperature of 264 nK and lensed to 11nK.

Keywords: Atom Interferometry, Light-Matter Interaction, Bragg Diffraction

References

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