Evaluation of atom-environment interaction based on decoherence of sodium atom interferometry

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Recently, it has been discussed whether one can access the spacetime fluctuation which comes from quantum gravity through measurement of the decoherence $\rho$ of atom interferometer (AI). Mang and co-authors derived the following equation $\rho = 1/3\lambda^3 (M/M_p)^2(T/T_p)$ where $\lambda$ is a cutoff parameter which defines a scale $\ell = \lambda L_P$ ($L_P$ is Plank length) that the spacetime fluctuation reaches [1-2]. As an example, they estimated $\lambda \geq 1890$ using the $\rho$ of the cesium AI experiment [3]. Of course, the decoherence must be affected due to other atom-environment interactions. Therefore, it is necessary to remove them in order to evaluate $\lambda$ accurately. We examined several sources of decoherence using the cold sodium AI (Fig. 1). As a result, we found that main source is a non-uniform magnetic field, and the theoretical curve (solid curve) based on the width of Rabi spectrum was in good agreement with the experimental values (Fig. 2).


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Fig. 1. Ramsey fringes of sodium AI. Separation time $T=0.1$ms. Visibility $V=0.69$. Fig. 2. Decoherence of sodium AI. Decoherence $\rho = 1 - V(T)/V(1)$. 