Optimal Control of an Atomic Magnetometer Based on Noise Spectrum Estimation

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Improving sensitivity is one of the primary goals in atomic magnetometer research, and the characterization and suppression of system noise are essential for achieving optimal measurements. In this work, we experimentally demonstrate and validate a sensitivity optimization method based on noise spectrum estimation. Using the output signals from non-destructive measurements in an atomic magnetometer, we apply noise spectrum estimation theory to reconstruct the system's noise spectrum from experimental data. Based on the measured noise spectrum, we design an adaptive control algorithm that enables the reverse derivation of optimal control parameters for detecting radio-frequency fields at specific target frequencies. This method improves magnetic field sensitivity compared to traditional radio frequency field measurements. This method does not rely on specific initial state preparation and exhibits strong generality, making it applicable to other types of quantum measurement systems.

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