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Low-crosstalk triaxial dynamic measurement method for wearable OPM-MEG

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Optically pumped magnetometers (OPMs) have significantly advanced the field of biomagnetic sensing, particularly in wearable applications such as magnetoencephalography (MEG). Triaxial measurement techniques further enhance the localization accuracy of these systems by capturing full vector information. However, the precision of triaxial OPM measurements is still constrained by two major issues: crosstalk introduced by multiple modulated magnetic fields and interference from low-frequency ambient magnetic field fluctuations.

To address these limitations, we propose a dynamic triaxial magnetic field measurement method that employs a single modulated magnetic field to reduce crosstalk. Additionally, it incorporates a closed-loop control system to suppress low-frequency magnetic field fluctuations under moving experiments. Experimental results demonstrate that the proposed method achieves measurement sensitivities of 20.3, 9.6, and 42.2 fT/Hz$^{1/2}$ along the x, y, and z axes, respectively. Moreover, the approach reduces scale factor fluctuation by 95.2% and decreases simulated MEG amplitude error by 64.2% under magnetic interference conditions. These improvements not only enhance measurement accuracy but also expand the practical potential of high-density wearable OPM-MEG systems.

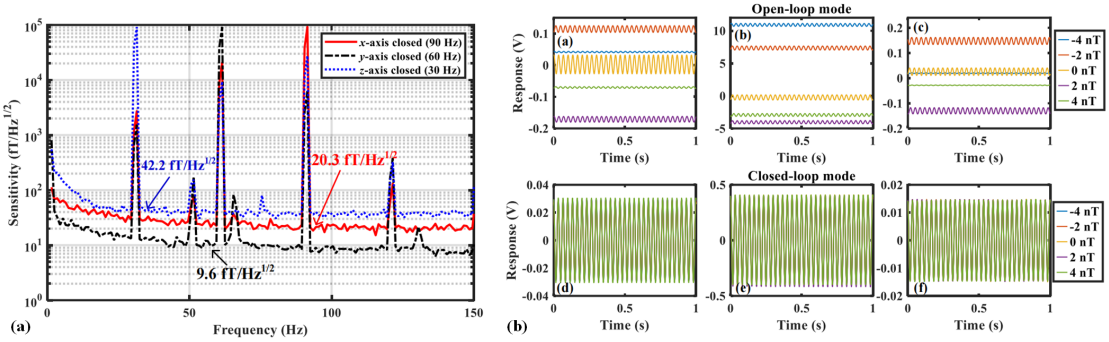

Figure 1: Results of triaxial dynamic measurement. (a) The triaxial measurement sensitivities of an OPM in the closed-loop mode. (b) Measurements of sinusoidal calibration signals under residual magnetic field fluctuations.

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