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Scalar-Mode OPMs with Spin-Echo Technique

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The precision of magnetic field estimation using a scalar-mode optically pumped magnetometer (OPM) is significantly degraded in the presence of environmental magnetic noise. Spatial inhomogeneity in the noise magnetic field reduces the transverse relaxation time, resulting in a shorter, noisier free induction decay (FID) signal. To address this issue, we employ a spin echo technique using a refocusing π radio frequency (RF) pulse. This π pulse inverts dephased spins, compensating for the spatial inhomogeneity of the noise field, as illustrated in Fig. 1. Unlike conventional methods, where FID signals decay rapidly in highly inhomogeneous fields, the proposed method extends the observable signal duration.

We conducted an experiment with a scalar-mode OPM in an open-door magnetic shield. The resonance frequency of the bias magnetic field was set to approximately 15 kHz, and the gradient magnetic field of the spatially inhomogeneous noise field was approximately 3 μT/m. As shown in Fig. 2, a $\frac{\pi}{2}$ pulse was applied at 0 seconds, followed by a π pulse at approximately 1.5 ms. While the FID signal decayed with a time constant of 0.9 ms, the spin echo signal exhibited a longer time constant of 3.0 ms, indicating an extended observation window.

We experimentally confirmed that spin echo signals can be observed even in the presence of spatially inhomogeneous environmental magnetic fields. Future work will investigate the effectiveness of the spin echo technique outside the magnetic shield.

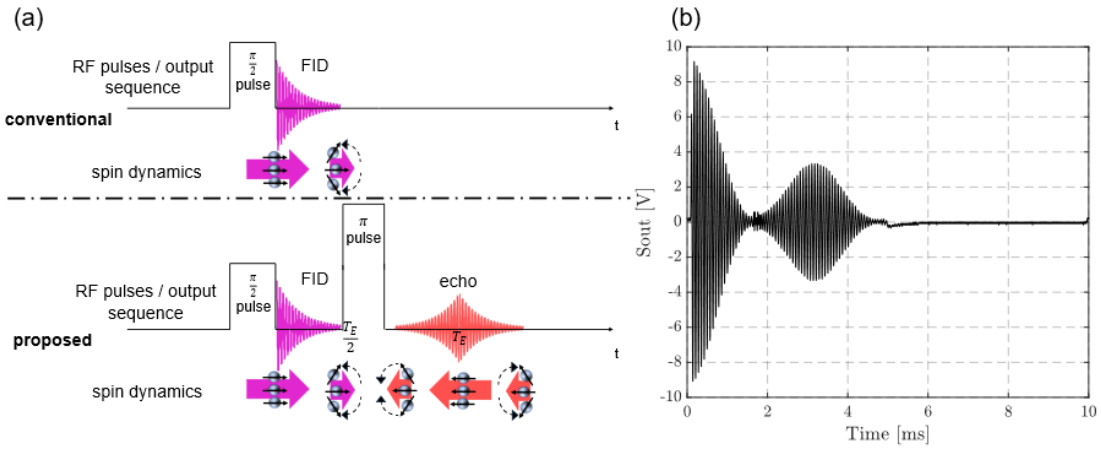

Figure 1: (a) Concept of proposed method (b) Experimental result

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