^{4}He zero-field vector optically pumped magnetometer operated in the Earth magnetic field

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Geophysical applications seek low noise and high bandwidth vector magnetometers with good accuracy. Since the European Spatial Agency's Swarm mission, ^{4}He absolute scalar magnetometers with vector mode proved their ability to offer precious measurement for geophysics studies [1]. More recently, ^{4}He zero-field magnetometers were demonstrated to reach improved vector sensitivities lower than 50 fT/$\sqrt{\text{Hz}}$ with a bandwidth larger than 1 kHz [2].

We present here the operation of such a vector zero-field ^{4}He magnetometer in Earth field using closed-loop operation achieving a dynamic range of $\pm$70 μT with DC to 1 kHz bandwidth. After calibration, the reconstruction of the scalar field from vector measurements shows a 1 nT$_{RMS}$ standard deviation residual. Sensitivities of 130 fT/$\sqrt{\text{Hz}}$ for the two most resolved axis and 170 fT/$\sqrt{\text{Hz}}$ for the less resolved one are obtained in the worst cases. Such performances provide a promising sensor for geophysics that could deliver measurements very similar to fluxgates, but with a noise floor improved by more than a factor 10 (Fig. 1).

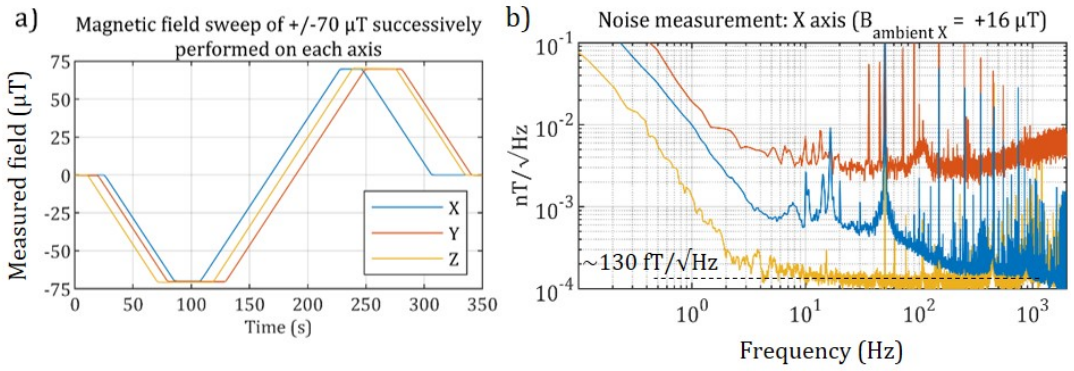

Figure 1: a) Magnetometer closed-loop response to a 70 μT$_{pp}$ magnetic field ramps along each axis. b) Noise spectrum of the B$_x$ component of the magnetic field with our sensor inside magnetic shield (yellow), in unshielded environment (blue) and of a commercial fluxgate sensor in unshielded environment (orange).

References

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[2] W. Fourcault *et al.*, Optics Express **29**, 10, 14467 (2021).