Dual-axis single-probe Hanle magnetometer based on atomic alignment

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Our team develops optically pumped magnetometers (OPM) based on metastable helium-4, working at any temperature, needing no heating nor cooling. We have made proof-of-concept recordings of both cardiography [1] and encephalography [2] with magnetometers using radio-frequency (RF) fields to excite parametric resonances. In the perspective of building a magnetometer array, it is desirable to find compact architectures without RF to avoid cross-talks and spurious effects. However, the usual Hanle effect on oriented atoms architectures require several orthogonal optical accesses to the vapor cell, hindering the compactness and the simplicity of the sensors. Hanle effect on aligned atomes may provide an answer to this need. Recently, Beato et al. [3] noted that transverse components of alignment contain dispersive dependences on several components of the magnetic field. We explored how these dependences could yield actual measurements of the magnetic field with two probe beams of different polarizations but propagating in the same direction. We found a scheme that allows measuring two components of the magnetic field from a single optical access to the vapor cell, which combines the two probe beams with different polarizations and a pump beam forming a small angle with them. The sensitivity as function of the magnetic field direction was measured experimentally for the two probe polarizations and the results, shown in Fig. 1, are in good agreement with the theoretical predictions. We will also discuss an extension of such alignment-based architecture that allows measuring the third component of the magnetic field using a partially depolarized pumping beam.

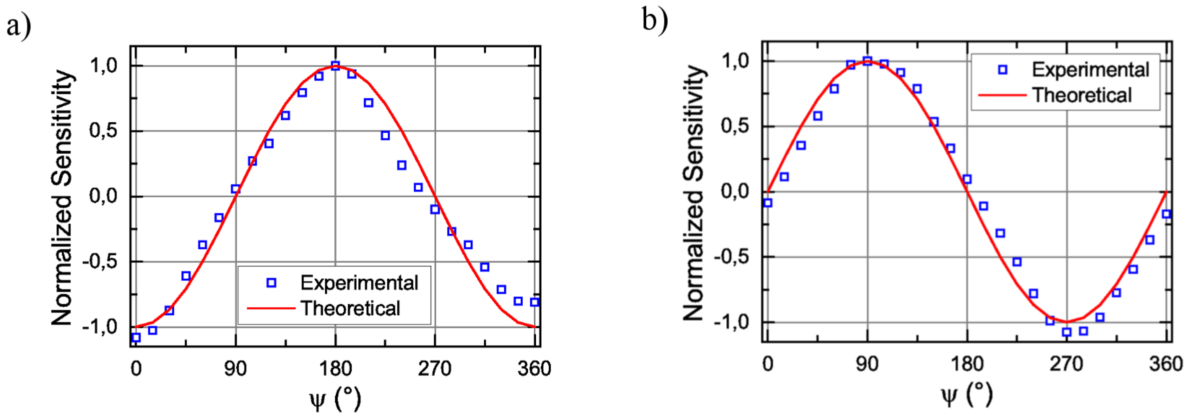

Figure 1. Evolution of the sensitivity with the direction of the magnetic field, denoted by the spherical angle ψ, for the two different probe polarizations.

[1] S. Morales et al., Phys. Med. Biol., Vol. **62**,n°**18** (2017).
[2] E. Labyt et al., IEEE Trans. Med. Imaging, Vol. **38**,n°**1** (2019).
[3] F. Beato et al., Phys. Rev. A, Vol. **98**, n°**5** (2018).