Proof of the feasibility of a wide-range optical vapor magnetometer based on nanocells

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In the past decade, optical nanocells (NC) of about 40 nm to 1 μm thickness in light propagation direction have proven to be efficient spectroscopic tools, allowing to perform linear Doppler-free spectroscopy with a simple one-beam experimental setup. We have recently shown that the derivative of selective reflection (dSR) from NC allows one to record atomic spectra with a about 50 MHz linewidth [1]. The sub-Doppler nature of recorded signals and the linearity with respect to the atomic transitions strength make the NC-based dSR technique an extremely convenient tool for studying the splitting of hyperfine atomic transitions in a longitudinal magnetic field and modification of their transition probabilities [2]. Our theoretical model, based on the articles [3,4], has shown a very good agreement with the recorded experimental spectra in a wide range of magnetic field variation covering evolution from Zeeman to hyperfine Paschen-Back regime.

Based on these studies, we have explored the feasibility of designing a nanocell-based optical magnetometer having a measurement range of 0.1 – 5.0 kG with a precision of about 1 G. To do so, a Raspberry Pi computer coupled to an Arduino Due board records the Rb D_2 line from a NC exposed to the magnetic field to be measured. After fitting the experimental spectrum by minimizing the residuals between experiment and theory, our Mathematica program returns the measured magnetic field value. To demonstrate its efficiency, the magnetometer was used to measure the inhomogeneous magnetic field produced by a permanent neodimuim-iron-boron alloy ring magnet at different distances from the cell. The standard deviation of the measurements remains under 5% in the magnetic field range of 2 – 0.4 kG. Possible optimization and outlook are addressed.

References

[1] A. Sargsyan, E. Klinger, Y. Pashayan-Leroy *et al.*, J. Exp. Theor. Phys. Lett. **104**, (2016).
[2] A. Sargsyan, E. Klinger, G. Hakhumyan *et al.*, J. Opt. Soc. Am. B **34**, (2017).
[3] P. Tremblay, A. Michaud, M. Levesque, *et al.*, Phys. Rev. A **42**, 2766 (1990).
[4] G. Dutier, S. Saltiel, D. Bloch *et al.*, J. Opt. Soc. Am. B **20**, 793 (2003).