Phd Thesis Defense: Cavity-Enhanced, Optically Pumped Magnetometry and its Miniaturization

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This thesis presents the development and experimental implementation towards a miniaturized cavity-enhanced atomic magnetometer designed for high sensitivity and high spatial resolution. The proposed technique relies on a cavity-based optical readout of atomic polarization using the Pound Drever Hall technique.
The magnetometer was experimentally realized and characterized, including a design compatible with biological measurements. The magnetometer can operate with one endcap open in a weak shielding environment (only only layer of mu-metal.) The system was applied to the study of magnetotactic bacteria, whose magnetic response arises from the alignment and relaxation dynamics of intracellular magnetosome chains. Time resolved measurements of the magnetic signal were analyzed assuming exponential relaxation. Furthermore, the

model was expanded using a stochastic model to detect deviations from exponential behavior associated with sample evaporation.
The achieved sensitivity and stability of the magnetometer enabled the reliable detection of magnetic signals on the nanotesla scale, with a sensing characteristic length Lat=1.5 mm. These results demonstrate the potential of cavity-enhanced atomic magnetometry for the investigation of biological magnetic systems. This work establishes a versatile platform for high-sensitivity magnetic measurements and opens promising perspectives for future applications in biophysics and magnetic microscopy.

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