Optically pumped magnetometer for biomedical applications

K. Jensen[1,2], M. Zugenmaier[2], J. Arnbak[2], H. Stærkind[2], M. V. Balabas[2,3], and E. S. Polzik[2]

[1] School of Physics and Astronomy, University of Nottingham, University Park, Nottingham NG7 2RD, England, United Kingdom

[2] Niels Bohr Institute, University of Copenhagen, Blegdamsvej 17, 2100 Copenhagen, Denmark

[3] Department of Physics, St Petersburg State University, Universitetskii pr. 28, 198504 Staryi Peterhof, Russia

We have developed a highly sensitive optically pumped magnetometer (OPM) based on cesium atomic vapor. The magnetometer is operated at room temperature and is well suited for biomedical applications. Using that magnetometer, we have performed proof-of-principle experiments where we have detected nerve impulses in a frog sciatic nerve [1] and the heartbeat of an isolated guinea-pig heart [2]. OPMs could potentially also be used to non-invasively image the electrical conductivity of biological tissue using a technique called magnetic induction tomography. This is a challenging task due to the low conductivity $\sigma \lesssim 1$ S/m of biological tissue. As a step towards imaging biological tissue, we have detected small containers with a few mL of salt-water with conductivity ranging from 4–24 S/m (see Figure 1). For those measurements, we employed a noise-canceling differential technique which increased the signal-to-noise ratio by more than three orders of magnitude. Our work [3] opens up new avenues for using OPMs to image low-conductivity biological tissue including the human heart which would enable non-invasive diagnostics of heart diseases [4].

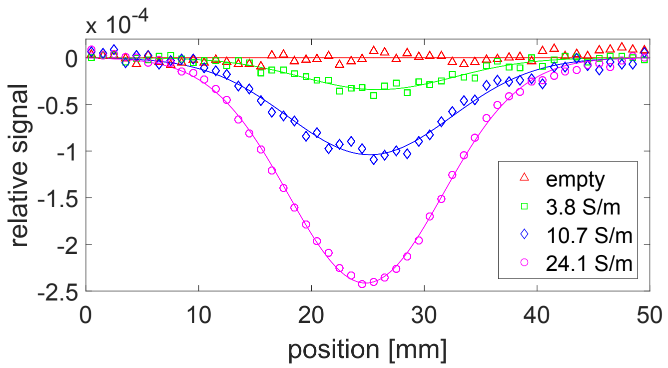

Figure 1. Detection of a salt-water with varying conductivity.

[1] K. Jensen et al., Non-invasive detection of animal nerve impulses with an atomic magnetometer operating near quantum limited sensitivity, Sci. Rep. **6**, 29638 (2016).

[2] K. Jensen et al., Magnetocardiography on an isolated animal heart with a room-temperature optically pumped magnetometer, Sci. Rep. **8**, 16218 (2018).

[3] K. Jensen et al., Detection of low-conductivity objects using eddy current measurements with an optical magnetometer, arXiv:1905.01661 (2019).

[4] L. Marmugi and F. Renzoni, Optical Magnetic Induction Tomography of the Heart, Sci. Rep. **6**, 23962 (2016).