Helium-4 optically pumped magnetometers for medical imaging

W. Fourcault[1], F. Beato[1], G. Lieb[1], G. Le Gal[1], R. Garcs Malonda[1],
E. Labyt[1], M. Le Prado[1] and A. Palacios-Laloy[1]

[1] CEA LETI, MINATEC Campus, F-38054 Grenoble, France
Univ. Grenoble Alpes, F-38000 Grenoble, France

Our team develops optically pumped magnetometers (OPM) based on metastable helium-4 atoms. This sensitive species works at any temperature, needing no cooling nor heating, unlike SQUID or alkali OPM based on the SERF effect. This allows setting the sensors in contact with the surface of the body, as close as possible to signals to be observed in medical imaging. These last years we have made proof-of-concept recordings of both magneto-cardiography (MCG) [1] and magneto-encephalography (MEG) [2] with ^{4}He magnetometers based on parametric resonance.

A full rework of the sensors has allowed us to obtain sensors with compact footprints of 2x2 cm. In contrast with other OPM we pump the atoms with linearly polarized light. This configuration allows measuring the component of the field radial to the head using light that propagates radially [3], which allows closer packing and a simpler optical setup. Our sensors currently have 2 kHz bandwidth, a dynamic range of several hundredths of nanotesla and resolutions better than 50 fT/Hz$^{1/2}$.

We are currently progressing towards a closed-loop magnetometer array with automatic correction of the cross-talks between the sensors. We are also exploring how the coupling of our OPMs with appropriate optical structures could allow reaching the Standard Quantum Limit of intrinsic noise.

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