Multi-channel radio-frequency optically pumped magnetometers and their applications in MRI

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Radio-frequency optically pumped magnetometers (RF OPMs) can operate in a broad frequency range from kHz to MHz with a bias field tuning. Their sub-fT sensitivity is promising for many applications, including magnetic resonance imaging (MRI). At Los Alamos, we have designed a multi-channel RF OPM with the goal of applications in multi-channel parallel MRI at ultra-low field (Fig.1).

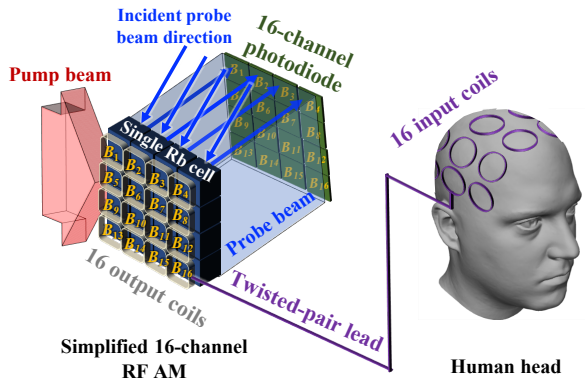

Figure 1: Illustration of the multi-channel OPM parallel ULF MRI device.

A long-standing problem in MRI applications is that an OPM would lose its sensitivity in the presence of the MRI fields and gradients. A simple solution, compatible with anatomical imaging, is to use a flux transformer (FT) that carries out only the RF component of MRI signals into the OPM. In a multi-channel FT-OPM system, it is important to sufficiently reduce crosstalk between FTs. According to our analysis, an array of partially overlapping pick-up coils in a non-resonance operation can minimize the mutual flux between the FTs. In contrast, an array of pick-up coils would require a resonant operation to reach fT sensitivity without OPMs, which would make the FT decoupling a very challenging technical problem. We performed theoretical simulations [1] to address the FT decoupling question and estimated the sensitivity of the multi-channel FT-OPM system. In this talk, we will report our progress on the multi-channel MRI and related questions, such as design of low-noise 100 aT RF shield [2] from which MRI and other high-sensitivity OPM applications will greatly benefit. This work is supported by LANL LDRD program, grant # 20200393ER.

References

[1] Young Jin Kim and Igor Savukov, J. Appl. Phys. **128**, 154503 (2020).
[2] Igor Savukov and Young Jin Kim, J. Appl. Phys. **128**, 234501 (2020).