Towards innovative multimodal neuroimaging using K-Rb spin-exchange hybrid OPMs

Tetsuo Kobayashi

Graduate School of Engineering, Kyoto University, Nishikyo-ku, Kyoto, 615-8510 Japan

In recent years, optically pumped magnetometers (OPMs) operating under spin-exchange relaxation-free (SERF) conditions have reached sensitivities comparable to and even surpassing those of superconducting quantum interference devices (SQUIDs). In 2005, Savukov and Romalis reported that high-density OPMs are able to be very sensitive outside SERF regime. Since 2006, we have been studying the SERF and high-density SERF-like OPMs with pump-probe arrangement. In 2011, we proposed the first high-density K-Rb spin-exchange hybrid OPM. In the hybrid OPM, a circularly polarized pump beam and a linearly polarized probe beam crossed orthogonally in the cell including two vaporized K and Rb atoms together. The homogeneity of the sensing characteristics of the hybrid OPMs is able to be increased inside the cell [1, 2] and its sensitivity is also be improved by setting the optimal densities of the K and Rb atoms as well as their optimal density ratio [3]. After introducing the principle of the K-Rb spin-exchange hybrid OPM, we present our recent results on multi-channel MEG measurements.

Meanwhile, magnetic particle imaging (MPI) can realize high-speed hemodynamics imaging as a new method of neuroimaging. Since the sensitive frequency of the high-density OPM with pump-probe arrangement is tunable, it is capable of operating MPI scanners at a relatively low excitation or driving frequency using the OPM as a detector instead of an induction coil. This is an important advantage in the fabrication of human-size MPI scanners. Finally, we show that magnetic nanoparticle signals from the Resovist solution with Fe of 0.01 μmol could be detected remotely by a OPM module [4].

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