Development of Optically Pumped Magnetometers for Geomagnetic and Biomagnetic fields

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Optically pumped magnetometers (OPMs) exploiting alkali metal vapours for accurate, precise magnetometry have benefited from improvements in components and operating modalities in recent years. Microfabrication of alkali cells and chip-scale lasers allows mass-production of compact sensors, and spin-preparation and feedback techniques, such as light-narrowing, allow enhanced performance, comparable with cryogenic SQUID magnetometers. I will introduce four OPM modalities developed at Strathclyde for geomagnetic and biomagnetic measurements: the digital alkali-spin maser [1], allowing precise geomagnetic measurements, our free-precession magnetometer, with its ultra-high accuracy geophysical measurement [2], our vector zero-field OPM, developed to suppress systematic errors in biomedical measurements, and our self-calibrated ULF/VLF OPM, with applications in communication and range-finding. I will discuss the potential impacts of these techniques in a wide range of applications and the progress in components and sub-systems which underpins the development of all four.

Figure 1. Photograph of the field-deployed DC OPM, which may be operated as a PID-locked double-resonance sensor or a digital self-oscillator, to achieve high dynamic range and bandwidth.

[1] Ingleby, S., Griffin, P., Dyer, T. et al. A digital alkali spin maser. Sci Rep 12, 12888 (2022)
[2] Hunter, D., Mrozowski, M. S., McWilliam, A., Ingleby, S. J., Dyer, T. E., Griffin, P. F. and Riis, E. Optical pumping enhancement of a free-induction-decay magnetometer, J. Opt. Soc. Am. B 40, 2664-2673 (2023)