A metastable helium-4 OPM for medical imaging

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Our team works on OPM based on a gas of helium-4 atoms excited to their F=1 metastable state, which can be significantly populated by using a low-intensity rf discharge of only a few mW. This species has been used in scalar OPMs for Space exploration, notably the one of the Swarm missions that was commissioned by ESA to our team [1].

Since helium is a gas at room temperature no heating of the sensitive element is needed. This allows operating the magnetometers at any temperature, and notably in direct contact with patient skin or scalp without any thermal discomfort.

A full rework of our helium-4 OPM has allowed us to obtain sensors with more compact footprints than previously. In contrast with other OPM metastable helium-4 atoms being a spin-one species, we can optically pump atoms with linearly polarized light, yielding atomic alignment [2]. This configuration allows measuring the component of the field radial to the head using light that propagates radially, which allows closer packing and a simpler optical setup.

Thanks to numerous improvements, the intrinsic noise of the sensor has been reduced to less than 50 $fT/Hz^{1/2}$, in the close vicinity of the photon noise of the probe laser. Closed-loop operation where the local magnetic field is continuously canceled thanks to 3-axis compensation coils, allows a virtually unlimited dynamic range. Our sensors currently have a 2-kHz bandwidth, a dynamic range of >300nT [3].

We have currently set up an array of 5 magnetometers working in closed-loop with automatic correction of the cross-talks between the sensors. This array of sensors is being tested in three medical trials for different neurology and cardiology applications.

References

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