Optically pumped magnetometer for biomedical applications

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Optically pumped magnetometers (OPMs) are highly sensitive quantum devices which can detect tiny magnetic fields from the human body, for instance, OPMs have detected brain activity and the adult and fetal heartbeat. Our magnetometer is based on room-temperature cesium atomic vapor and we have previously demonstrated sub-fT/sqrt(Hz) sensitivity and entanglement-assisted magnetometry [1]. More recently, we have detected bio-magnetic signals from animal nerve impulses [2] and the heartbeat of a guinea-pig heart [3] with our magnetometer.

OPMs can potentially also be used to non-invasively image the electrical conductivity of the heart using a technique called magnetic induction tomography (MIT) [4]. In MIT of the heart, one or more coils are used to induce eddy currents in the heart and an image of the heart is constructed from measurements of the associated induced magnetic field. This is a challenging task for several reasons, with the main one being the low conductivity $\sigma < 1$ S/m of the heart. As a step towards imaging the heart, we have detected low-conductivity objects with our magnetometer using a differential technique which increased the signal-to-noise ratio (SNR) by more than three orders of magnitude [5]. We detected small containers with a few mL of salt-water with conductivity ranging from 4—24 S/m with a good SNR. Our work opens up new avenues for using OPMs to image low-conductivity biological tissue including the human heart which would enable non-invasive diagnostics of heart diseases.

References

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