Measurement of human weak magnetic field by high sensitivity multi-channel quantum magnetometer

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The weak magnetic fields produced by human body, such as cardiac and brain magnetic fields, contain a wealth of physiological and pathological information. Over the past several decades, superconducting quantum interference device (SQUID) magnetometers have become the dominant technique in the field of biomagnetic measurements. However, some technical limitations of SQUID magnetometers hinder the widespread use. With the rapid advances in atomic physics and laser techniques, optically pumped atomic magnetometers have emerged as a most promising non-cryogenic alternative to the SQUID magnetometers. Without the requirement for cryogenic cooling, the ongoing maintenance costs are significantly reduced. More importantly, without the liquid-helium-cooled dewar, the head of the subject is free and allowed to move naturally during the experiment.

In light of this, our group develop two typical kinds of optically pumped atomic magnetometers to detect the cardiac and brain magnetic fields. One is operating in the free induction decay (FID) configuration for magnetocardiography (MCG) measurements [1]. The FID magnetometer utilizes the separated pump and probe beam. The magnetic field is obtained by monitoring the free Larmor precession. Four such magnetometers, located with spacing 2 cm, record the four real time MCG signals from a healthy volunteer. Another type of magnetometer is the optically pumped atomic magnetometer based on spin exchange relaxation free (SERF) regime. The SERF magnetometer with high enough sensitivity and small enough size is the only type of optically pumped atomic magnetometer that can be used to observe the magnetoencephalography (MEG) signals. This high sensitivity is obtained by operating the magnetometer near a zero magnetic field and high atomic density. In the SERF regime, the spin exchange relaxation, which limits the sensitivity of atomic magnetometer, is eliminated. To measure the MEG signals, we develop two kinds of multi-channel SERF magnetometers based on a single large vapor cell [2,3]. By using the four-channel magnetometers, auditory evoked response MEG recordings are achieved.

References

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