Optimization of the MEG-OPM sensor for environmental conditions

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The core component of every optically pumped magnetometer sensor is the cell that contains the alkali atoms. It is therefore important to optimize the size of such cell to obtain the best actual sensitivity in noisy conditions. We present a mathematical model and figure of merits to find the optimal length of the vapour cell for a single NMOR and SERF sensor as well as an array of sensors for magnetoencephalography.

OPMs produce a signal that is proportional to the magnetic field measured within the sensing element, and can be calculated using Sarvas's equations[1]. Our model takes into account the intrinsic sensor noise that originates from atomic and photon shot noise. We also include the influence of an unwanted brain signal simulated as described in [2] and the uncorrelated white environmental noise.

For a single sensor we demonstrate how the optimal length of the cell that yields the highest signal-to-noise ratio changes with the depth of the equivalent current dipole and the level of the environmental noise. For the array of sensors we calculate how the volumetric error representing the localization accuracy[2] decreases with the number of sensors and show that there is no significant improvement in localization for arrays of $>$ 100 sensors. Using the figure of merit E_{tot} developed in [3] for the beamformer reconstruction accuracy, we find that the optimal length of the cell is 13mm. This optimum point is the balance between decreasing of the intrinsic sensor noise and blurring of the field distribution from the ECD with the lengthening of the cell.

References

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