MEG and EEG sensing revisited: From fields to samples

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With OPMs on-scalp sensing of MEG has become possible. Due to the proximity of the sensors to neural sources, such on-scalp OPM arrays would benefit from denser field sampling than SQUID-based arrays. Compared to EEG, which senses electric potential differences on scalp, on-scalp MEG arrays should offer clear advantages in spatial detail of the measurement, as magnetic field is not as heavily low-pass filtered by the head tissue. Here, we analyse spatial characteristics of the normal component of the magnetic field as measured on the scalp (~5 mm; OPMs) and outside the head (~2 cm; SQUIDs) as well as of the electric potential on scalp. We simulate the fields with a BEM using a realistic four-compartment head model [1]. We quantify spatial-frequency spectra of the fields generated by individual sources and the field covariance of source distributions. An example of spatial-frequency field analysis is presented in Fig. 1. We conclude that to capture 99% of the field variance of identically and independently distributed sources, on-scalp MEG requires about three times more orthogonal components than SQUID-MEG and four times more than EEG. Those components in OPM-MEG are measurable at higher sample noise level than those in SQUID-MEG. The head model analysis shows that the number of those components in OPM- and SQUID-MEG does not depend on head conductivity structure. In contrast, EEG is affected by the head conductivity model so that adding detail to the model reduces the number of components explaining 99% of the variance.

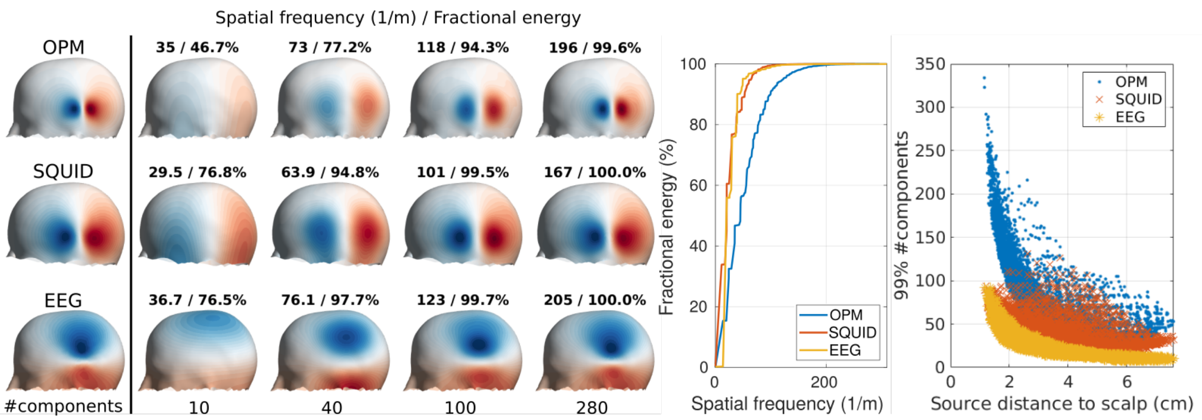

Figure 1. Spatial-frequency analysis of the normal component of the magnetic field and the electric potential. Left: Representation of magnetic field and electric potential with a spatial-frequency expansion. Center: Fractional energy of the expansion as a function of maximum spatial frequency. Right: The number of components that capture 99% of the source field energy as a function of source depth.

[1] M. Stenroos and A. Nummenmaa, Incorporating and compensating cerebrospinal fluid in surface-based forward models of magneto- and electroencephalography, PLoS One, **11**, e0159595 (2016).