Секция «Нейрофизиология и физиология ВНД»

A first MEG-feasible fluxgate magnetometer

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Magnetoencephalography (MEG) is the only non-invasive neuroimaging technique combining high spatial and temporal resolutions. Since 1972 [1], MEG has been implemented using Superconducti QUantum Interference Devices (SQUIDs). However, extremely high price of the SQUID-MEG was preventing wide spreading of MEG until a new type of sensors - optically pumped magnetometers (OPMs) - emerged in 2010 [2]. Both modalities, nonetheless, have serious disadvantages, and the field of MEG still demands a research for new devices. In the current work, we provide a first feasibility study for a high-sensitive solid-state sensor overcoming drawbacks of SQUIDs and OPMs.

The sensor under research is a fluxgate magnetometer based on appropriately shaped yttrium-iron garnet (YIG) film [3]. YIG magnetometer (YIGM) is flat shaped (Fig.1) and able to detect both tangential and radial magnetic field components (Fig.2). To prove the feasibility of YIGM in terms of MEG, we registered a simple human brain rhythm - alpha rhythm. Each trial consisted of 30 s eyes-opened state followed another 30 s, when subjects were asked to keep their eyes closed. All experiments were conducted for 3 healthy adult subjects and validated by an array of QZFM (QuSpin Inc., USA) OPMs appearing currently to be well-established in the context of MEG.

Both modalities show successful registration of alpha rhythm in all subjects having similar frequencies lying between 9 and 11 Hz, which conforms well with expected range for 26-35 y.o. subjects. The signal amplitudes appear to be comparable for both sensor types. Two out of three subjects displayed more pronounced tangential component of the alpha rhythm when measured with YIGM (Fig.3), which is expected due to longer scalp-sensor distance in the case of OPMs measurements (Fig.4).

In this work, we demonstrated for the first time the feasibility of solid-state magnetometers in terms of MEG. This study is a big step forward in MEG evolution. Our future work will be devoted to creation of multichannel YIGM system as well as its validation with existing techniques and investigation of more complex evoked brain responses.

Acknowledgments

The work was done with support of Moscow MEG-center (MSUPE) and Russian Quantum Center. Authors express their gratitude to prof. Koshev N.A., prof. Ossadtchi A.E. and Vetoshko P.M.

References

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Illustrations

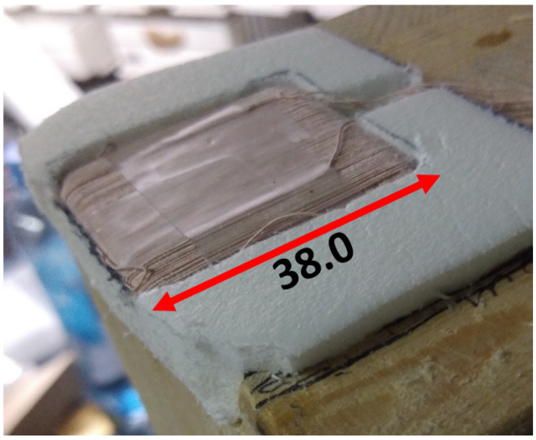

Рис. 1. YIGM sensitive element in winding. Linear size given in mm.

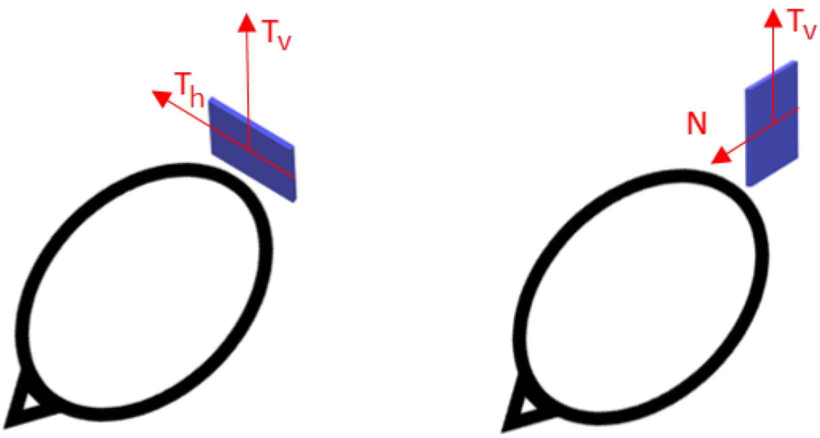

Рис. 2. YIGM sensitive axes with respect to mutual head-sensor location: tangential setup (left) and normal setup (right). Here "T" stands for tangential, while "N" – for normal field component, "h" – for horizontal and "v" – for vertical.

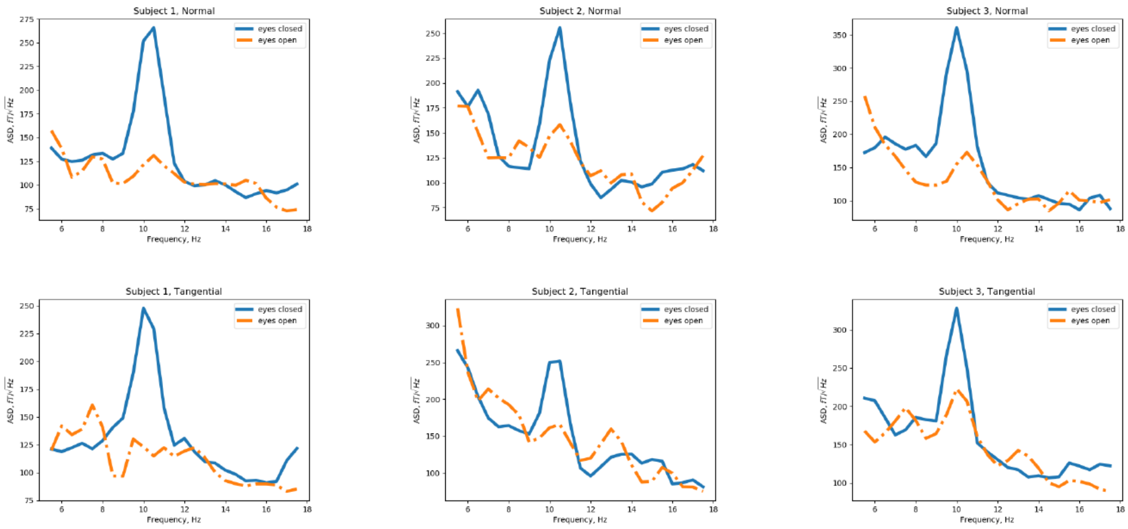

Рис. 3. Spectra of YIGM signal measured in all subjects: top panel – normal component of the field registered along N sensitive axis; bottom panel - tangential component of the field registered along Th sensitive axis.

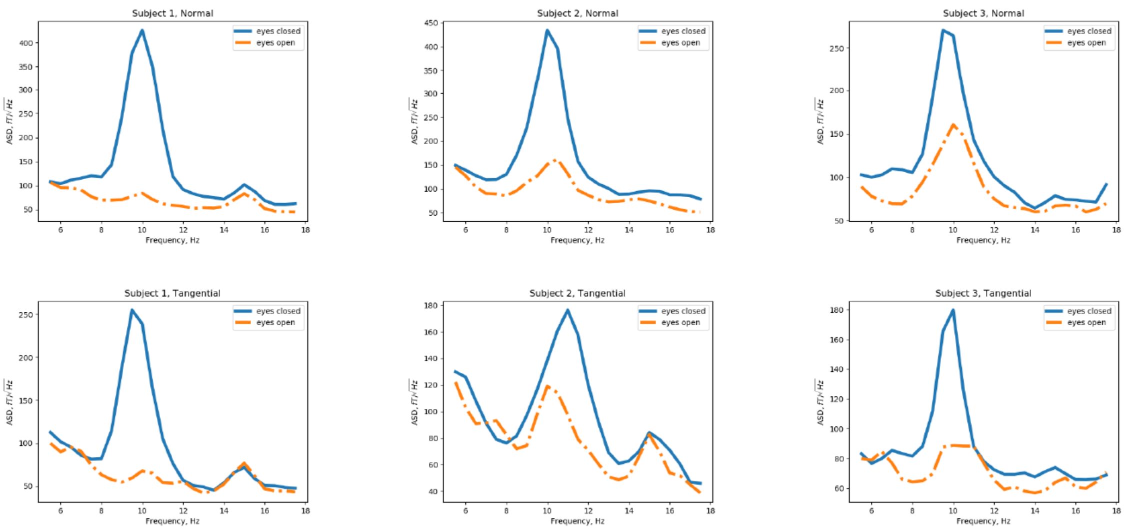

Рис. 4. Top and bottom panels – spectra of OPMs signal measured in all subjects along normal and tangential sensitive axis, respectively.