Impact of Superconducting Devices on Imaging in Neuroscience

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Abstract - Since the development of the first SQUID magnetometers, it was clear that these devices could be used to measure the ultra-low magnetic signals associated with the bioelectric activity of the neurons of the human brain. After 40 years from the first measurement of magnetic alpha rhythm performed by David Cohen, MagnetoEncephaloGraphy (MEG) has become a fundamental tool for the investigation of brain functions. The simple localization of cerebral sources activated by sensory stimulation performed in the early years has been successively expanded to the identification of sequence of neuronal pool activations, thus decrypting information on the hierarchy underlying cerebral processing. This goal was achieved due to the development of complex instrumentation allowing simultaneous measurement of magnetic fields all over the scalp, namely whole head systems. The availability of more user friendly, commercial apparatuses, permitted to apply the methodology in the clinical field, where significant results were and are being obtained. The latest development in MEG instrumentation regards the possibility of improving the quality of source analysis by simultaneously recording MEG signals and MRI of the head with the same set. Indeed, the progress of technology has recently permitted the fabrication of ultra-sensitive SQUIDs able to tolerate relatively high field pulses, suitable to be used as detectors in an ultra-low field MRI scanner. The first whole head MEG/MRI prototype has been recently assembled as the result of an European project. Finally, one of the most important topics in neuroscience of the last decade is the study of brain networks, i.e., how the brain organize itself in a coherent and stable way. Brain networks have been identified not only during task execution, but also during brain "idle" periods (resting state networks), and are thought to account for the largest energy consumption ("dark energy" used by the brain). Although the first approach to the problem was carried out by functional MRI, the possibility of investigating brain signals with a very high time-resolution technique able to study brain activity in to the source space, such as MEG, has proved to be very successful. Today MEG is a must tool to investigate spontaneous cerebral rhythms and to unveil the complex dynamics at the base of resting state networks, thus contributing to the identification of the "human connectome".

Keywords - *Neuroscience, functional imaging, Biomagnetism, Magnetoencephalography, functional connectivity, brain magnetic field, SQUID, time resolution, multichannels systems, Ultra-low Field Magnetic Resonance Imaging*