Biomagnetism and Brain-wave Magnetic Resonance

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일시: 2021.04.16 (금) 오후 5시

장소: 과학도서관 611호

Abstract

Superconducting quantum interference devices (SQUID) and atomic magnetometers have widely been used for state-of-the-art precision measurements in various scientific research areas in range of metrology to basic physics. Beyond the fundamental applications, magnetoencephalography (MEG) based on the ultra-low magnetic field sensing technology is the most developed non-invasive brain research tool for studying neuronal dynamics. Measuring and exploring human perception with MEG could give us neurophysiologic guidelines in standardization and quantification of human sensory and cognitive functions. In this seminar, I will talk about the technical background of biomagnetism, developed clinical applications, and a novel non-cryogenic ultra-sensitive atomic magnetometer in substitution of the SQUID magnetometer.

Meanwhile, based on the established SQUID technology, we have been developing ultra-low field (ULF) nuclear magnetic resonance (NMR) measurement systems. By applying micro-Tesla magnetic field rather than several Tesla in conventional NMR/MRI, we can see new physics in bio- and chemical material so that we could utilize the new properties to develop useful clinical applications and new scientific analysis tools. As an interesting research topic, I will introduce a novel brain functional imaging idea which directly detects neuronal currents in a brain. I named the technique Brain-wave magnetic resonance (BMR) since it measures the nuclear magnetic resonance signal of protons around the activating neurons. To match the proton magnetic resonance to the neuronal magnetic field oscillation, the static field should be of an order of micro-Tesla. Under such a low field, Larmor frequency of a proton is too slow to generate a sufficient Faraday induction to be detected inductively, hence, we utilize low-Tc SQUID sensors to detect the signal. We expect that the BMR becomes the next-generation brain research tool imaging functional connectivity.