High-temperature superconducting biomagnetometers

In the growing field of on-scalp magnetoencephalography (MEG), the neuromagnetic field arising from brain activity is non-invasively sampled using sensors that can be flexibly placed in close proximity to the subject's head. By using high-temperature superconducting (high-Tc) magnetometers made from YBCO, we can reduce the sensor-to-room temperature standoff distance from roughly 2 cm in conventional MEG systems down to 1 mm, which leads to higher available signal amplitudes.

I will first describe the development of high-Tc superconducting quantum interference device (SQUID) magnetometers for a multi-channel on-scalp MEG system. I will show how the sensor performance could be optimized by combining measurements and simulations, leading to excellent agreement between experimental results and theoretical predictions. The importance of kinetic inductance is discussed, and how reliable sensor calibration and low feedback flux crosstalk can be achieved.

Next, the design and performance of our 7-channel on-scalp MEG system based on the fabricated magnetometers is presented. MEG measurements with our system demonstrate the feasibility of the approach and even indicate that retrieval of information unavailable to conventional MEG is possible.

I will then continue with two promising alternative technologies for the next generation system: replacing the grain-boundary junctions with Dayem bridge junctions and using inductively coupled flux transformers.

Finally, I will present the first high-Tc kinetic inductance magnetometer (KIM) – an LC resonator with rf readout that does not require Josephson junctions.