UNIVERSITY of HOUSTON TcSUH

HTS Device Applications & Nano-Biophysics

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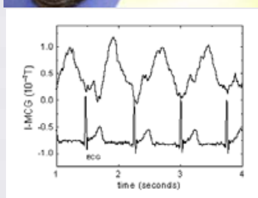

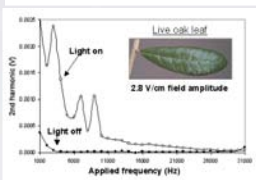

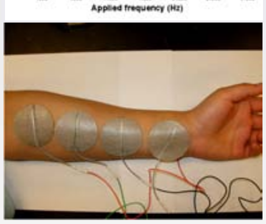

Top : Impedance magnetocardiography setup and measurements using SQUID
Middle Figures: Harmonic generation spectroscopy measurements of live organisms
Bottom: Electrode-based biosensors

Current Projects/Achievements:

We study and develop novel applications of sensitive magnetic sensors, known as superconducting quantum interference devices (SQUIDs), and utilize other electromagnetic techniques, such as impedance spectroscopy and harmonic generation spectroscopy, for the study of biological systems.

APPLICATIONS OF HIGH-TC SQUIDs

Impedance Magnetocardiography: Impedance magnetocardiography (IMCG) measures imped-ance changes in the thorax as the heart pumps blood during its cardiac cycle, providing information about stroke volume and cardiac output of blood flow. We use high-T_c SQUIDs to measure the magnetic fields produced by tiny ac currents introduced via electrodes.

Chemomagnetism: We have discovered that numerous chemical reactions generate tiny magnetic fields due to the motion of ions. We measure such fields using SQUIDs, and have found that many reactions exhibit ‘avalanche-like’ behavior in their dynamics.

IMPEDANCE SPECTROSCOPY OF BIOLOGICAL SYSTEMS

Cytoskeletal proteins: Alpha-beta tubulin heterodimers have a large electric dipole moment, which plays a major role in their self assembly to form microtubules. Our frequency-dependent admittance measurements show that the ac conductivity of tubulin suspensions peaks at the critical concentration for microtubule polymerization and reveal a large electric charge per dimer.

Dielectric response of whole cells: Our group has shown that the low-frequency ‘alpha’ di-electric response correlates with cell concentration and cellular membrane potential, providing a powerful noninvasive assay of cells in suspension.

HARMONIC GENERATION SPECTROSCOPY OF BIOLOGICAL SYSTEMS

Pumps in the plasma membrane: Using SQUIDs to directly probe induced currents, we have observed 2^{nd} and higher harmonics generated by proton pumps in response to sinusoidal fields.

Light activated behavior in chloroplasts and plants: Plants and other photosynthetic organisms are ideal “model organisms” because much of their enzyme activity is light activated. We observe significant differences in both linear and nonlinear (harmonic) response to ac electric fields, which depend on the presence or absence of light.

Detection of enzyme activity in the mitochondrial electron transport chain: We observe features in frequency-dependent harmonics generated by mitochondria and whole cells that appear to correlate with activity of complexes responsible for the production of ATP.

Detection of mitochondrial dysfunction in diabetes & heart disease: Mitochondrial dysfunction plays a major role in type-2 diabetes, heart disease, cancer, and numerous specific mitochondrial disorders. We have initiated a collaboration with Methodist Hospital physicians to develop and validate sensors capable of detecting mitochondrial dysfunction in patients with diabetes and heart disease.

Personnel

Jie Fang, Hans Infante, Kimal Rojapakshe, Graduate RAs, Dept. of Physics and TcSUH
Vijay Vajrala, PhD, Postdoctoral Fellow, Dept. of Physics and TcSUH

Resources

Solartron Impedance Analyzer, (2) Stanford Research Dynamic Signal Analyzers, Olympus IX-71 Inverted Fluorescence Microscope, SQUID Sensors and Electronics; Electromagnetic Shielded Enclosure