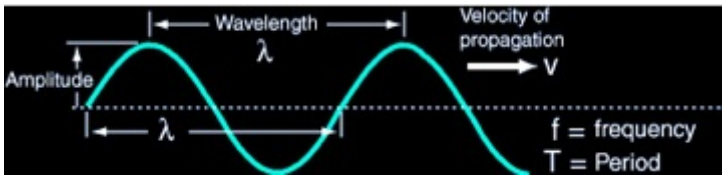
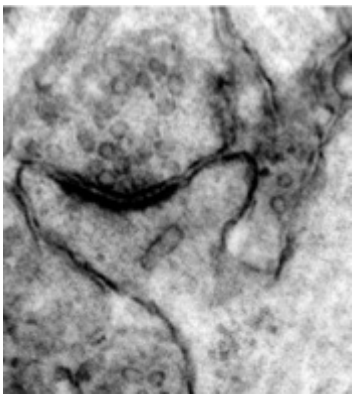
Forging Disruptive Innovations in Deep-Brain Stimulation

SynSonix
Ultrasonic Neuromodulation Technology

We are studying methods for the noninvasive remote control of neuronal activity in intac circuits using pulsed ultrasound (ultrasonic neuromodulation).

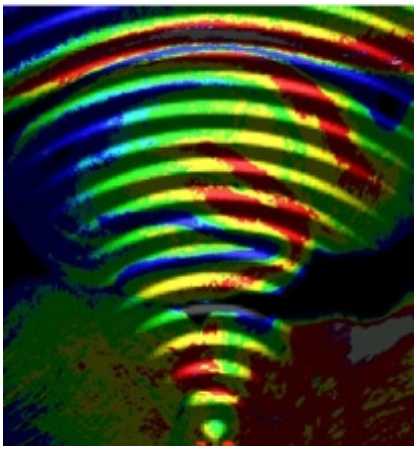




Several neuromodulation (i.e. deep brain stimulation; DBS) techniques have received great attention due to their therapeutic utility in the management of many neurological/psychiatric diseases and disorders such as Parkinson's, coma, epilepsy, stroke, depression, schizophrenia, addiction, neurogenic pain, cognitive/memory dysfunction and many others. Further, the field of neural control has recently been ignited by experiments demonstrating the optical control of individual neurons in intact brain circuits using light-gated ion channels and transporters. Despite the promise of vagal nerve stimulation, transcranial magnetic stimulation (TMS), and DBS, several concerns regarding their therapeutic applications can be raised, including their relatively invasive nature, which often requires the surgical implantation of stimulating electrodes. Although offering the greatest spatial and temporal control, light-gated ion channels require the introduction of exogenous genes.

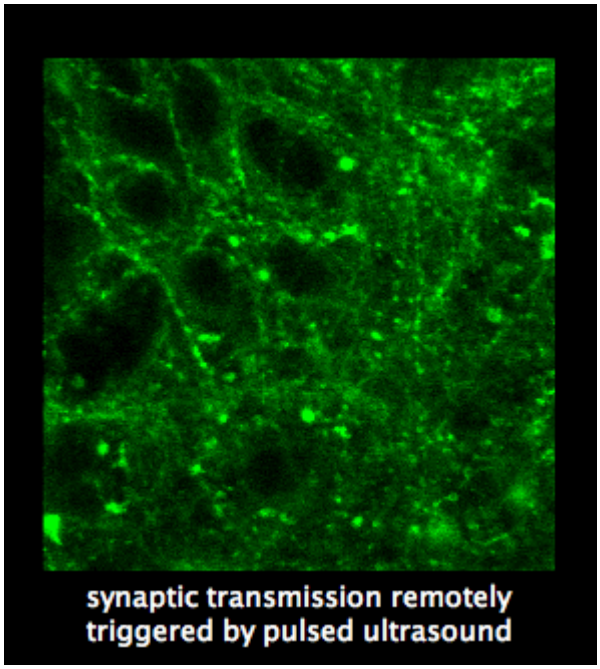
Vagal Nerve Stimulation Transcranial Magnetic Stimulation Deep Brain Stimlation

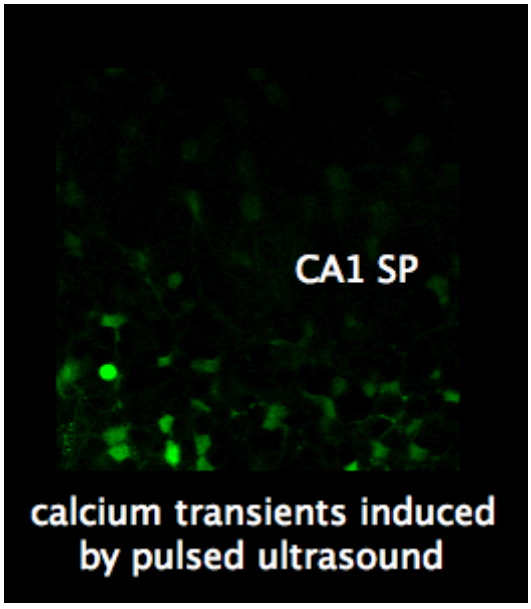
The images above depict several neuronal stimulation methods used in human patients for the treatment of neurological/ psychiatric disorders and disease states. Images were modified from http://www.biotele.com.



Using a variety of optical probes, we are developing methods for modulating ion channel activity, neuronal activity, and synaptic transmission using low-intensity, low-frequency ultrasound (LILFU), which is capable of noninvsively penetrating the skull in a focused manner. Our approach enables us to quickly screen specific transducers and/or stimulus waveform characteristics, which modulate neuronal activity more or less efficiently. To date, we have identified several waveforms capable of directly modulating the activity of voltage-gated ion channels and synaptic transmission. The use of ultrasound waves to modulate neuronal activity will be of great interest to the basic and clinical neuroscience communities since it may alleviate the need for surgically implanted electrodes.

Below are examples of hippocampal synaptic transmission (*left*; reported by synaptopHluorin) and calcium transients in CA1 pyramidal cells (*right*; reported by OGB-1 AM), which were stimulated in response to pulsed ultrasound waveforms.





Ultrasonic Neuromodulation may provide a novel approach to delivering noninvasive therapies for a host of neurological, psychiatric, and/or developmental disorders such as: Parkinson's Disease, Alzheimer's Disease, Epilepsy, Autism, mental retardation, stroke, traumatic brain injury, depression, mania, addiction, anxiety, pain