UCI researchers to develop non-invasive, cheaper and more accurate method for mapping brain regions related to epileptic seizures, autism

Project develops new MEG technology based on Sagnac interferometer developed by UCI physicist

Pre-surgical teams may soon have a more reliable, cost effective and non-invasive method to help pinpoint areas in a patient's brain causing epileptic seizures. A new method for magnetoencephalography (MEG) will allows researchers to measure brain activity at a millimeter scale with millisecond temporal resolution. The technique also has applications in non-invasive mapping of brain function and brain connectivity in disorders such as Autism.

"Measuring the magnetic field of the brain using MEG is potentially the best approach for accurately mapping brain activity because it has very high temporal resolution and can be used to localize brain activity through magnetic source imaging," says Ramesh Srinivasan, UCI Professor of Cognitive Science and Biomedical Engineering. "But current MEG technology has been developed using expensive coils that have to be kept at absolute zero temperature; as a consequence, MEG systems have more than 3 centimeter thick insulation layer between the scalp and sensor. The impact of this distance between sensors and the brain is to lose weaker signals from the brain and to reduce spatial resolution. In addition, MEG equipment costs millions, and liquid helium cooling systems are expensive to maintain."

Jing Xia, Associate Professor of Astronomy and Physics, and Srinivasan are developing a method to measure MEG using sensors at room temperature that are placed directly against the scalp. They will adapt Sagnac interferometer technology developed by Xia for magnetic field measurements in physics application. The Sagnac interferometer uses laser-charged pure atomic vapor as a sensing media that will measure the brain's magnetic field.

"The Sagnac interferometer allows you to calibrate and measure the size of the magnetic field coming from the brain." says Xia. "The laser aligns all of the atomic spins; if there's no magnetic field, they'll spin in one particular direction. If a magnetic field is imposed on it, the spins of the atoms are modified which can be detected by the interaction of the atomic media with a probe laser."

"The resulting measurement has very high temporal resolution as compared to MRI, and the spatial resolution is much better than EEG," says Srinivasan. "Useful information on where the seizures are occurring could be available before doctors open a patient's skull, potentially reducing the need for extensive intracranial mapping. We estimate that the cost of the Sagnac MEG will be one-tenth the cost of a conventional MEG machine, with 5 times higher spatial resolution and 10 times higher sensitivity, potentially allowing for recording from deep brain structures "

The technology has immediate implications in pre-surgical mapping by clinicians and numerous possibilities in basic and clinical research including Autism research. Srinivasan and Xia are affiliated with UCI's Center for Autism Research and Translation which provided seed funding for this research. One of their long-term goals is to apply MEG for non-invasive brain mapping of connectivity in autistic patients.

"One of the most reliable markers of Autism are changes in connectivity measured using EEG. Prof Xia and I would like to perform this research with our new MEG technology to improve the specificity of brain areas showing changes in connectivity" says Srinivasan.

The scientists have received $367,000 from the National Institutes of Health to modify the interferometer to work for MEG. When complete, they'll begin testing with phantom heads and then on human subjects. Funded work began in July and will run through June 2017.