UC SANTA BARBARA

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Using A Laser to ‘See’ the Smallest World

A multi-university team has employed a high-powered laser based at UC Santa Barbara to dramatically improve one of the tools scientists use to study the world at the atomic level. The team used their amped-up electron paramagnetic resonance (EPR) spectrometer to study the electron spin of free radicals and nitrogen atoms trapped inside a diamond.

The improvement will pull back the veil that shrouds the molecular world, allowing scientists to study tiny molecules at a high resolution.

The team, which includes researchers from UCSB, University of Southern California (USC), and Florida State University, published its findings this week in Nature.

"We developed the world's first free-electron laser-powered EPR spectrometer," said Susumu Takahashi, assistant professor of chemistry at the USC Dornsife College of Letters, Arts and Sciences, and lead author of the Nature paper. "This ultra high-frequency, high-power EPR system gives us extremely good time resolution. For example, it enables us to film biological molecules in motion."

By using a high-powered laser, the researchers were able to significantly enhance EPR spectroscopy, which uses electromagnetic radiation and magnetic fields to excite electrons. These excited electrons emit electromagnetic radiation that reveals details about the structure of the targeted molecules.

EPR spectroscopy has existed for decades. Its limiting factor is the electromagnetic radiation source used to excite the electrons –– it becomes more powerful at high magnetic fields and frequencies, and, when targeted, electrons are excited with pulses of power as opposed to continuous waves.

Until now, scientists performed pulsed EPR spectroscopy with a few tens of GHz of electromagnetic radiation. Using UCSB's free electron laser (FEL), which emits a pulsed beam of electromagnetic radiation, the team was able to use 240 GHz of electromagnetic radiation to power an EPR spectrometer.

"Each electron can be thought of as a tiny magnet that senses the magnetic fields caused by atoms in its nano-neighborhood," said Mark Sherwin, professor of physics and director of the Institute for Terahertz Science and Technology at UCSB.

"With FEL-powered EPR, we have shattered the electromagnetic bottleneck that EPR has faced, enabling electrons to report on faster motions occurring over longer distances than ever before. We look forward to breakthrough science that will lay foundations for discoveries like new drugs and more efficient plastic solar cells."

The research was funded by the National Science Foundation and the W. M. Keck Foundation.

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Mark Sherwin

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