# Free-Electron Laser-Based Pulsed EPR at 240 GHz and Beyond

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Like NMR, pulsed EPR becomes more powerful at high fields and frequencies. The spectral and orientation resolution, sensitivity, polarization, and time resolution improve dramatically. The highest-field commercial NMR magnets push the Larmor precession frequency for spin ½ electrons above 500 GHz. However, at frequencies above 100 GHz, it is extremely difficult to generate a programmable sequence of phase-coherent pulses with the high peak powers and nanosecond durations needed to realize the potential of pulsed EPR at high magnetic fields. The UC Santa Barbara Free-Electron Lasers (FELs), which generate high-power pulses across the frequency band of interest, are now being used to drive the world's first FEL-based pulsed EPR spectrometer, which operates at 240 GHz. This talk will focus on the design, operation, scientific goals, and future prospects for FEL-based pulsed EPR spectrometers. In particular, this talk will describe UCSB's FELs, which are unusual in that they are powered by an electrostatic rather than a radio-frequency accelerator;[1] locking the FEL frequency to a microwave source;[2] ultrafast light-activated switches for turning THz beams on and off; the current performance of the instrument; and planned experiments in solids and measurements of the functional dynamics of light-activated proteins. New accelerator technologies promise transformative improvements in the performance of electrostatic accelerator-based FELs, and hence pulsed EPR spectrometers based on such FELs.

References:
[1] Ramian, G., Nuclear Instruments and Methods in Physics Research A318, 225-229 (1992).
[2] Takahashi, S., Ramian, G., Sherwin, M.S., Brunel, L.C., & Van Tol, J., Applied Physics Letters 91 (2007).

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