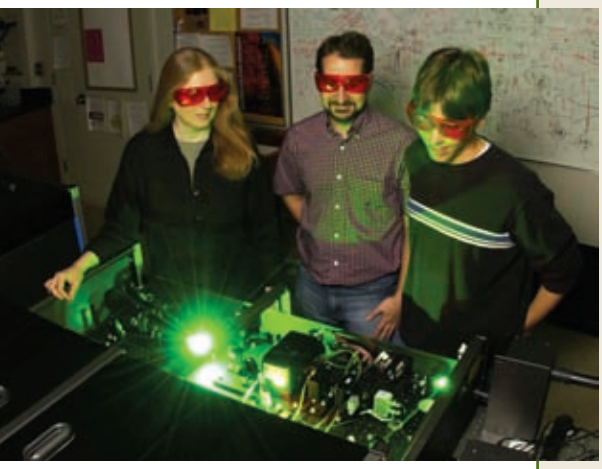
Life in the Ultrafast Lane



Professor Susan Dexheimer in her femtosecond laser laboratory with students Fran Morrissey and Phil Peterman.

A nanosecond, one billionth of a second, is short, but it is an eternity for physics professor **Susan Dexheimer**. She uses cutting-edge laser techniques in the *femtosecond* regime to detect physical phenomena that occur on ultrafast time scales. A femtosecond is 10^{-15} second, or a millionth of a billionth of a second. Femtosecond laser pulses are short compared to the time scales of atomic-scale motions in molecules and solids, and of charge carrier interactions in electronic materials. Therefore, femtosecond spectroscopy stands out as a powerful tool to time-resolve processes that are otherwise too fast to study.

Current research in Dexheimer's laboratory involves ultrafast dynamics in emerging electronic materials, and includes both fundamental physics as well as issues important for future applications. One major research focus involves probing the underlying physics of how electronic excitations interact with atomic motions. These experiments use ultrashort light pulses to time-resolve fast changes in the local atomic structure, and have succeeded in resolving the formation dynamics of localized electronic states, processes important for understanding conductivity mechanisms in molecular and nanoscale electronic materials. The Dexheimer research group also carries out research on photoinduced charge carrier processes in semiconductors, promising for solar cell applications. "It turns out that what happens to the electrons right after they have been generated by light has an enormous impact on the efficiency of a solar cell," said Dexheimer. The state-of-the art photovoltaic materials studied in this work come from collaborations with materials scientists at the National Renewable Energy Laboratory, a Department of Energy national lab, and also with WSU chemistry professor **Jeanne McHale**.

Dexheimer has been advancing the emerging technique of time-resolved THz (far-infrared) spectroscopy in her studies of ultrafast photoconductivity. Fast dynamics in the far-infrared spectral range have only recently begun to be explored, and these techniques have the potential to address a wide range of problems in condensed matter, molecular, and biological systems. Dexheimer is the editor of the book *Terahertz Spectroscopy: Principles and Applications*, which will be published later this year by Taylor and Francis as a part of their Optical Science and Engineering Series, and will be the first book to provide a comprehensive treatment of fundamental principles, instrumentation, and applications of these recently developed techniques.

"Designing and building complex instruments and adapting them for specific experiments is an integral part of our work. The combination of rigorous basic research with practical 'hands-on' experience provides an ideal training ground for students," said Dexheimer. Graduate students and postdocs in her research group have been well-prepared to enter positions in both academia and industry, given their background in both basic and applied work. A number of undergraduate students have also worked with her, carrying out research that advanced their interest in pursuing scientific careers.

Dexheimer's research on the dynamics of localized photoexcitations has been funded by more than one million dollars in consecutive grants from the National Science Foundation, beginning with a prestigious NSF Faculty Early Career Development (CAREER) award, which she received in 1998. Her work on materials for photovoltaic applications has been funded by an exploratory grant from the NSF and by a $365,000 Department of Energy National Renewable Energy Laboratory grant. In addition, Dexheimer has been largely responsible for the development of an ultrafast laser facility funded by a $397,000 NSF Major Research Instrumentation grant. "Professor Dexheimer's work is an important part of the department's focus area in materials and optics," noted acting chair Matt McCluskey. "Our emphasis on understanding interactions between photons and materials makes us unique in the northwest, and Professor Dexheimer is a leader in that effort."

In addition to being a world-class researcher, Dexheimer is a popular and rigorous instructor. Her course on optics is in especially high demand. She also provides valuable, high-visibility service to the scientific community, and has recently completed a six-year term on the committee for the International Conference on Ultrafast Phenomena, the leading conference in her research field.

Susan Dexheimer earned her bachelor's degree at MIT and her doctorate at UC Berkeley. She joined the WSU physics faculty in 1996, and won the College of Sciences Young Faculty Achievement Award in 2000.