Dr. Yi Guo synchronizes semiconductor laser arrays at Stevens with NSF grant

September 20th, 2010

The National Science Foundation has announced funding for Dr. Yi Guo's research at Stevens Institute of Technology into a rigorous mathematical approach to the analysis and control of coupled semiconductor laser systems. Dr. Guo, from the Department of Electrical and Computer Engineering, will partner with Dr. Leonid Bunimovich at Georgia Institute of Technology, Dr. Yehuda Braiman of Oak Ridge National Laboratory (ORNL), and graduate students at Stevens, Georgia Tech, and the University of Tennessee-Knoxville.

Dr. Guo and her team are approaching semiconductor laser arrays as complex systems exhibiting collective behaviors that can be measured and manipulated to achieve desirable results. Since the 1950s, diverse researchers have been studying collective systems and structures to observe and quantify behavior at the individual agent and system levels. Despite recent progress in the study of these system behaviors, analysis has historically been limited to organizations and structures that produce feedback linearly or offer static observations. Research in laser arrays has also demonstrated limitations in the science, as many studies assume all devices in a system are identical, which is not an accurate representation of realistic scenarios.

Collective behavior is a complex but familiar phenomenon, observable in gene and neuron development, the flocking of birds, and the operation of man-made structures such as large power distribution systems, transportation networks, and computer sensor components. Although relationships between objects in these complex systems have been described, the possibility of working with a laser array presents a unique opportunity to precisely analyze collective behavior in a highly-controlled environment.

"Semiconductor lasers have many contemporary and future applications to science and industry," says Dr. Yu-Dong Yao, Director of the Electrical and Computer Engineering Department at Stevens. "Through their focused, mathematical approach, Dr. Guo and her research colleagues will also contribute to our understanding of collective behavior benefiting scientists in many disciplines."

Coupled lasers act as collective structures since the devices, each operating with a different intrinsic frequency, must be synchronized with one another to derive the exponential results offered by phase-locked beams. Furthermore, a phase-locked system is not necessarily steady, and the synchronization may degenerate to incoherence. Despite these complexities, laser arrays are also interactive and controllable, with distinctly measurable outputs and results. Synchronizing the arrays thus provides the research team an opportunity to systematically test their mathematical model of collective behavior while solving the real-world problem of collective synchronization of laser devices.

"The potential applications of this research go beyond the boundaries of Dr. Guo's own research and could be applied widely to predict behavior in complex systems studied by biologists, physicists, computer scientists, and other scholars," says Dr. Michael Bruno, Dean of the Charles V. Schaefer, Jr. School of Engineering and Science. "Her work puts Stevens at the cutting edge of multiple developing research fronts."

In addition to the research component of the NSF grant, Dr. Guo and the other researchers will conduct educational outreach to K-12 teachers and students through the Center for Innovation in Engineering and Science Education at Stevens. Dr. Guo and Dr. Bunimovich both teach fundamental undergraduate and graduate courses at their respective institutions, and will apply this cutting edge research to classroom instruction. Dr. Braiman's laser facility at ORNL will also provide the research team's associate graduate students with unique hands-on learning experiences. Dr. Guo is especially invested in encouraging women to pursue careers in science and engineering, and will continue to provide mentoring and leadership to female scientists at Stevens and elsewhere.

Provided by Stevens Institute of Technology

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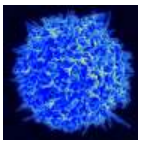

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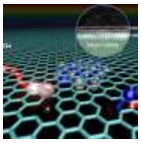

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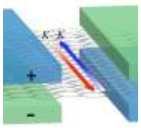

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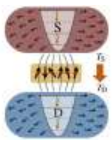

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