Rice researchers gain new insight into nanoscale optics

New research from Rice University has demonstrated an important analogy between electronics and optics that will enable light waves to be coupled efficiently to nanoscale structures and devices. The research is available online from the journal *Nano Letters* and will appear in an upcoming print edition.

"We've discovered a universal relationship between the behavior of light and electrons," said study co-author Peter Nordlander, professor of physics and astronomy and of electrical and computer engineering. "We believe the relationship can be exploited to create nanoscale antennae that convert light into broadband electrical signals capable of carrying approximately 1 million times more data than existing interconnects."

Both light and electrons share similar properties, at times behaving like waves, at other times like particles. Many interesting solid-state phenomena, such as the scattering of atoms off surfaces and the behavior of quantum devices, can be understood as wavelike electrons interacting with discrete, localized electrons. Now, Rice researchers have discovered and demonstrated a simple geometry where light behaves exactly as electrons do in these systems.

In recent years there has been intense interest in developing ways to guide and manipulate light at dimensions much smaller than optical wavelengths. Metals like gold and silver have ideal properties to accomplish this task. Special types of light-like waves, called plasmons, can be transmitted along the surfaces of metals in much the same way as light in conventional optical fibers.

When small metallic nanoparticles are positioned on the metal film, they behave like tiny antennae that can transmit or receive light; it is this behavior that has been found to mimic that of electrons. Until now, the coupling of light waves into extended nanoscale structures has been poorly understood.

Nordlander's research was conducted under the auspices of Rice's Laboratory for Nanophotonics (LANP), a multidisciplinary group that studies the interactions of light with nanoscale particles and structures. The study was co-authored by LANP Director Naomi Halas, the Stanley C. Moore Professor of Electrical and Computer Engineering and professor of chemistry.The findings stem from a relatively new area of research called plasmonics, which is a major LANP research thrust.

In the latest research, Halas' graduate student Nyein Lwin placed a tiny sphere of gold -- measuring about 50 nanometers in diameter, within just a few nanometers of a thin gold film. When a light excited a plasmon in the nanosphere, this plasmon was converted into a plasmon wave on the film, for certain specific film thicknesses.

The experiments confirmed theoretical work by Nordlander's graduate student Fei Le, who showed that the interactions between thin-film surface plasmons and the plasmons of nearby nanoparticles were equivalent to the "standard impurity problem," a well-characterized phenomenon that condensed matter physicists have studied for more than four decades.

Other co-authors on the paper include Halas's graduate student Jennifer Steele, now a Professor at Trinity University, and former Texas Instruments Visiting Professor Mikael Käll of Chalmers University of Technology in Gothenburg, Sweden.

Source: Rice University