Magnetism flicks switch on 'dark excitons'

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Tests at leading magnetic labs shed light on nanotube mystery

In new experimental research appearing in this week's issue of *Physical Review Letters*, a Rice University-led team of nanoscientists and electrical engineers has flipped the switch on 'dark excitons' in carbon nanotubes by placing them inside a strong magnetic field.

The research offers new insight into the fundamental optical properties of semiconducting nanotubes, hollow straw-like molecules of pure carbon. Leading computing companies would like to use nanotubes as optical components in next-generation microchips that are faster, more powerful and more energy efficient.

"Single-walled carbon nanotubes offer engineers the intriguing possibility of building chips where electrical inputs can be converted into light and moved about the chip as optical signals rather than electrical signals," said lead researcher Junichiro Kono, associate professor of electrical and computer engineering at Rice. "Thus far, the poor optical performance of nanotubes -- in some cases as few as one in 100,000 incoming photons causes a fluorescent emission -- has prevented engineers from developing the technology for applications."

Kono said the new research may help scientists formulate new tests to answer some of the most perplexing questions about the optical properties of nanotubes. For example, scientists are currently debating whether low fluorescence efficiencies in nanotubes arise from the intrinsic physical structure of nanotubes or from external factors like structural defects and impurities. Some of the leading theories have the missing light disappearing into "dark" excitons – odd quantum pairings of electrons and electron "holes" that are forbidden by quantum rules from fluorescing. The new magnetic method of overcoming this dark exciton effect could be used to probe the intrinsic properties of nanotubes and help settle the debate.

The team tested materials in some of the world's most powerful magnetic fields. Experiments were conducted at both the Laboratoire National des Champs Magnétiques Pulsés in Toulouse, France, and at the National High Magnetic Field Laboratory at New Mexico's Los Alamos National Laboratory.

"We hope that our experimental methods will help better inform theorists and ultimately aid in the development of new devices with far superior functions than those based on existing technology," said Sasa Zaric, whose doctoral dissertation will be based on the work.

Nanotubes are a fraction of the size of transistors used in today's best microchips. As electronic components, nanotubes could reduce power demands and heating in next-generation chips. But as optical components they offer far more. The replacement of copper cables with fiberoptics revolutionized the volume and speed of data transmission in the telecom industry 20 years ago, and the parallels in microchips are tantalizing.

Source: Rice University