Breakthrough in Molecular Design Could Unleash the Full Speed of the Internet

PULLMAN, Wash. - Researchers at Washington State University have created design guidelines for new molecules that could enhance the speed of internet communications and other optical technologies.

Physics graduate student Juefei Zhou, physicist Mark Kuzyk and mathematician David Watkins used computer simulations to design molecules that will interact very strongly with light. The vigor with which a material interacts with light affects high-tech applications such as the speed of the internet, the amount of information that can be stored in a hologram and the efficacy of some cancer therapies.

"These molecules can be built up into materials to make tiny electro-optical switches to manipulate light the way a transistor manipulates electricity," said Kuzyk.

Their results are published in an upcoming issue of the journal Optics Letters. A preprint is available online at Physics Archives (http://www.citebase.org/cgi-bin/fulltext?format=application/pdf&identifier=oai:arXiv.org:physics/0605187).

Ever since optical technologies became prominent in the 1970s, researchers have tried to improve the materials used to handle light. In 1999, Kuzyk discovered a fundamental limit to how strongly light can interact with matter. He went on to show that all materials ever examined fell far short of that limit. Even the best molecules had 30 times less "optical brawn," as he calls it, than was theoretically possible.

He also showed that certain widely-publicized molecules, such as the soccerball-shaped "buckyballs," interacted strongly with light because they tended to gather in large clumps, not because they inherently responded to light well.

Kuzyk said that, to date, efforts to create materials that interact strongly with light have assumed the best molecules will have long stretches where electrons can move freely from end to end. By contrast, his team's new work suggests a very different approach, in which constituents such as carbon, nitrogen, sulfur and various ring structures are interspersed in a uniform molecular chain.

"Our results show that you need to place some obstacles along the way," he said. "An electron in a molecule can be viewed as the metal ball in a pinball machine. The nuclei are the bumpers and hazards that knock the ball around."

The WSU team developed a computer program that Zhou then used to test different configurations of "bumpers" for their effect on a virtual molecule's interaction with light. Their work found molecular designs that should reach within about 30 percent of the fundamental limit - a drastic improvement over the best molecules previously tested.

Ted Sargent, holder of the Canada Research Chair in Nanotechnology at the University of Toronto and author of the book "The Dance of Molecules," praised the findings.

"The work of Kuzyk and colleagues ushers in a new strategy to maximize the nonlinear optical behavior of materials," Sargent said. "To do so is of critical importance to realize ultrafast optical switches - building blocks of a new, blazing-fast, all-optical internet."

Koen Clays of Belgium's University of Leuven and a leader in the characterization of optical materials said the WSU results have led him to examine molecules he previously might have overlooked. "Their paradigm is giving us lots of new ideas," he said.

Kuzyk is Boeing Distinguished Professor and associate chair and Zhou is a graduate student in the Department of Physics and Astronomy. Watkins is a professor in the Department of Mathematics and Statistics

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