Former UCSD Physicist Shares Descartes Award for Material that Reverses Light’s Properties

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David R. Smith, a physicist formerly at the University of California, San Diego, has been awarded the European Union's Descartes Prize for Excellence in Scientific Research for developing at UCSD a new class of composite materials with unusual physical properties that scientists theorized might be possible, but had never before been able to produce in nature.

Smith, now an associate professor at Duke University's Pratt School of Engineering, shared with four European researchers the €1.1 million euro prize-equivalent to $1.29 million U.S. dollars-for their contributions to the development of a new class of materials known as "left-handed metamaterials."

The five scientists, whose achievements created a new sub-discipline of physics, will be presented with the Descartes Prize, named in honor of the French mathematician, scientist and philosopher Rene# Descartes, at a ceremony held at the Royal Society in London on December 2.

Selected from a pool of 85 research teams from 22 countries, Smith shares this year's top European Union prize for research with Sir John Pendry of the UK, Martin Wegener of Germany, Ekmel Ozbay of Turkey and Costas Soukoulis of Iowa State University and Greece. "It's great to receive this kind of recognition for our work," Smith said. "This group of people has collectively made many significant contributions to really establish this field. It's been a real collaborative effort."

"We're extremely proud of David for his ground-breaking research on 'left-handed metamaterials' and congratulate him on receiving this prestigious prize," said M. Brian Maple, chair of UCSD Department of Physics. "We're especially pleased that the world's first left-handed metamaterials were demonstrated by David and Sheldon Schultz and their co-workers in Professor Schultz's laboratory here at UCSD."

The unusual property of left-handed metamaterials is its ability to reverse many of the physical properties that govern the behavior of ordinary materials. One such property is the Doppler effect, which makes a train whistle sound higher in pitch as it approaches and lower in pitch as it recedes. According to Maxwell's equations, which describe the relationship between magnetic and electric fields, microwave radiation or light would show the opposite effect in this new class of materials, shifting to lower frequencies as a source approaches and to higher frequencies as it recedes.

Similarly, Maxwell's equations further suggest that lenses that would normally disperse electromagnetic radiation would instead focus it within this composite material. This is because Snell's law, which describes the angle of refraction caused by the change in velocity of light and other waves through lenses, water and other types of ordinary material, is expected to be exactly opposite within this composite.

In 2000, Smith and Sheldon Schultz, a physics professor at UCSD, headed a team of UCSD physicists that demonstrated the first realization of a "left-handed metamaterial," a composite of copper rings and wires that reverses familiar properties of light. (see: http://ucsdnews.ucsd.edu/newsrel/science/mccomposite.htm) The concept underlying the development of that material was patented and licensed by UCSD's Office of Technology Transfer and Intellectual Property Services.

While the material behaves in a manner consistent with the laws of physics, the composite exhibits a reversal of one of the "right-hand rules" of physics which describe a relationship between the electric and magnetic fields and the direction of their wave velocity.

As a result, it is part of a class of materials the UCSD physicists refer to colloquially as "left-handed materials," after a term coined by Russian theorist V. G. Veselago, who predicted the possibility of such materials in 1968, because they reverse this relationship as well as many of the physical properties that govern the behavior of ordinary materials.

In a paper published in the journal *Science* the following year, Smith, Schultz and physicist Richard Shelby of UCSD reported the first experimental demonstration that a wedge-shaped metamaterial gives negative refraction. (see: http://ucsdnews.ucsd.edu/newsrel/science/mcreversed.htm) The initially controversial finding was later confirmed and named one of the journal *Science* 's top ten breakthroughs of the year in 2003.

In natural materials, light always refracts or bends at a positive angle with respect to the angle at which it entered, Smith explained. "The novel properties of artificial metamaterials therefore bring a degree of design flexibility that was not possible before," Smith said.

Many applications for left-handed materials are anticipated. Scientists have already shown how the ability to focus radio waves could lead to smaller and improved magnetic resonance imaging (MRI) machines. (see: http://ucsdnews.ucsd.edu/newsrel/science/smetamaterial.asp) Metamaterials also have many potential applications for the communications industry, including antennas and waveguides that are much smaller and lighter than those of today.

The Descartes Prize for Excellence in Scientific Research, now in its sixth year, is the most prestigious prize awarded by the European Union in the field of science, recognizing outstanding scientific and technological results achieved through international collaborative research in diverse disciplines. Winners are selected by a grand jury of experts in science, industry and the general public.

Additional details about Smith's development of metamaterials at UCSD can be found at http://physics.ucsd.edu/lhmedia/ Information about the Descartes Prize is available at: http://europa.eu.int/comm/research/descartes/index_en.htm

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