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Prof. Cory exploring QIP theory

"If you can change the rules in a fundamental way, you can propose to do truly outrageous things." says David Cory, Professor of Nuclear Science & Engineering. He's talking about the science of Quantum Information Processing (QIP), a means of designing tools that operate on the basis of quantum mechanics rather than classical everyday physics.

The usual example is the quantum computer. Such a computer might work by treating each particle as a single quantum bit, each with their computational state determined by the direction the particle's spin. This would allow a small group of such particles to act like a CPU, and by exploiting quantum interference they could exceed the performance of anything operating with today's chip technology. The trick is finding ways to correct the errors that inadvertently arise and to do so for a relatively large number of particles.

A device controlling as few as 21 particles would match the performance of today's best desktop PC, while about 35 particles would outperform the best supercomputer. "It scales up very quickly." He says, "The problem is that quantum computers today are also exponentially harder to build."

The Cory lab is currently working on a test bed for exploring QIP theory through experimentation and testing. His target for this device is 15 particles. Although simulations of this type of device have been done, they are not complete. "There's a lot going on down there," says Cory.

Other applications of this quantum thinking would take measurements or act as actuators. In fact, students from the NSE undergraduate course 22.033, Nuclear Systems Design Project, took on the task of designing a neutron interferometer that uses quantum techniques to effectively cancel out noise from mechanical vibrations. Changes proposed in this design would make such instruments thirty times more sensitive and much more precise. It's the kind of outrageous change that would enable new types of physics, and is made possible by looking at the problem through the lens of quantum physics. That group is one of the finalists for this year's American Nuclear Society Student Design Competition.

These types of changes using the quantum perspective have the potential to enable new types of physics and engineering. Professor Cory's group and these NSE students are taking the first steps in that direction.❁

Prof. David Cory in his lab.

Nanofluids and Nuclear Power

Some members of the Nanofluids Research Group: (l-r) Bao Truong, Graig Gerardi, Andrew Lerch, Ulzie Rea, Prof. Jacopo Buongiorno and Dr. Tom McKrell.

One of the highlights of NSE research over the past year has involved the use of nanofluids to increase the power output and safety of nuclear reactors. Experiments led by NSE Assistant Professor Jacopo Buongiorno and Principal Scientist Lin-wen Hu of the Nuclear Reactor Laboratory, indicate that a small amount of nanoparticles added to water can significantly enhance the critical heat flux (CHF). Given that all water-cooled nuclear systems are CHF-limited, the use of nanofluids could afford considerable economic and safety gains.

A second but especially interesting aspect of the research concerns the mechanism by which the enhancement is achieved. Briefly, as the nanofluids boil, a porous layer of nanoparticles forms on the container's surface. This material is currently being investigated for potential manufacturing applications.

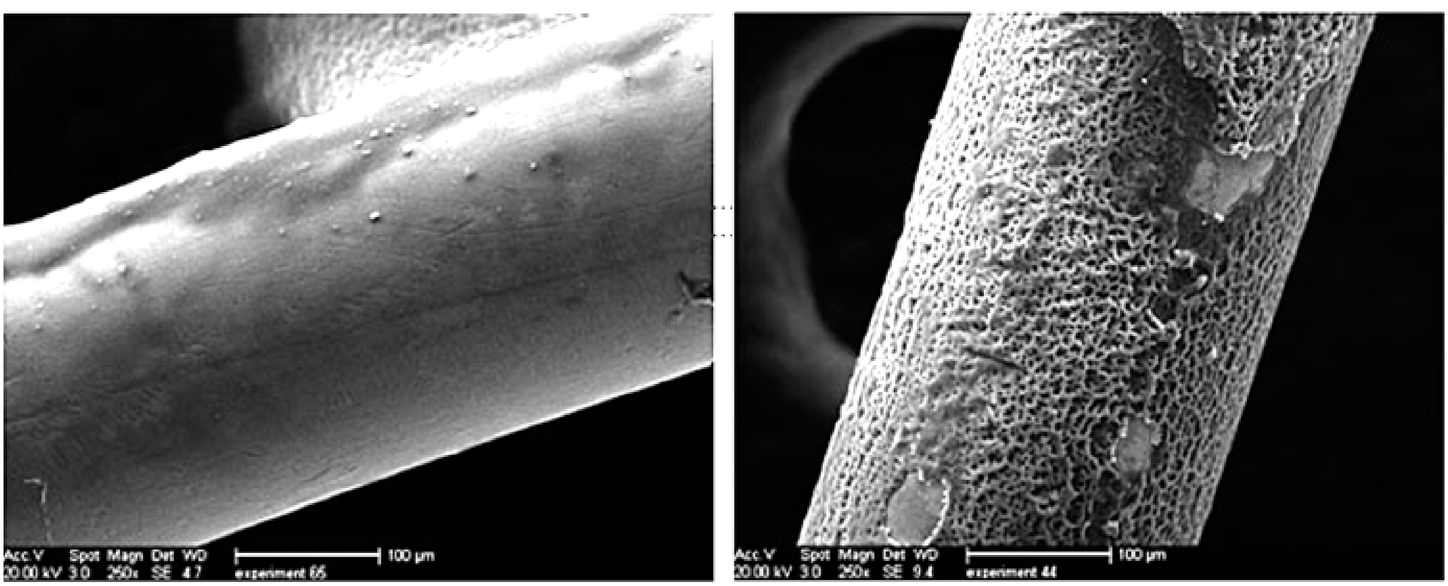
Professor Buongiorno, a native of Milan, joined the NSE faculty in 2004, after receiving his doctorate from the department in 2000. A gifted teacher, he has received several teaching awards, including the School of Engineering's Graduate Teaching Award in 2005 and the Spira Award for Distinguished Teaching in 2006. In June he was appointed as the Carl R. Soderberg Professor of Power Engineering.

What are Nanofluids?

Nanofluids are "colloidal suspensions of nanoparticles (1-100 nm) in a base fluid, usually water. The size of the particles imparts unique characteristics to the fluids, including enhanced energy, momentum and mass transfer, as well as reduced tendency for sedimentation and erosion of the containing surfaces. Nanofluids are being investigated for many applications, including cooling, manufacturing, chemical and pharmaceutical processes, and medical treatments.

In 2004, Professor Buongiorno and Dr. Hu formed the Center for Nanofluids Technologies at MIT, in collaboration with colleagues from the departments of Aero-Astro Engineering, Chemical Engineering, Electrical Engineering & Mechanical Engineering.

Further reading:
" Nanotech + nuclear = more electricity" (http://web.mit.edu/erc/spotlights/nano_nuclear.html).



(Left) Wire after boiling of distilled water; (Right) Wire after boiling of nanofluid. Upon boiling, nanoparticles deposit on surface, creating a porous layer. This material is currently being investigated for potential manufacturing applications.