Pitt-led researchers to build foundation for quantum supercomputers

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This is Pitt physics and astronomy professor Jeremy Levy. Credit: University of Pittsburgh

A research team based at the University of Pittsburgh has received a five-year, $7.5 million grant from the U.S. Department of Defense to tackle some of the most significant challenges preventing the development of quantum computers, powerful devices that could solve problems too complex for all of the world's computers working together over the age of the Universe to crack. The project was one of 32 nationwide selected from 152 proposals to receive a grant from the Multi-University Research Initiative (MURI) program; a total of $227 million was distributed to institutions that include Harvard University, the Massachusetts Institute of Technology, the University of Illinois at Urbana-Champaign, and the University of Pennsylvania.

Jeremy Levy, a professor of physics and astronomy in Pitt's School of Arts and Sciences, will lead a team of researchers from Cornell University, Stanford University, the University of California at Santa Barbara, the University of Michigan, and the University of Wisconsin in combining the properties of semiconductors—such as those used to make computer processors, and superconductors—which allow for the perfect flow of electricity, into a single material suitable for the development of quantum computers. The team will use these superconducting semiconductors to develop new types of quantum memory, perform quantum simulation, and create new methods for transferring quantum information from one medium to another.

These functions are essential to realizing quantum computers—which are yet to exist in any practical form—but require a precise control of the laws of quantum physics that has so far been difficult to achieve, Levy explained.

One of the most significant challenges with any approach to quantum computation is the inevitable loss of information. Group member Chetan Nayak, a physics professor at UC-Santa Barbara, has theorized that very thin sheets of certain types of superconductors have topological quantum excitations that can be used to make quantum memories highly immune to errors. The development of materials that can support these excitations will be undertaken by Chang-Beom Eom, a professor of materials science and engineering at Wisconsin; Harold Hwang, a professor of applied physics at Stanford; and Darrell Schlom, an engineering professor at Cornell. Xiaoqing Pan, a University of Michigan professor of materials science and engineering, will perform atomic-scale characterization of these structures.

A second research goal involves using superconducting semiconductors to perform quantum simulations of physical systems. To do this, the team will use a technique Levy developed that allows for atomic-scale devices such as transistors and computer processors to be created and erased on a single platform that functions like a microscopic Etch A SketchTM, the drawing toy that inspired Levy's idea; Levy reported on the platform in the Feb. 20, 2009, edition of Science. For the MURI project, Levy will create a new near-atomic scale lattice that will be used to experiment with new materials and search for superconducting phenomena.

The project's third thrust involves the transfer of quantum information from one physical system to another. Quantum bits are efficiently stored in nanoscale defects found in diamonds. David Awschalom, a professor of physics and electrical engineering at UC-Santa Barbara, will develop ways of transferring quantum information between these diamond defects and superconducting microwave resonators.

Provided by University of Pittsburgh