Sound over silicon: Computing's wave of the future

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Pierre Deymier believes phonons could power the next generation of supercomputers. Credit: University of Arizona

With a combined $1.8 million from the W.M. Keck Foundation and the University of Arizona, materials science and engineering professor

Pierre Deymier explores building a quantum computer that uses sound instead of quantum particles to process information.

As computer parts grow tinier—billions of transistors are now packed onto silicon chips the size of a fingernail—silicon's performance shrinks too, and the material can overheat.

Engineers are in a race to perfect quantum computers, which store, transmit and process information in fundamentally different ways than their digital cousins and have exponentially greater computing capability.

Pierre Deymier, a University of Arizona professor of materials science and engineering, has received a $900,000 grant from the W.M. Keck Foundation, matched by the UA, for a total of $1.8 million to build a type of quantum computing analogue that might perform as well as existing quantum computers and overcomes problems that plague current quantum computing prototypes.

He is a pioneer in the field of phononics, in which scientists and engineers manipulate phonons, quasi-particles that transmit sound and heat waves in unconventional ways to provide new forms of energy.

With his collaborators on the project, professor Pierre Lucas and researcher Keith Runge in the UA Department of Materials Science and Engineering, Deymier will build a prototype phonon-based computer.

"Phonon-based computing has the power to change the world as we know it," said Deymier, the department's head, "not just for making more powerful computers, but for artificial intelligence, cryptography and analysis of big data. For example, a phononic computer could rapidly map a person's entire genome for developing more targeted medical therapies."

Quantum Leap in Computing Power

In binary digital, or regular, computing, information is stored on transistors in "bits" that can be in one of two states: 1 or 0, akin to on or off.

In quantum computing, a quantum bit, or qubit, can be in both states at the same time—a so-called "superposition" of states. Multiple qubits can also be "entangled" to form a whole that cannot be separated into its parts. Operating on the information stored in one qubit is equivalent to operating on the information stored in all of the entangled qubits.

This is what gives quantum computing so much greater mathematical prowess and may represent the wave of the future in information processing.

Few functioning quantum computers currently exist. Those that do, like the D-Wave, can make calculations millions of times faster than classical computers.

But they have problems, in part because qubits are extremely sensitive to environmental conditions like heat. To overcome this drawback, researchers must cool the qubits to cryogenic temperatures. The D-Wave takes up an entire room for cooling it to temperatures approaching absolute zero on the Kelvin scale.

Introducing the Phi-Bit

Deymier believes that phonons, in units he has named "phase-bits" or "phi-bits," are the answer.

He has shown that information can be stored as phi-bits in a superposition state, like qubits, and that multiple phi-bits can be assembled so they cannot be separated—analogous to qubit entanglement. And phi-bits are less sensitive than qubits to external conditions.

"I can make phi-bits at room temperature in my lab," he said.

Deymier has been working with Tech Launch Arizona, the UA's commercialization arm, to apply for multiple patents surrounding a number of phi-bit inventions, including the quantum computer itself. "We're excited to work with Pierre Deymier on more patent applications as the Keck Foundation-funded research progresses," said Bob Sleeper, TLA licensing manager for the College of Engineering.

The potential of phi-bits to transform computing capability and manage big data appears limitless, Deymier said.

"Let's suppose you have a million phi-bits, with each one having both a 0 and a 1 in conventional computing bits. That means the amount of information you can process is 2 to the power of 1 million—which may be more than the number of atoms in the universe!"

He added, "I believe quantum computing with phononics will be feasible, possibly in the next 10 years."

Provided by University of Arizona College of Engineering

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