NEW PHYSICS PROFESSOR STUDIES QUANTUM COMPUTING

By Amanda Glensky, journalism '09

PROFESSOR PHIL JOHNSON SEEKS TO understand why one can observe certain quantum phenomena in the microscopic world of electrons, atoms, even molecules, but not in the larger, macroscopic realm.

"Many physicists, including me, believe that quantum mechanics applies to everything in the universe. If that's really true, I want to know what that implies about the macroscopic world," Johnson said.

To find this out, he builds state-of-the-art computer simulations of many complex quantum systems and is actively involved in the worldwide effort to build a quantum computer. Johnson also collaborates as a theorist at some of the most advanced quantum physics laboratories in the world.

Though he predicts it is decades from completion, a quantum computer could perform computations impossible with an ordinary computer because of quantum parallelism—the ability of microscopic objects to be in many places and configurations simultaneously, he said.

As a theorist, he builds computer simulations of quantum systems and runs them on an ordinary computer to understand how these systems behave and how to manipulate them.

Before coming to AU, Johnson was a National Research Council postdoctoral fellow at the National Institute of Standards and Technology (NIST), the premier national physics lab in the country. Johnson continues to work with NIST as part of its efforts to build a quantum computer and understand quantum information.

When at NIST, he works with a group headed by Bill Philips, one of the winners of the 1997 Nobel Prize for work on cooling and trapping atoms using lasers. NIST researchers are currently building on that work through a project that uses lasers to hold atoms in space. Each atom represents a single quantum bit or "qubit" of information. The interaction between all the atoms together will form a quantum computer. The experiment is still in its beginning stages; they are first studying how to control and direct a few atoms at a time.

The NIST group recently conducted an experiment to control the wave functions of individual atoms, confirming a number of Johnson's theoretical predictions. Everything in the quantum world is determined by these wave functions, Johnson said. An atom has no single position, but a wavelike probability of where it might be. To control quantum mechanical systems, he and fellow researchers found, one must control this wave function.

Johnson also collaborates with a leading group at the University of Maryland that is trying to build qubits using superconductors.

He often finds his quantum mechanics research overlaps with the material in his Modern Physics course, knowledge that he shares with his students. "It's a fun challenge to figure out how to do that," he said. Johnson plans to involve his students in quantum physics research projects he hopes they will continue after the semester.

The desire to teach at a liberal arts university influenced Johnson's decision to come to AU. "I tend to like to work on a lot of different ideas," he said, "including exploring ideas outside of pure science."

Teaching inspires new ideas for research, he said, but it can also be its own reward.

"When you teach something, even when it's something you thought you understood," he said, "when you actually go back and teach it, you're forced to go back, relearn it, and see it fresh."