International collaboration seeks to develop noninvasive quantum electron microscope

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Moving closer to creating a microscope that can peer through atoms and molecules without disturbing them, leading physics researchers have joined together with support from the Gordon and Betty Moore Foundation to launch an international collaboration to lay the groundwork for the development of a novel quantum electron microscope.

The $4 million, three-and-a-half-year effort will be spearheaded by Dr. Mark Kasevich at Stanford, Dr. Peter Hommelhoff at The Max Planck Institute of Quantum Optics, Drs. Fatih Yanik and Karl Berggren at Massachusetts Institute of Technology and Dr. Pieter Kruit at Delft University of Technology in the Netherlands. The research groups will work together to demonstrate interaction-free measurements with electrons, which, if successful, would form the basic principles for future development of an electron microscope with the potential to yield important discoveries in many areas of science.

The theory was first proposed by Dr. Yanik's team at MIT in a paper for *Physical Review Rapid Communications* in October 2009 (Phys Rev A 80, 040902(R) 2009). This new international collaboration will begin testing the theory, making significant strides towards its realization.

"The Gordon and Betty Moore Foundation's Science Program seeks to support high-impact scientific research, and we see this project as exactly that kind of opportunity," said Vicki Chandler, chief program officer for Science at Moore. "We expect that the work this team is

doing will enable exciting new science through technology, and the scientists will acquire fundamental new knowledge in quantum mechanics and manipulation of electrons."

Although light and electron microscopes have shaped our modern understanding of biology—with discoveries as fundamental as the eukaryotic cell, bacteria and viruses, to name just a few—major barriers to answering fundamental biological questions remain, including the inability to visualize molecules interacting within living cells. The light microscope can image living things, but not at molecular resolution. The electron microscope, on the other hand, can image molecules and atoms, but cannot be used to study live samples due to the intense radiation the sample is exposed to. A quantum electron microscope, however, promises to overcome these deficiencies in current imaging technologies by allowing scientists to peer into living cells at molecular resolution without radiation damage, dramatically expanding our understanding of how cells work.

Recent advances in the quantum-level control of electrons open the door to development of an electron microscope based on non-destructive quantum measurement principles. These instruments may enable real-time, non-destructive imaging of biological samples. A three-year, coordinated program to develop the foundational ideas in support of this technology will involve each university team taking parallel but distinct technical and scientific approaches.

Throughout its history, science has relied on technical advances and surges in new knowledge that have offered researchers unexpected breakthroughs—and new questions. The quantum electron microscope will offer transformational new approaches, with the potential for an enduring impact on fundamental physics, engineering and biology.