

## Field 7 – Project Abstract

A new field of research is proposed: *correlated nanoelectronics*. By combining the paradigm of quantum transport in semiconductor nanostructures with the rich properties of complex-oxide materials, new families of nanoscale electronic devices will be created that control and exploit strong attractive electron interactions. The research, if successful, will lead to quantum-enabled nanoelectronics, a novel solid-state approach to quantum simulation, and the development of technologically important new materials by design.

The proposed area of research is based on an innovative technique, developed by Levy, for creating nanoelectronics at the  $\text{LaAlO}_3/\text{SrTiO}_3$  interface with a precision of just two nanometers. A remarkable variety of device concepts have already been demonstrated, including nanoscale transistors, THz emitters and detectors, single-electron transistors, quantum point contacts and superconducting nanostructures. The proposed research program will leap forward from these demonstrations toward much more ambitious goals: we will create a novel class of electronic devices that make essential use of strong electronic correlations—at the single-electron level—for quantum sensing, computation and simulation applications. We will develop the first reconfigurable platform for solid-state quantum simulation, which will work alongside other theoretical tools like density functional theory to rapidly explore quantum behavior of model physical systems. And we will work to develop detailed models of the electronic structure of the  $\text{LaAlO}_3/\text{SrTiO}_3$  system, including a microscopic understanding of the pairing “glue” that leads to superconductivity. Collectively, this new field of correlated nanoelectronics will provide original breakthrough technologies that control quantum systems at fundamental scales.

The proposed research will approach its goals from two directions. The first approach investigates the basic electron pairing mechanism in  $\text{SrTiO}_3$ -based nanostructures, which provides the fundamental correlations to be used in devices. The second approach will explicitly develop a solid-state platform for quantum simulation—the first of its kind—using reconfigurable oxide nanoelectronics.