



IU BLOOMINGTON

# EMERGING AREAS OF RESEARCH

## Abstract Template -- Due June 30, 2017

Title of initiative to be proposed:

Center for Quantum Science and Engineering

Name of lead PI, with title, department/school:

Gerardo Ortiz, Professor, Physics/College of Arts and Science

Key team member names and departments/schools (up to 10 names):

David Baxter, Roger Pynn, Phil Richerme, Mike Snow: Physics/College of Arts and Science  
Alexander Gummenik: Intelligent Systems Engineering/School of Informatics and Computing  
Amr Sabry: Computer Science/School of Informatics and Computing

Description of area to be proposed. What constitutes this area of research or creative activity as emerging?  
(Word limit=500)

Quantum mechanics governs the properties of atomic scale systems, and understanding its details is fundamental to most of modern technologies (from mechanistic understanding of synthetic chemistry and nuclear physics, to the foundations of the semiconductor and magnetic storage industries, to name but a few examples). Taming the most unique aspect of quantum phenomena, entanglement, is key to achieving critical progress in future technologies. Entanglement lies at the heart of some of the most perplexing problems in materials physics, and it has also led to burgeoning revolutions in computing, cryptography, and other fields. Recently, the promise for entanglement to open major new technical horizons as our ability to control and understand this most unique aspect of the quantum universe has been described as the second quantum revolution. So-called quantum computers promise to provide exponential speed-up in solving problems that are fundamentally beyond the capabilities of conventional computers, and entanglement is believed to be the key distinguishing factor separating quantum from conventional computation. This is an area in which the National Science Foundation envisions making major investments over the upcoming decades, and it is also an area that has seen increased funding from the Defense agencies over the last decade. Technology companies, such as Microsoft, IBM and Google, have also identified this as a key area for future development and have devoted significant resources to the field recently.

IU Bloomington has a core group of faculty with overlapping interests in this field, and we are seeking to broaden and link more effectively these efforts through the EAR initiative. Physics has three distinct experimental groups developing novel approaches to control and characterize entanglement in systems of many particles, and faculty members in both Physics and Informatics are exploring ways to recast conventional theories of computation in light of these new developments. Furthermore, the Intelligent Systems Engineering (ISE) Department brings in prototyping, characterization, and system integration capabilities in a number of application areas, such as quantum sensing, devices, cloning, cryptography, and data routing. A small number of hires in areas complementary to our existing efforts (such as large-scale (conventional) computational approaches to simulating several-body quantum systems, studies of trapped atom systems, and quantum measurement techniques) would provide a significant boost to the international profile of our group while also providing enhanced connections to the wider Quantum Information Technology community for our future graduates. Funding of this EAR proposal will result in IU Bloomington becoming an internationally recognized leader in Quantum Simulation and the use of entangled states as a probe of quantum systems. Such funding will also greatly enhance ties between the College and ISE in this emerging area of quantum technology, and put the campus in a strong position to lead a burgeoning Midwest effort in Quantum Engineering that could involve partners such as IUPUI, U. Chicago, U. Illinois at Chicago, Argonne National Lab, and others.

Please submit to [earprogram@indiana.edu](mailto:earprogram@indiana.edu)