$15 million NSF Software-Tailored Architecture for Quantum co-design (STAQ) project to create first practical quantum computer

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CQuIC’s Professor Akimasa Miyake will participate in a $15 million, multi-university collaboration as part of a National Science Foundation program designed with the audacious goal of building the world’s first practical quantum computer. Dubbed the Software-Tailored Architecture for Quantum co-design (STAQ) project, the effort seeks to demonstrate a quantum advantage over traditional computers within five years using ion trap technology. The program is the NSF’s largest quantum computing effort to date. The project is the result of a NSF Ideas Lab—a week-long, free-form exchange among researchers from a wide range of fields that aims to spawn creative, collaborative proposals to address a given research challenge. “There’s a really clear path to getting to two-to-three dozen ion trap qubits working together in a quantum computer,” said Kenneth Brown, leader of the STAQ team collaboration. “But it will take at least twice as many to solve a challenging calculation.” “Quantum computing requires experts from a range of fields, with individuals applying complementary insights to solve some of the most challenging problems in science and engineering,” said NSF Chief Operating Officer Fleming Crim. “NSF’s STAQ project uniquely addresses that need, providing a cutting edge approach that promises to dramatically advance U.S. leadership in quantum computing.” “A new challenge is to develop a stack of software such as operating systems and compilers, in order to make the experimental hardware of ion qubits useful to real-world applications,” said Akimasa Miyake.

STAQ will also organize a Quantum Ideas School, during Summer School, June 17-21, 2019 at Duke University.

ELIZABETH CROSSON
Professor Elizabeth Crosson joined UNM faculty in Physics and Astronomy in September 2018 after a search for an interdisciplinary quantum information science theorist to join the CQuIC team. She received a joint-appointment in the Computer Science Department in October 2018.

Her research touches on several theoretical aspects of quantum computation, including adiabatic computation and optimization, quantum error correction, and Hamiltonian complexity. Her goal at UNM is to work with graduate students and continue doing research both on fundamental long-term questions in quantum information science, and on developing immediate applications of the noisy intermediate-scale quantum computing devices that are now becoming available.

Prof. Crosson plans to build a high-performance computing system dedicated to performing classical simulations of quantum systems. She will serve as a Project Director for CQuIC’s NSF FRHTP and PI on her Google-funded Low Depth Algorithms for Quantum State Generation project.
The STAQ researchers focus on four primary goals:

1) Develop a quantum computer with a sufficiently large number of qubits to solve a challenging calculation.

2) Ensure that every qubit interacts with all other qubits in the system, critical for solving fundamental problems in physics.

3) Integrate software, algorithms, devices, and systems engineering.

4) Involve equal input from experimentalists, theorists, engineers, and computer scientists.

Now in the planning stage, STAQ will also organize a Quantum Ideas School, during Summer School, June 17-21, 2019 at Duke University during the first year, to recruit and train new students and current industrial scientists in quantum information skills.

**ELOHIM BECERRA CHAVEZ**

In April 2017, Professor Elohim Becerra Chavez received the 2018 NSF Career Award for his proposal, *Quantum Measurements for Optical Communications*. The Faculty Early Career Development (CAREER) Program is NSF’s most prestigious award in support of junior faculty who exemplify the role of teacher-scholars through outstanding research, excellent education, and the integration of education and research within the community. The NSF CAREER program helps early-career faculty get strong starts on their academic careers.

Prof. Becerra’s research interests are in optics and experimental research in quantum optics, nonlinear optics and quantum information. Becerra is a faculty member in the new Quantum Optics track for the UNM Optical Science and Engineering program and leader of the Quantum Optics Research Group.

The quantum properties of physical systems have a large potential for enabling technologies with unprecedented capabilities. The Quantum Optics group’s interests include the study of measurements with sensitivities beyond conventional limits of detection, and the study of quantum-state superpositions from the interaction of light and matter for quantum information and communication protocols.

The group studies technologies that can be enabled by these quantum systems and seeks to understand the limits of such quantum technologies. Applications of these studies include quantum and coherent communications, metrology, and quantum information processing.

Becerra has been the Principal Investigator (PI) and Co-PI for a number of published papers.

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**BECERRA GROUP 2018 PUBLICATIONS**


- Robust measurement for the discrimination of binary coherent states in *Physical Review Letters*, 121, 023603, July 2018
Strengthening our collaboration with our National Laboratory partners at Sandia and Los Alamos is an important priority. New partnerships are forming with the growing QIS industry. CQuIC is proud to be the recipient of 2 out of total of 8 prestigious Google Focus Awards to develop new applications for the next generation of quantum computers.

With all of these components – transdisciplinary research, strengthened national laboratory partnerships, and a growing interaction with industry, CQuIC is poised to do what it does best – to train students with strong research apprenticeships in an intensely collaborative community. CQuIC has a proud track record in this regard, as seen in our alumni who are today’s QIS leaders. To keep this tradition strong, we are launching the Carlton M. Caves CQuIC Scholarship Fund, in honor of CQuIC’s founding Director. Carl was the pioneer who put UNM on the map as a leader in QIS. All of our alumni have had an incredible experience at UNM with Carl at the helm. Let’s live up to his standards for the next generation!

CQuIC is poised to contribute significantly to the success and sustainability of quantum information science.

-NSF Review-
Latent computational complexity of symmetry-protected topological order with fractional symmetry in Physical Review Letters, 120, 0170503, April 2018

Classical simulation of quantum circuits by dynamical localization: Analytic results for Pauli-observable scrambling in time-dependent disorder in Physical Review A, 98, 012309, July 2018

For outstanding achievements in quantum theory" QCMC 2018 Award Committee

As a 10% faculty, enjoying riding his bike whenever he wants and working on science with the postdocs. Terrific!

"for Measurement-based Quantum Computation and Symmetry-protected Topological Order"
POSTDOCTORAL FELLOWS

CQuIC’s NSF Focused Research Hubs in Theoretical Physics (FRHTP) award serves to advance the frontiers of quantum information science (QIS) by developing a highly collaborative postdoctoral research environment with new emphasis on the development, mentoring and career enhancement of a diverse group of postdoctoral theorists.

CQuIC has a noted track record of providing superior training to students and postdocs, many of whom move on to faculty positions around the world.

-NSF Review-

The postdocs travel to collaborate with the Jessen and Guha research groups at the University of Arizona, CQuIC’s partner institution, and to other institutions within the U.S. and internationally, to broaden the collaborative scope.

-NSF Review-

Christopher Jackson Sayonee Ray, Pablo Poggi, and Rafael Alexander, CQuIC Postdoctoral Fellows (pictured above), work with research groups led by CQuIC faculty, LANL and SNL associate faculty and PhD graduate students.

-NSF Review-

Each of the postdocs has identified challenging problems at the cutting edge of QIS. If they are successful, the impact of their work will be very significant. One example is the extension of “Union Jack” quantum graph states to continuous variables, which could open new avenues for implementing quantum computing.

-NSF Review-

Scientific collaboration is already taking place among all of them and with the PIs, on several distinct projects. One recent notable result is the analytical formulation of, and consequent experimental proposal for, the quantum tomography of spin coherent states, something that was long thought impossible.

-NSF Review-

The collegial atmosphere of the weekly group meeting is reinforced by the fact that the postdocs interact with students who see them as important collaborators and guides for their research.

-NSF Review-
2018 SEMINAR SPEAKERS

CQuIC welcomed several speakers to the CQuIC Seminar series and UNM Physics and Astronomy Colloquium.

Monika Schleier-Smith • Patrick Coles • Mark Raizen • Meenu Kumari • Ludwig Kunz • Nathan Lemke • Lincoln Carr • Alain Aspect • Lukasz Cincio • Mike Martin • Gavin Brennen • Jeff Kimble • Sergio Boixo • Jason Twamley • Victor Acosta • Dalziel Wilson • Scott Diddams • Ben Baragiolla • Diego Dalvit • Todd Brun • Alberto Marino • Scott Aaronson • Christopher Chubb • Zheshen Zhang • Alejandro Manjavacas • Andrew Baczewski • Paul Kwiat • Garnett Bryan • Michel Devoret • Boubecar Kante • Jay Gambetta • Norbert Lutkenhaus

described the phenomena of evanescent nature of fields in the band gap when mediating strong atom-light interactions using nanoscale dielectric devices. “To describe such phenomena” says Kimble, “a formalism beyond traditional quantum optics is required in terms of the Green’s functions for the nano-photonic structures.”

VISITING SCIENTISTS

GAVIN BRENNEN Professor at Macquarie University and UNM Ph.D Alumni visited CQuIC April 16 – May 6, 2018 to collaborate on research with the Miyake and Deutsch groups on problems relating to quantum simulation and quantum computational supremacy. Prof. Brennen’s research lies at the intersection of quantum information theory, many-body physics, quantum field theory, and quantum optics. He is the Deputy Director QSITECH, which investigates and utilizes complex aspects of Quantum Information Science to probe the quantum nature of reality.

ALBERTO MARINO Professor at the University of Oklahoma is on sabbatical in Albuquerque for the 2018-2019 academic year, working at Sandia Laboratories. He will also be a weekly visitor at CQuIC to collaborate on research with the Deutsch, Becerra and Manjavacas groups. Prof. Marino’s research has focused on the generation and control of quantum states of light known as twin beams through the use of four-wave mixing in atomic vapors. His research intersects with that of CQuIC investigators through his work on the spatial properties of quantum states of light and on the interface between quantum states of light and plasmonic structures.

EXTERNAL ADVISORY BOARD

In August 2018, the EAB members, Steven Girvin of Yale University, Christiane Koch of the University of Kassel, and David Wineland of the University of Oregon, took part in a roundtable discussion led by CQuIC Director, Ivan Deutsch that brought together UNM leadership from multiple disciplines. The goal was to garner interest in preparing for a future of quantum information science at UNM that includes a multidisciplinary approach.
NEW CQuIC FACULTY ASSOCIATES

ALEJANDRO MANJAVACAS of UNM and SAIKAT GUHA of UA accepted appointments as CQuIC Research Associate Faculty in July 2018 to collaborate on CQuIC projects and mentor PhD students.

PROF. MANJAVACAS is a theoretical physicist working on light-matter interactions, particularly relating to quantum effects in plasmonics and nanophotonics. His research group works to understand how nanostructures interact with light and uses that knowledge to develop novel applications in photonics. His group is very interested in the study of phenomena arising from the quantum and thermal fluctuations of the electromagnetic field, such as Casimir interactions and radiative heat transfer.

PROFESSOR GUHA’S expertise lies at the intersection of quantum optics and quantum information theory. His research focuses on quantum limits of classical communications, super-resolution in optical imaging and sensing, quantum repeaters and network protocols, and all-photonic quantum computing.

ALL ABOUT SQuInt

20TH ANNUAL WORKSHOP
February 22-24, 2018
Santa Fe, New Mexico

A record 225 participants, including 79 graduate and 18 undergraduate students gathered in Santa Fe for a full 3-day program including a panel discussion on the progress of quantum information and SQuInT.

21ST ANNUAL WORKSHOP
February 10-12, 2019
Albuquerque, New Mexico

Expect another great scientific program this year! Invited speakers include:

- Erika Andersson
- John Bollinger
- Anne Broadbent
- Howard Carmichael
- Manuel Endres
- Shohini Ghose
- Mercedes Gimeno-Segovia
- Patrick Hayden
- Lee McCuller
- Jason Petta

ACCEPTING DONATIONS

Carlton M. Caves CQuIC Scholarship Fund
Established to honor Carlton M. Caves, Distinguished Professor of Physics and Astronomy, and to promote academic excellence, this fund will be used to recruit and support student involvement in academic work in the area of quantum information science.

In 2009, Caves was appointed the founding Director of the Center for Quantum Information and Control (CQuIC), which is focused on the control of complex quantum systems. CQuIC aims to make quantum systems march to our orders, instead of doing what comes naturally. His teaching and publications have impacted a generation of scientists and students.

CQuIC Events Fund
This fund provides support for a variety of events that enhance the reach of our curriculum by disseminating information about current research among the quantum information science community.

To make an on-line donation, click the links above or visit:

https://cquic.unm.edu/donate/
Next Issue: Focus on CQuIC Alumni

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Your feedback and input are welcome at cquic@unm.edu