NATIONAL SCIENCE FOUNDATION
2415 Eisenhower Avenue
Alexandria, Virginia 22314

NSF 18-062

Dear Colleague Letter: EQuIP: Engineering Quantum Integrated Platforms for Quantum Communication

April 10, 2018

Dear Colleagues:

In 2016, the National Science Foundation (NSF) identified 10 Big Ideas for Future Investment. The opportunity described in this Dear Colleague Letter (DCL) overlaps with two of those Big Ideas: Quantum Leap, which is a multipronged effort to advance the fundamental understanding of quantum phenomena, materials, and systems, toward revolutionary advances in quantum information science, and Convergence Research, which fosters the merging of ideas and approaches from widely diverse fields through individual research projects as well as partnerships and collaborative research.

This DCL aims at pushing the frontiers of engineering in quantum information science and technology by exploring integrated approaches that go beyond the individual devices and components to demonstrate a proof of concept that encompasses novel device integration and circuits in a quantum communication system.

Future performance improvements in communication, computing, and sensing rely on the availability of new concepts and disruptive technologies that are based on quantum principles. The last decade has seen tremendous progress in both basic research and in technological advances in devices for generation, storage, manipulation, propagation, and detection of quantum information. However, many technical challenges remain in the development and realization of large-scale systems. There is a need to move beyond single components — such as the transmitter, channel, and receiver in a communication system — to pursue new approaches that integrate the various components and optimize system performance. To address these challenges, it is necessary to establish strong collaboration among researchers with different expertise from materials and devices to functional circuits motivated by the performance needs of integrated systems.

This DCL also aims at developing the future science and engineering workforce in this domain. Educating and training researchers in quantum science and engineering is an important objective of this program.

Project Preparation

This DCL seeks collaborative, multidisciplinary proposals that span quantum device and circuit technology and system-level concepts in the design, analysis, development, and demonstration of integrated quantum communication systems. The proposals must address in an integrative fashion two or more of the following research topics: (1) revolutionary quantum device approaches based on photonic and electronic principles for generating signals that encode quantum information (qubits); (2) novel media for quantum signal propagation, storage, and/or routing that achieve minimum signal disturbance and loss; (3) disruptive quantum receiver technologies that achieve high-fidelity detection of encoded qubits. Auxiliary systems for creating entanglement between the transmitter and receiver may be utilized, and information encoding that involves multiple qubits is also desirable.

The proposed approaches are expected to encompass a well-defined integrated system perspective, with performance benchmarking in terms of operational parameters such as communication speed, coherence, memory, and temperature requirements, as well as necessary operational requirements such as electromagnetic frequency, phase, and field strength. Benchmarking parameters may go beyond those described above by way of example, and should reference and discuss the current state of the art.

It is expected that a proposed complete system design would enable a new experimental research platform for addressing fundamental technological questions and challenges that are relevant to real-world applications but beyond the reach of current platforms. Such a platform would also enable exploration and comparison of various devices and approaches for quantum communication and sensing, which may be at varying levels of technological maturity. The proposal must clearly discuss such advances enabled by the proposed integrated system.

The successful research teams will be expected to provide a proof-of-concept technological demonstration of the proposed devices and integrated quantum communication circuit or system by the end of the project. The multidisciplinary team should explore new platforms that have the potential for higher performance, integration of the various functionalities, and scalability. Hybrid approaches addressing cross platform aspects are of interest. It is anticipated that the collected results of the projects supported in response to this DCL will help address the following questions critical to scalability:

- *Can quantum functionalities be developed as building blocks that achieve optimal performance, while allowing integration into circuits and systems?*
- *Could these functionalities be provided under constraints (including physical size, operating temperature, and power) that would apply in the intended real-world applications and, if so, what further technological hurdles would need to be overcome?*
- *Would this require exploring new material platforms or heterogeneous integration techniques?*

Examples of potential approaches include, but are not limited to: use of high-purity materials; generation, control, and detection of the signatures of correlated quantum states; topological phase-engineered solutions in 1D quantum materials or 2D layered devices; devices utilizing concepts involving coupling of electromagnetic waves with an electric or magnetic dipole-carrying excitation; devices utilizing optical and spin properties in conjunction with defects; concepts permitting the establishment of interface between valleytronic and photonic operation; devices with low-energy ordered quantum states; approaches using spin waves in nanostructures; and novel approaches for encoding and decoding information to and from quantum states, tailored to the propagation medium characteristics.

This DCL also encourages teams to collaborate with industry using the Grant Opportunities for Academic Liaison with Industry (GOALI) proposal framework (https://www.nsf.gov/eng/iip/goali.jsp) to pursue use-inspired research of strong industrial significance. Active NSF grantees seeking to expose and better train their graduate students in state of the art non-academic research activity pertaining to quantum science and technology are encouraged to explore the opportunities provided in the INTERN program as described in NSF 17-091 (https://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf17091).

Anticipated Funding Amount: $5,000,000

The total amount of funds anticipated for this program is up to $5,000,000, subject to the availability of funds. It is anticipated that approximately 7 projects, each at an average of $750,000 for three years, will be supported. Estimated program budget, number of awards, and average award size/duration will be subject to the availability of funds. NSF encourages proposals that include international collaboration when those efforts enhance the merit of the proposed work by incorporating unique resources, expertise, or facilities of international partners; however, the international partners generally should have support or obtain funding through non-NSF sources.

NSF Proposal Submission

Principal Investigators (PIs) must follow the guidance for Research Advanced by Interdisciplinary Science and Engineering (RAISE) proposals specified in the NSF Proposal and Award Policies and Procedures Guide (PAPPG; see Chapter II.E.3). Eligible PIs must contact by email at least two cognizant program officers (listed below) with a one-page, PDF-formatted research concept outline describing the project, and must obtain prior written authorization from those program officers before submitting their proposals. The research concept outline must include a title prefaced by RAISE-EQuIP, the list of PIs and their affiliations, and the primary investigator contact information.

Investigator Team Requirement:

The team must consist of at least two principal investigators with complementary expertise in quantum device technology (EPMD) and quantum information processing techniques (CCSS), as typified by the EPMD and CCSS programs of the Electrical, Communications and Cyber Systems (ECCS) Division, and the proposed research must address both aspects in an integrated and coherent fashion in the context of the proposed quantum communication system.

Submission Deadlines

Research concept outline PDFs are to be submitted by e-mail to relevant Program Officers by May 15, 2018.

Following an emailed invitation, full proposals are to be submitted to the ECCS division, via FastLane, by July 6, 2018. Please preface your proposal’s title with the RAISE-EQuIP acronym. The full proposals may be evaluated by external reviewers.

For further information, please contact the cognizant NSF program officers:

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The NSF Division websites can be accessed at:

- ECCS: https://www.nsf.gov/div/index.jsp?org=ECCS
- IIP: https://www.nsf.gov/div/index.jsp?org=IIP

Signed,
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