NATIONAL SCIENCE FOUNDATION
2415 EISENHOWER AVENUE
ALEXANDRIA, VIRGINIA 22314

NSF 18-046

Dear Colleague Letter: Enabling Quantum Leap: Achieving Room-Temperature Quantum Logic through Improved Low-Dimensional Materials

February 15, 2018

Dear Colleagues:

Future quantum information technologies will utilize devices that control, detect, and process information through mechanisms that rely on increasingly novel materials and operational paradigms. This Dear Colleague Letter (DCL) addresses the need for fundamental research into eliminating obstacles to achieving low-dimensional materials suitable for room-temperature quantum information processing. For such materials to be practicable, current impediments in the form of decoherence, losses, and limited scalability must be overcome.

This DCL is intended to challenge the fundamental research community to achieve the materials solutions needed for demonstrating room-temperature quantum logic in low-dimensional materials, thus enabling a new platform for quantum information control and processing.

Recently, low-dimensional systems have emerged as a nascent class of materials that may offer the control and robustness required for room-temperature quantum logic. Moreover, low-dimensional materials exist at the nexus of several schemes that have been proposed for quantum information processing, using photons, polaritons, topological states, and pseudospins. The aim of this DCL is to challenge researchers to propose exploratory research enabling the successful experimental demonstration of room-temperature quantum logic in low-dimensional materials. Of primary interest to this DCL is quantum logic enabled by materials-mediated photon interactions. Materials and systems may include, but are not limited to: monolayers, interfaces and metasurfaces with large single-photon optical nonlinearities; room-temperature polaritonic condensates; 2D and quasi-2D materials with very large excitonic binding energies; topological polaritons and many-body localized systems.

Research projects are expected to be exploratory and therefore high-risk and high-payoff, addressing primarily the basic properties of novel materials, and, at a fundamental level, pathways towards applicability. Prospective PIs should address the fundamental materials challenges in the context of a proposed mechanism to achieve quantum logic operations, clearly articulating the main materials barriers to realizing quantum logic in the specified paradigm, as well as the plan for surmounting the identified obstacles. Metrics for evaluating success should be clearly delineated.

Examples of desired outcomes of investigations into fundamental materials properties may include: greatly enhancing single-photon optical nonlinearities, decreasing decoherence, and increasing operational frequency, while demonstrating room-temperature control and manipulation of coherent states in quantum logic operations. While experiment/theory interactions are strongly encouraged, collaborative proposals should be limited to no more than 3 participants.

The Division of Materials Research (DMR) invites submission of high-risk and high-payoff proposals aiming at fundamental research to demonstrate room-temperature quantum logic using low-dimensional materials, and encourages PIs to submit EArly-concept Grants for Exploratory Research (EAGER) proposals. Prior to submission of an EAGER proposal, a one-page whitepaper must be prepared and discussed with a cognizant Program Director. The proposal title must begin with "EAGER: Enabling Quantum Leap:" Proposals must be focused on fundamental materials research aspects within the scope of DMR and offer previously untested, exploratory concepts of room-temperature quantum logic in low-dimensional materials, with a high-risk / high-payoff characteristic. Award size and duration are limited to no more than $300,000 over a maximum of two years. EAGER proposals can be submitted throughout the year, with no specific submission window. Guidelines for preparing EAGER proposals can be found in Chapter II.E. 2 of the *NSF Proposal & Award Policies & Procedures Guide* (PAPPG).

This opportunity is managed by the Electronic and Photonic Materials (EPM) Program and EAGER proposals should be submitted to EPM. PIs may identify other programs within DMR for potential co-review. Specifically, the Condensed Matter and Materials Theory (CMMT) program would be appropriate if a strong theory component is envisioned, and the Condensed Matter Physics (CMP) program would be helpful for assessing the fundamental materials physics aspects of a proposal.

An investigator may be included in only one white paper and subsequent proposal submission pursuant to this DCL. DMR has no other specific priorities and restrictions.

Key contacts:

EPM: Miriam Deutsch, mdeutsch@nsf.gov
CMMT: Daryl Hess, dhess@nsf.gov
CMP: Tomasz Durakiewicz, tdurakie@nsf.gov

Dr. Linda Sapochak
Division Director
Division of Materials Research

Dr. Anne Kinney
Assistant Director
Mathematical and Physical Sciences Directorate