NATIONAL SCIENCE FOUNDATION
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Dear Colleague Letter: Funding Opportunity - A "Quantum Leap" Demonstration of Topological Quantum Computing

February 6, 2017

Dear Colleagues:

In May of 2016, the Director of NSF unveiled Big Ideas, developed to answer important societal problems while building the transdisciplinary portfolio of focused fundamental research over the next decade. One of these ideas, "Quantum Leap", advances quantum technologies of the future: quantum communication, quantum computing, quantum sensors and quantum simulators. The powerful language provided by quantum mechanics almost a century ago becomes the foundation upon which to build new industries. This process, sometimes called "the second quantum revolution" is marked by the development of practical and marketable solutions for quantum technologies. This Dear Colleague Letter (DCL) is intended to challenge the fundamental research community to achieve the transformative experimental realization of topological quantum computing.

Quantum computing is based on the ability to generate, manipulate, read, entangle and write quantum states of physical qubits. Various types of qubits, like those based on Josephson junctions, trapped ions, vacancies in diamond or quantum dots, are already being experimentally investigated. Associated quantum states have limited longevities leading to loss of quantum coherence. Decoherence leads to state dissipation and increases errors in computation. In contrast, qubits based on topological states offer a potentially robust vehicle to quantum computing. Conceptual approaches to topological computing include braiding anyon world lines, interferometry, fusing, dynamical topology or symmetry defects. The aim of this DCL is to challenge researchers to propose transformative research leading to **the successful experimental demonstration of a topological qubit based on braiding anyon world lines or other known or creative new mechanisms enabling viable topological quantum computing.** This DCL answers the specific need expressed by the participants of the workshop: "Frontiers of Condensed Matter Physics: CMP Principal Investigators Workshop on Topological Phases of Matter", http://scholar.princeton.edu/nsfcmp, supported by increasing global interest in fundamental research in topological quantum computing.

The Division of Materials Research (DMR) invites submission of high-risk / high-payoff proposals aiming at fundamental research to realize topological qubits 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: BRAIDING:" Proposals must be focused on fundamental materials research aspects within the scope of DMR **and** offer potentially transformative exploratory concepts of topological computing 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 within the *NSF Proposal and Award Policies and Procedures Guide*: https://www.nsf.gov/pubs/policydocs/pappg17_1/index.jsp.

This opportunity is managed by the Condensed Matter Physics (CMP) program and EAGER proposals should be submitted to CMP. PIs can identify other programs as potential partners. Specifically, the Condensed Matter and Materials Theory (CMMT) program would be appropriate if strong theory participation is envisioned, and the Electronic and Photonic Materials (EPM) program would be helpful if light-matter interactions is essential in this opportunity.

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:

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