



NATIONAL SCIENCE FOUNDATION
2415 EISENHOWER AVENUE
ALEXANDRIA, VIRGINIA 22314

NSF 22-018

Dear Colleague Letter: Cryogenics below 1 K - Systems, Cycle, and Materials

November 22, 2021

Dear Colleagues:

The advancement of quantum-enabled devices for many applications, such as computing, sensing and communications, is dependent upon the use of ultra-low temperatures, <1K. Significant cooling power is needed to maintain the devices at their optimal operating temperature. Currently, options for the refrigeration at these low temperatures are commercially limited largely to ^3He -dilution refrigerators. The ^3He isotope is one of the rarest within the terrestrial environment, with a natural isotopic abundance at a scant 0.00014%. Given the present and projected shortage of ^3He , advances in the fundamental science and engineering of ultra-low temperature refrigeration are needed to meet the projected needs for quantum applications and to conserve scarce ^3He . Research needs include the design, discovery, and development of materials that can function at ultra-low temperatures and methods that provide advantages over current ultra-low temperature refrigeration approaches.

With this Dear Colleague Letter (DCL), the National Science Foundation's (NSF) Directorate for Engineering (ENG) and Directorate for Mathematical & Physical Sciences (MPS) invite the submission of Early-concept Grants for Exploratory Research (EAGER)* proposals to focus on new approaches to refrigeration at <1K, materials needed to enable ultra-low temperature refrigeration, and new processing techniques needed to fabricate these new types of refrigeration systems.

Potential area of research include:

- New refrigeration approaches and cycles that do not use ^3He and are capable of cooling to <1K with significant cooling power
- Understanding of the thermodynamics of disruptive, ultra-low temperature cooling concepts

New means of active and passive thermal control, including solid-state thermal switches with high switching ratios below 4K.

- Discovery of new materials central to new modes of refrigeration, such as materials that have controlled large entropy changes near 0K or provide active cooling.
- New processes that address the need for high precision manufacture and surface finish in complex geometries for low temperature applications
- New materials for the construction of vacuum technology useful at these low temperatures

*The EAGER type of proposal is described in Chapter II.E.3 of the [NSF Proposal & Award Policies & Procedures Guide](#) (PAPPG):

Proposed research projects that are responsive to this DCL should be based on the close collaboration between experiment and theory, and/or to novel, unconventional, and high-risk/high-reward ideas or strategies to address key scientific challenges in ultra-low temperature refrigeration.

Submission of EAGER proposals in response to this DCL is by invitation only; the process is initiated by the submission of a Research Concept Outline (RCO) describing the proposed high-risk / high-reward project that addresses this challenge.

The RCO must clearly describe the idea with a clear explanation of why it is innovative, potentially transformative, or otherwise potentially impactful. RCOs are strictly limited in length to 2 pages, including references, plus a half-page justification of proposed budget, for a total of 2.5 pages. All correspondence, inquiries and RCOs must be via email to one of the Program Directors listed below.

EAGER proposals submitted without prior submission of a corresponding RCO and subsequent invitation will be returned without review. Per the PAPPG, the email invitation from an NSF Program Director serves as documentation and must be uploaded in the Supplementary Documentation section of the invited EAGER proposal. The RCO and proposal titles must begin with “EAGER: CRYO:” followed by a brief descriptive title. For consideration by this DCL opportunity, RCOs must be submitted by April 30, 2022, and invited EAGER proposals must be submitted by June 30, 2022. An investigator may participate as a PI, co-PI, or Senior Personnel in only one RCO and subsequent proposal submission pursuant to this DCL.

The following NSF programs are participating in this opportunity and will accept RCOs:

- *Advanced Manufacturing (ENG/CMMI)*
- *Topical Materials Research Programs (MPS/DMR)*
- *Thermal Transport Processes (ENG/CBET)*

Key contacts:

CMMI: Thomas F. Kuech, tkuech@nsf.gov
CBET: Ying Sun, yisun@nsf.gov
DMR: Birgit Schwenzer, bschwenz@nsf.gov

Sincerely,

Susan Margulies
Assistant Director, Engineering

Sean Jones
Assistant Director, Mathematics and Physical Science