



NATIONAL SCIENCE FOUNDATION  
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**NSF 23-129**

## Dear Colleague Letter: Searching for New Physics Beyond the Standard Model Using Precision Measurements (BSM-PM)

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June 30, 2023

Dear Colleague:

The research envisioned in this Dear Colleague Letter will seek to push forward the frontier of measurement accuracy by substantial factors in order to contribute to one or both of the following long-term goals: (1) improve the constraints on parameters in theoretical alternatives to the Standard Model of Particle Physics, or similarly overarching fundamental models in other domains of physics such as gravitational physics, or (2) determine the values of known parameters to an unprecedented level of accuracy such that deviations from predictions would signal the discovery of new fundamental physics.

The discovery of the Higgs boson at the Large Hadron Collider (LHC), the world's highest-energy collider, provided remarkable confirmation of the Standard Model of Elementary Particle Physics, which forms the bedrock for our understanding of the physical world at the most fundamental level. Yet we know that the Standard Model is not a complete description of Nature. It does not account for the observed matter-antimatter asymmetry in the universe, dark matter, dark energy, gravity, or neutrino masses and mixings, for example. There also remain many features of the Standard Model itself which are not understood, and which may find their answers in speculative ideas beyond the Standard Model such as super-symmetry, large extra dimensions, and/or extended Higgs sectors.

While direct detection of new particles at facilities such as the LHC would provide clear evidence of new physics, experimental and theoretical studies involving Precision Measurements (PM) at relatively low (e.g. atomic-scale) energies can in some cases also provide evidence for new phenomena beyond the Standard Model. For example, quantum field-theoretic methods can be used to calculate with great precision how virtual particles at all mass scales populate the quantum vacuum and manifest themselves in potentially measurable quantities such as an electron or neutron electric dipole moment. Likewise, advances in techniques developed in the Atomic, Molecular, and Optical Physics community, including those involving emerging quantum sensors and high-accuracy clocks, open the

door to a variety of measurements that may indicate the presence of new physics beyond the reach of present-day particle colliders. These measurements may involve looking for signals of new physics in an important "next digit" of a precisely known quantity, or by looking for the first non-zero amplitude of a previously unobserved quantity.

This Dear Colleague Letter encourages interdisciplinary research proposals that target these new approaches across the core physics sub-disciplines within the purview of the Physics Division. The development of new methods or techniques not previously explored for such measurements is of particular interest, although work that will advance mature techniques by unusually large factors will also be considered. Experimental designs that incorporate empirical exploration of unknown systematics are desirable. Proposals for theoretical work will benefit from describing how uncertainties in the resulting quantitative predictions will be assessed, and how they will be used to guide the development of new experiments and/or interpret experimental data. Conversely, proposals for experimental work will benefit from describing how the results will test fundamental theory. Proposals that seek to connect two or more of the core sub-disciplines above, and/or develop *new* methods that have not been previously demonstrated and that hold promise of advancing the current precision frontier by an order of magnitude or more will be given priority.

Proposals addressing the goals of this Dear Colleague Letter should be submitted to one of the participating programs as described above and should have a title that begins with the "BSM-PM:" prefix. Participating programs and their respective proposal deadlines are listed in the current [Division of Physics: Investigator-Initiated Research Projects \(PHY\)](#) solicitation. More information about these programs is provided in the solicitation and the respective Program Descriptions. Where the scientific scope of a proposal overlaps multiple programs, the proposal should be submitted to the program most closely aligned to the proposal goals. Secondary programs may be indicated during submission. Prior to submission, proposers are strongly encouraged to contact the program director(s) for the program to which they intend to submit.

Sincerely,

Sean L. Jones  
Assistant Director  
Directorate for Mathematical and Physical Sciences