DMS Funding Opportunities Update

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With this update on National Science Foundation (NSF) funding opportunities, we intend to draw attention to some of the interdisciplinary programs and workforce-development programs of the Division of Mathematical Sciences (DMS) that should be of high interest to the mathematical sciences community. While the bulk (roughly 75 percent) of DMS investment in mathematical sciences research is carried out by the DMS Disciplinary Research Programs, DMS also participates as a partner in several crosscutting initiatives. Furthermore, there is a significant workforce development program within DMS itself, encompassing the Postdoctoral Research Fellowships (MSPRF) program, the Enhanced Doctoral Training (EDT) program, the Research Experiences for Undergraduates (REU) program, and the Research Training Groups (RTG) program.

This brief article is intended as a synopsis of some new and updated interdisciplinary and workforce-development funding opportunities of interest to the mathematical sciences community. More information about these programs is available via the DMS home page.

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Mathematical Sciences Innovation Incubator (MSII) Activity

The Division of Mathematical Sciences recently launched the MSII activity in recognition of the fact that the ideas, tools, and language of mathematics and statistics play important roles in every area of science and engineering research supported by the National Science Foundation; it is widely acknowledged that interactions between the mathematical sciences and other fields catalyze developments in both. DMS wishes to foster the participation of more mathematical scientists, from every area of mathematics and statistics, in such important interdisciplinary work. In support of this goal, the MSII activity provides funding to catalyze the involvement of mathematical scientists in research areas where the mathematical sciences are not yet playing large roles.

The MSII activity emphasizes scientific research areas of high national priority that would benefit from innovative developments in mathematics and statistics. For example, modern communication, transportation, science, engineering, technology, medicine, manufacturing, security, and finance all depend on the mathematical sciences. Success in meeting crucial challenges currently facing the nation in these areas will rest on advances in mathematical sciences research.

The MSII activity provides support for collaborative research projects in these and other areas of national priority that are managed by NSF programs outside of DMS and that involve mathematical scientists in the research. Mathematical scientists are encouraged to consider establishing research collaborations with researchers in other NSF-supported disciplines and to make collaborators aware of the possibility of MSII support for

the activity. Please see the MSII webpage for more information.

In addition to the MSII activity, which is focused on the involvement of mathematical sciences researchers in projects managed by non-DMS programs, DMS manages some special programs that support research in the mathematical sciences with direct applicability to other important areas of emphasis. The newest of these are DMREF and CDS&E-MSS. Following is a brief description of these two programs.

Designing Materials to Revolutionize and Engineer Our Future (DMREF)

DMREF is the primary program through which the NSF participates in the national Materials Genome Initiative (MGI) for Global Competitiveness. MGI recognizes the importance of materials science to the well-being and advancement of society and aims to "deploy advanced materials at least twice as fast as possible today, at a fraction of the cost."

DMREF seeks to promote activities that significantly accelerate materials discovery and development by building the fundamental knowledge base needed to progress towards designing and making materials with specific and desired functions or properties from first principles. Also of interest is research that seeks to advance fundamental understanding of materials across length and time scales to elucidate the effects of microstructure, surfaces, and coatings on the properties and performance of materials and devices.

Controlling material properties through design requires understanding the interrelationships of composition, processing, structure, properties, performance, and process control. The approach envisioned in DMREF to achieve this goal involves modeling, analysis, and computational simulations, validated and verified through measurement, experimentation, or device demonstration. DMREF aims to support collaborative and iterative research wherein theory guides computational simulation, computational simulation guides experiments, and experiments further guide theory.

This requires efforts spanning topics in materials science, chemistry, mathematics, statistics, computer science, and engineering to develop new data analytic tools and statistical algorithms; advanced simulations of material properties; advances in predictive modeling that leverage machine learning, data mining, and sparse approximation; and software and data infrastructure that is accessible, extensible, reliable, interoperable, and reusable. The mathematical sciences community has a valuable role to play and much to contribute in these efforts. Please see the recent DMREF program solicitation for additional details. Readers also may be interested in a special NSF-SIAM Minisymposium associated with DMREF to be held in connection with the SIAM conference on Computational Science and Engineering in Salt Lake City in March 2015.

Computational & Data-Enabled Science & Engineering in Mathematical and Statistical Sciences (CDS&E-MSS)

The CDS&E-MSS program supports research confronting the host of mathematical and statistical challenges presented to the scientific and engineering communities by the ever-expanding role of computational modeling and simulation on the one hand, and the explosion in production of digital and observational data on the other. The goal of the program is to promote the creation and development of the next generation of mathematical and statistical theories and methodologies that will be essential for addressing such issues. To this end, the program supports fundamental research in mathematics and statistics whose primary emphasis is on meeting these computational and data-related challenges.

The CDS&E-MSS program has been run for three years. The awards cover a wide range of topics, including stochastic partial differential equations, Lie groups and representation theory, manifold learning, sparse optimization, data assimilation, partially-observed Markov processes, and high-dimensional learning. Many emerging methodologies have been proposed, for example, efficient parallel iterative Monte Carlo methods, accelerated Monte Carlo schemes, solving large-scale eigenvalue problems, and measurement model specification search. Some projects deal with newly emerged datasets, for example, algebraic, geometric, and computational tools for data cloud and data array, LiDAR point cloud data, and data with network structure. A wide range of applications areas can be found in the awards, including tumor microenvironment, genetic association, brain connectivity, coastal ocean modeling, and subsurface imaging. The online award abstracts include information about the broad spectrum of research projects supported by the program.

CDS&E-MSS is a part of the NSF-wide CDS&E program. There are differences: if the proposed work emphasizes mathematical or statistical foundations, CDS&E-MSS may be a fit. If the proposed work is more driven by particular scientific and/or engineering applications, the NSF-wide CDS&E program may be more suitable. Readers should note that the NSF-wide CDS&E program has varying proposal due dates, depending on the NSF Division to which a proposal is submitted; the next submission window for CDS&E-MSS will be November 25–December 9, 2014. Investigators are encouraged to contact the cognizant program directors prior to proposal preparation.

The primary mission of DMS is the support of research in the mathematical sciences, much of which includes the participation of students

and postdoctoral associates, who receive training through their involvement in these research projects. In addition, the Division also supports other activities by the community to enhance the training of the next generation of U.S. mathematical sciences researchers. Much of this additional support is provided through the DMS Workforce program activity, which comprises four programs centered on training through research involvement: Research Experiences for Undergraduates (REU) Sites, Enriched Doctoral Training in the Mathematical Sciences (EDT), Mathematical Sciences Postdoctoral Research Fellowships (MSPRF), and Research Training Groups in the Mathematical Sciences (RTG). The REU Sites and MSPRF programs are longstanding activities that we shall not discuss further here. However, we wish to take this opportunity to describe a new program (EDT), and to briefly summarize updates to a long running program (RTG).

Enriched Doctoral Training in the Mathematical Sciences (EDT)

The EDT program supports efforts to enrich research training in the mathematical sciences at the doctoral level by preparing Ph.D. students to recognize and find solutions to mathematical challenges arising in other fields and in areas outside today's academic setting. Graduate research training activities supported by EDT will prepare participants for a broader range of mathematical opportunities and career paths than has been traditional in U.S. mathematics doctoral training.

The long-range goal of the EDT program is to strengthen the nation's scientific competitiveness by increasing the number of well-prepared U.S. citizens, nationals, and permanent residents who pursue careers in the mathematical sciences and in other professions in which expertise in the mathematical sciences plays an increasingly important role. The program supports efforts by academic institutions or other qualified organizations to train mathematical sciences doctoral students so that they will be well-equipped to recognize opportunities for the development of mathematics and statistics in problems from other disciplines, and will be able to effectively apply advanced mathematics and statistics to solve problems originating outside the traditional academic mathematical sciences setting. The program will support projects that include training in areas supplementary to the dissertation research theme and that are instrumental for connections with business, industry, government, and the nonprofit sector, such as, for example, internships, research projects, consulting, and participation in complementary courses or summer schools. Projects are expected to train students to work in teams to refine, attack, and solve problems that are open-ended, not initially sharply formulated, and originate outside the academic mathematical realm.

DMS intends that the collection of projects funded will benefit students whose dissertation topics lie in all sub-fields of the mathematical sciences, and we are hopeful that a wide spectrum of departments will submit proposals for this program. The intent is, funding permitting, to have fifteen or more EDT projects running by the third year of the program.

Research Training Groups in the Mathematical Sciences (RTG)

The REU Sites, EDT, and MSPRF programs support enhanced training through research involvement at the undergraduate, doctoral, and postdoctoral levels, respectively. In contrast, the Research Training Groups (RTG) program spans all these levels of trainee seniority. The RTG program supports efforts to improve research training by involving undergraduate students, graduate students, postdoctoral associates, and faculty members in structured research groups centered on a common research theme. Research groups supported by the RTG program must include vertically-integrated activities that span the entire spectrum of educational levels from undergraduates through postdoctoral associates.

The potential of such vertically-integrated activities to enhance engagement, accelerate progress, and improve recruitment and retention in the discipline has been indicated by several reviews, as described in the RTG program solicitation. These observations reveal that well-implemented vertically-integrated research groups can generate enormous enthusiasm, high motivation, and accelerated research progress among participants at all levels.

The RTG program aims to further the adoption of this research group model in mathematical sciences programs that conduct training spanning the entire spectrum of educational levels from undergraduates through postdoctoral associates. The new RTG solicitation (re)emphasizes the essential importance of vertical integration and strong training plans in successful RTG proposals.

We wish to finish this brief review of some of the recent developments in the DMS portfolio by encouraging the mathematical sciences community to continue to submit strong proposals to the DMS Disciplinary Research Programs and also to take advantage, when appropriate, of the additional opportunities outlined here. More information about all of these opportunities is available through the program pages and program solicitations accessible via the DMS home page `www.nsf.gov/DMS`. As always, questions can be addressed to the program directors listed on the program pages for the various funding opportunities.