Renewable Energies for a Global Economy

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NH EPSCoR History

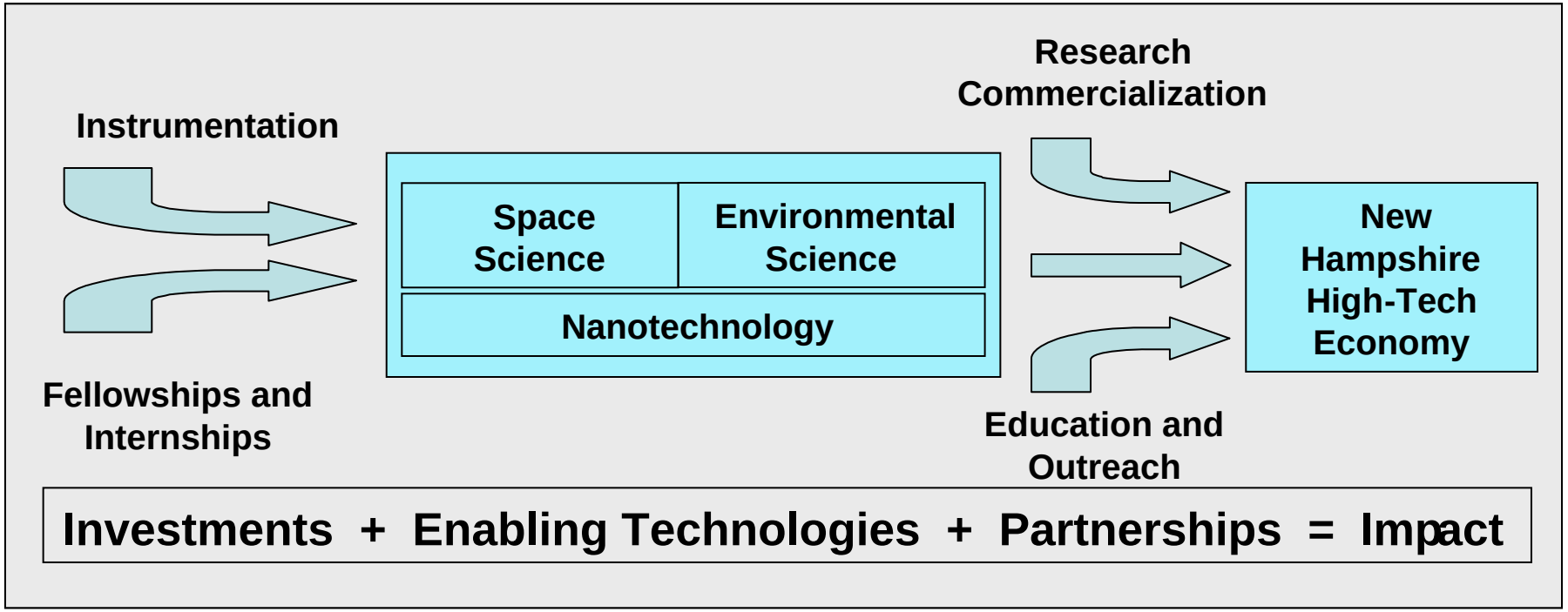
Statewide planning meeting	Dec. 2003
NSF planning grant awarded	Aug. 2004
Statewide committee formed	Sept. 2004
Two DEPSCoR grants awarded	April 2005
One DEPSCoR grant awarded	April 2006
One DOE grant awarded	March 2007
NSF Research Infrastructure Improvement (RII) grant awarded	June 2007

UNIVERSITY *of* NEW HAMPSHIRE

New Hampshire EPSCoR RII Vision and Strategy:

Enabling Technologies
for Scientific Innovation
through Sensor Development

New Hampshire EPSCoR RII



New Hampshire EPSCoR RII

There are clear synergies among these three interdisciplinary science fields.

- The space science team looks to new developments in nano-scale sensors to reduce costs and enhance reliability in the space environment.

- The nanotechnology team includes environmental scientists who will take newly developed sensors and test them under challenging field conditions for long-term monitoring applications.

- The large-scale experimental turbulence system will provide a proving ground for new sensors for atmospheric and aquatic environments, as well as a unique environment for studying turbulence itself.

Cluster for Integrated Computation and Analysis of Reconnection and Turbulence (CICART)

Amitava Bhattacharjee, Ph.D.

Paul Professor of Space Science

Institute for the Study of Earth, Oceans, and Space

and the Department of Physics

University of New Hampshire

CICART: A DOE/EPSCoR CLUSTER

- State of New Hampshire (NH) EPSCoR committee chose CICART as the sole proposal to be submitted from NH (July, 2006).
- Relevance to NH EPSCoR Research Themes:
  - Space Science Technologies
  - Information Technologies/Data Processing
- Enabling Technology Clusters:
  - Computational Tools/Geospatial Analysis
  - Environmental Technologies
- DOE Program Connections
  - Office of Fusion Energy Sciences (OFES) (S. Eckstrand, and J. Mandrekas)
  - Mathematical, Information, and Computational Sciences (MICS) (A. Deane)

CICART

***University of New Hampshire*:**

Project Director: A. Bhattacharjee
Co-Directors: B. Chandran, K. Germaschewski, P. Isenberg, J. Klewicki, C. S. Ng, and B. Vasquez

***Dartmouth College*:**

Institutional Project Director: B. Rogers

Collaboration with DOE laboratories (Princeton and Los Alamos) and other Universities under the auspices of Center for Magnetic Self-Organization (NSF Physics Frontier Center) and Center for Multiscale Plasma Dynamics (DOE), where UNH and Dartmouth are partner institutions.

CICART:

Interdisciplinary group drawn from:

applied mathematics
astrophysics
computational physics
fluid dynamics
fusion
plasma physics
and
space science communities.

It will consolidate OFES and MICS research
in one cluster for the first time in New Hampshire.

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GUIDING PRINCIPLES

CICART has a dual mission: we seek fundamental advances in physical understanding, *and* propose to achieve these advances by means of innovations in computer simulation methods and analytical models.

CICART premise: fundamental aspects of magnetic reconnection and turbulence in fusion devices, smaller-scale laboratory experiments, and space and astrophysical plasmas can be viewed from a common perspective, and that progress in understanding in any of these interconnected fields is likely to lead to progress in others. *Example*: Near-explosive energy release during reconnection events in fusion plasmas, magnetospheric storms, and solar flares.

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DoE/EPSCoR CRITERIA

Enhance energy-related research on computer simulations and analysis of reconnection and turbulence in magnetized plasmas, with strong applications to fusion energy science, by consolidating and building on existing strength at UNH and Dartmouth, and thereby position NH to be competitive as a leading state in these areas.

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DoE/EPSCoR CRITERIA, *continued*

Foster collaborative research among two NH institutions (UNH and Dartmouth), other major academic institutions, and two DOE laboratories (Princeton Plasma Physics Laboratory and Los Alamos National Laboratory) under the auspices of two recognized Centers supported by DOE and NSF [the Center for Magnetic Self-Organization in Laboratory and Astrophysical Plasmas and the Center for Multiscale Plasma Dynamics].

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DoE/EPSCoR CRITERIA, *continued*

Develop innovative interdisciplinary approaches on problems of longstanding importance by providing avenues of knowledge transfer between fusion physics and space and astrophysical plasma physics and fluid mechanics.

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IMPROVEMENT IN ACADEMIC RESEARCH INFRASTRUCTURE AND INSTITUTIONAL SUPPORT

New Program in Applied Mathematics and Computational Sciences at UNH

- UNH has committed to establish a new program in Integrated Applied Mathematics in the College of Engineering and Physical Sciences at UNH. This includes the two new faculty members plus UNH will cost-share and support a third faculty position with appointment in Physics and affiliated with the IAM program.
- CICART will support graduate students and train postdoctoral fellows in basic plasma science (relevant to fusion and space) and computational physics. UNH and Dartmouth will share graduate students who will be jointly supervised by UNH and Dartmouth faculty.

Matching Funds

- Dartmouth College and UNH will provide 50% of the DOE contribution in matching funds. (Total DOE budget $1.7M for three years, plus matching funds 50%)

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RESEARCH FOCI

Three fundamental topics pertaining to reconnection and turbulence

- **Impulsive reconnection: scaling and stabilization** (sawtooth trigger in tokamaks, impulsive growth phase in magnetotail substorms, impulsive solar and stellar eruptions)
- **Long-time gyrokinetic island dynamics** (kinetic effects on reconnection and island formation, energization of ions and electrons)
- **Anisotropic energy cascade in low-beta plasmas** (Turbulence produced in burning plasmas by multiple Alfven modes driven by alpha particles, ion heating by coupling of Alfven and fast waves in the solar wind and burning plasmas)

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HIGH-PERFORMANCE COMPUTING TOOLS

High-Performance Computing Tools

- **Magnetic Reconnection Code** (MRC), based on extended two-fluid (or Hall MHD) equations, in a parallel AMR framework (such as PETSc), with options for explicit and implicit time-stepping, the latter based on Newton-Krylov methods.
- **Explicit Particle-in-Cell (ExPIC)**, a fully parallelized electromagnetic 3D PIC code, with explicit time-stepping and realistic mass ratios of electrons and ions.
- **GS2 : the Gyrokinetic Code,** which relies on the existence of a strong magnetic field, and in that regime has been already demonstrated to be very useful in studies of reconnection and turbulence

The first two codes will be provided by UNH, the third by Dartmouth, and present a complete suite of codes that can cover fluid as well as kinetic regimes.

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Proposed Applications

- Implusive Reconnection: Scaling and Stabilization
- Long-time, Quasi-steady Saturated Magnetic Islands
- Geometry and Dynamics of 3D-Magnetic Reconnection
- Turbulent Reconnection
- Anisotropic Energy Cascade

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MANAGEMENT PLAN

- Task leaders for Reconnection, Turbulence, and High-Performance Computing will teleconference once a month to monitor progress towards milestones.
- Meetings held at UNH and Dartmouth once every 3 months to discuss research.
- Appoint External Advisory Committee for advise and evaluation of CICART performance, including research goals and contributions to the Applied Math and Computational Sciences program.