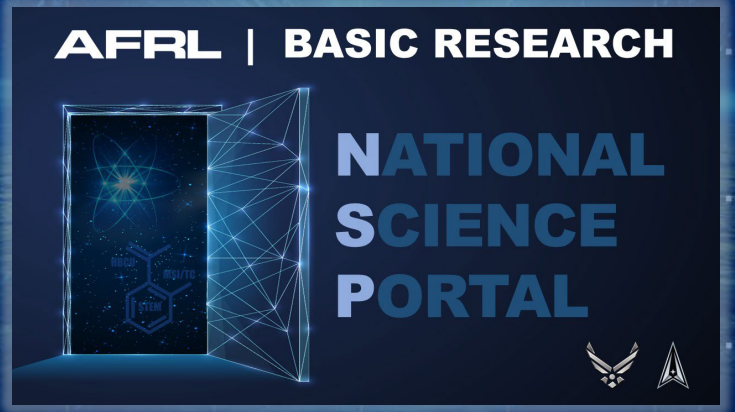
U.S. AIR FORCE

USSF

AFRL

Basic Research HBCU/MSI National Science Portals Pilot (NSPP) Funding Opportunity Announcement (FOA) Informational Webinar



AFRL/AFOSR | 19 April 2023

HBCU: Historically Black College and University
MI: Minority Institution
MSI: Minority-Serving Institution

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AFRL NSPP FOA Informational Webinar Agenda

AFRL

Start	Description / Topic	Speaker
1300	Opening Remarks and Overview of AFRL Basic Research National Science Portals Program	**Dr. Irina Pala** AFRL/AFOSR Division Chief, Science & Engineering Division
1315	Acquisitions Overview for Funding Opportunity Announcement	**Mr. Calvin Scott** AFRL/AFOSR Senior Procurement Analyst, Contracting Division
1325	Technical Topic: Directed Energy	**Dr. John Luginsland** AFRL/AFOSR Program Officer, Science & Engineering Division
1340	Break	
1350	Technical Topic: Fluid Surface Material Interaction	**Dr. Gregg Abate** AFRL/AFOSR Program Officer, Science & Engineering Division
1405	Technical Topic: Data, Models: Machine Learning for Scientific Discovery	**Dr. Fariba Fahroo and Dr. Ali Sayir** AFRL/AFOSR Program Officer, Science & Engineering Division
1425	Final Remarks	**Dr. Irina Pala** AFRL/AFOSR Division Chief, Science & Engineering Division
1435	Adjourn	

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Opening Remarks and Overview of AFRL Basic Research National Science Portals

Dr. Irina Pala
AFRL/AFOSR Division Chief (Acting), Science & Engineering Division

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AFRL/AFOSR Mission & Span of Influence

AFRL

Our Mission is to Discover, Shape, Champion, and Transition Basic Research to profoundly impacts the future Air and Space Force

Core Mission - With a broad, long term perspective, we identify areas for investment and collaboration to advance the Department of the Air Force's (DAF) research and development enterprise across the full spectrum of air, space, and cyber operations. We build bridges to the world's most prestigious universities and talented researchers to enhance partnerships and provide revolutionary science and technology discoveries to the Warfighter.

Span of Influence - 60+ World-class Subject Matter Experts manage 1,200+ grants at over 200 leading academic institutions across 50+ states/territories and 160+ countries, 100 industry-based contracts, and more than 250 internal AFRL research efforts.

Inherent in our mission, we strive to strengthen and shape the Science and Engineering talent pipeline through targeted outreach, research, internships, and fellowship programs to include a focus on Historically Black Colleges and Universities and Minority Serving Institutions. Fund DAF's K-12 STEM Outreach at 30+ bases supporting 500+ competitions!

DAF Link to Academia



Global Footprint and Reach



STEM Outreach Impact



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Science &Technology Portfolios

Engineering and Complex Systems	Information and Networks	Physical Sciences	Chemistry and Biological Sciences	International Office
Dynamic Materials and Interactions	Computational Cognition and Machine Intelligence	Aerospace Materials for Extreme Environments	Biophysics	Asian Office of Aerospace R&D Tokyo
GHz-THz Electronics	Computational Mathematics	Atomic and Molecular Physics	Human Performance and Biosystems	European Office of Aerospace R&D London
Energy, Combustion, and Non-Equilibrium Thermodynamics	Dynamical Systems and Control Theory	Electromagnetics	Mechanics of Multifunctional Materials and Microsystems	Southern Office of Aerospace R&D Santiago
Unsteady Aerodynamics and Turbulent Flows	Dynamic Data and Information Processing	Laser and Optical Physics	Molecular Dynamics and Theoretical Chemistry	North America - Arlington
High-Speed Aerodynamics	Information Assurance and Cybersecurity	Optoelectronics and Photonics	Natural Materials and Systems	
Aerospace Composite Materials	Mathematical Optimization	Plasma and Electro-Energetic Physics	Organic Materials Chemistry	
Multiscale Structural Mechanics and Prognosis	Science of Information, Computation, Learning, and Fusion	Quantum Information Sciences		
Propulsion and Power	Trust and Influence	Physics of Remote Sensing		
Agile Science of Test and Evaluation (T&E)	Complex Networks	Space Science		
	Cognitive and Computational Neuroscience	Ultrashort Pulse Laser-Matter Interactions		
		Condensed Matter Physics		



AFRL Basic Research National Science Portal (NSP) Proposal

AFRL

- Create National Science Portals (NSPs) to 1) accelerate science in research areas critical to the future DoD, and 2) capitalize on the excellence and build capacity in HBCU/MSIs to further goal #1
- Focus investment in ONLY HBCU/MSIs to address Department of Defense (DoD) scientific challenges for strategic competition
- Expect to be funded with basic research funds
  - Supplement with other programs, such as Defense University Research Instrumentation Program (DURIP) to supply equipment and build laboratories
  - Explore ways to connect NSP institutions with other DoD & Department of the Air Force (DAF) Outreach Programs for talent development
  - Explore ways to connect K-12 STEM with the NSP universities
- Pilot first NSP in FY24; explore optimal number of Portals in a given year

Addresses National Academies' Recommendations, Executive Orders and Congressional Direction

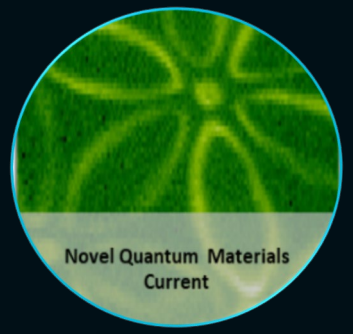
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Potential NSP Research Areas

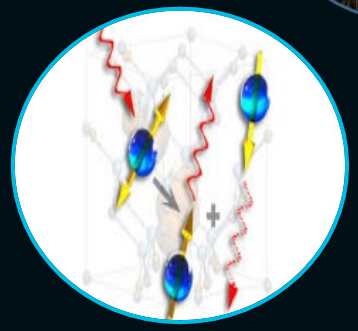
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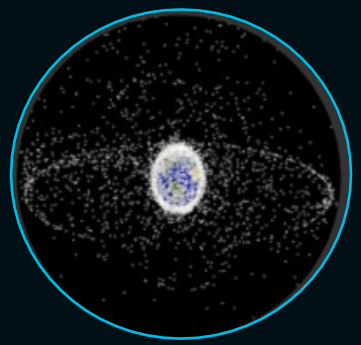


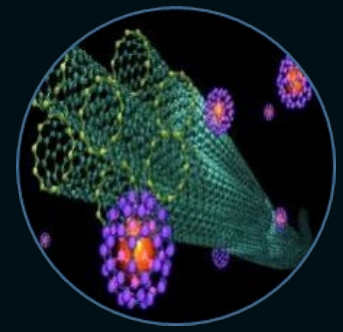












- Cislunar Space
- Non-traditional propulsion
- Synthetic Biology
- Int'l Polar/Arctic Initiative
- Data Analytics
- Autonomy for "Internet of Things" terrestrial/space
- Next Gen Software
- Digital Engineering
- Quantitative Biology
- Microelectronics

- Directed Energy
- 5G
- Biotechnology
- Hypersonics
- Fully Networked Command and Control
- Organic Electronics
- Quantum
- Artificial Intelligence
- Cyber

Match DoD Needs and HBCU/MSI Expertise using Data Analytics and Institution Input

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AFRL Basic Research National Science Portal Pilot

AFRL

- Launched AFRL NSP Pilot Funding Opportunity Announcement (FOA) in March 2023 on Grants.gov (See funding opportunity number FOA-AFRL-2023-0009)
- Funding several teams of HBCU/MSI researchers in three topic areas:
  - ***Directed Energy***
  - ***Fluid Surface Material Interaction***
  - ***Data, Models: Machine Learning for Scientific Discovery***
- **Encourages applicants to also view OSD Defense University Research Instrumentation Program (DURIP) FOA for relevant instrumentation to further build capacity**
- Expecting at least three awards of $750K - $1.5M per year per award for a maximum of three years

Bolstering MSIs will attract more students to STEM and increase U.S. minority STEM graduates FLOODING THE U.S. WITH DIVERSE STEM TALENT

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How to Work with Us

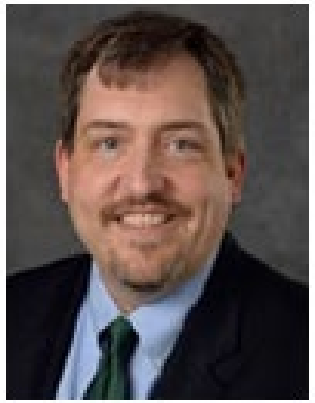
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Academia/ Interested Investigator



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National Science Portal Pilot 2023 Research Areas of Interest



Directed Energy

Dr. John Luginsland
john.luginsland@us.af.mil



Fluid Surface Material Interaction

Dr. Gregg Abate
gregg.abate@us.af.mil



Data, Models; ML for Scientific Discovery

Dr. Fariba Fahroo
fariba.fahroo@us.af.mil



Data, Models: ML for Scientific Discovery

Dr. Ali Sayir
ali.sayir.2@us.af.mil

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Acquisitions Overview for Funding Opportunity Announcement

Mr. Calvin Scott
AFRL/AFOSR Senior Procurement Analyst, Contracting Division

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FOA Important Dates

Anticipated Schedule of Events		
Event	Date	Time
Questions Regarding Eligibility and Technical Requirements	4/21/2023	
Pre-proposal inquiries or questions posted to grants.gov	4/25/2023	
White Papers Due (not required but strongly recommended)	5/1/2023	5:00 PM Eastern Time
Notifications of Initial Evaluations of White Papers	5/15/2023	
Proposals Due Date	6/12/2023	

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Budget Justification

- Proposals must include a detailed budget justification for all work to be performed containing a breakout of the proposed costs
- You should itemize labor, materials, supplies, travel, equipment (include quote), or any cost proposed
- Proposals including request to purchase equipment must include equipment quotes or vendor agreements
  - "Equipment" is nonexpendable, tangible personal property with a unit cost of $5,000 or more having a useful life of more than 1 year, unless determined otherwise by recipient's internal policy
  - Items that do not meet the "equipment" definition can be included under supplies

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Agency Point of Contacts

Topic Area	Primary POC
Topic 1: Directed Energy	DR. JOHN LUGINSLAND, AFOSR/RTB Email: john.luginsland@us.af.mil
Topic 2: Fluid Surface Material Interaction	DR. GREGG ABATE, AFOSR/RTA Email: gregg.abate@us.af.mil
Topic 3: Data, Models: Machine Learning for Scientific Discovery	DR. FARIBA FAHROO, AFOSR/RTA Email: fariba.fahroo@us.af.mil
General Inquiries and Questions	MS. DENISE M. JOHNSON Email: denise.johnson.19@us.af.mil

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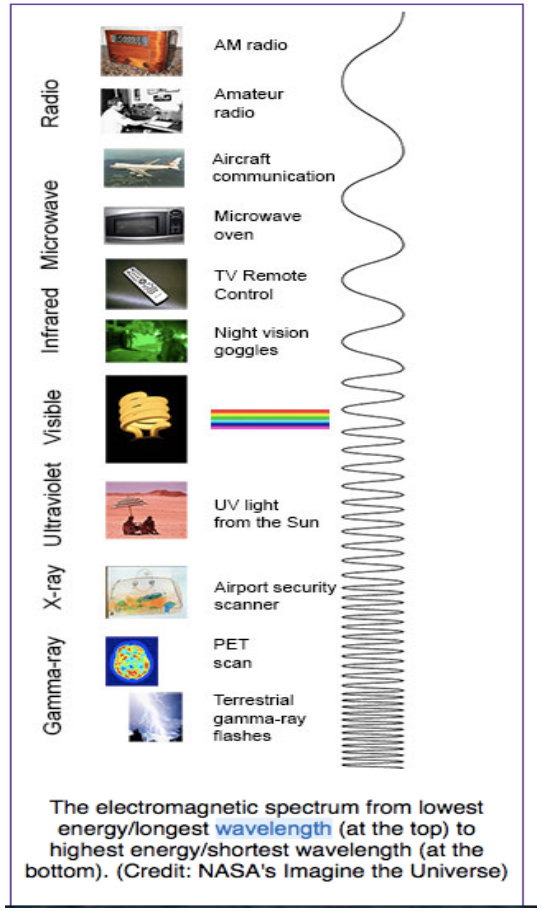
Technical Topic: Directed Energy

Dr. John Luginsland
AFRL/AFOSR Program Officer, High Energy Radiation Matter Systems

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High Energy Radiation Matter Systems (HERMES)





The electromagnetic spectrum from lowest energy/longest wavelength (at the top) to highest energy/shortest wavelength (at the bottom). (Credit: NASA's Imagine the Universe)

Bright, coherent (or incoherent light) across the whole EM spectrum

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Technical Focus Areas of HERMES

AFRL

HERMES is focused on the **controlling** the nonlinear/multi-scale/multi-physics phenomena that occurs at high energy density. This allows the **production of useful work** in the electromagnetic spectrum for a variety of missions:

- Directed Energy Attack/Counter-DE Defense
- Electronic Warfare
- Radar, LIDAR, Remote Sensing
- Communications
- Radiation Damage Simulators
- EM/Biophysics Safety



Images from Wikipedia

High-Energy/Power Lasers

- Production of coherent "short-wavelength" high power laser light with good beam quality and high efficiency
- Typically quantum physics

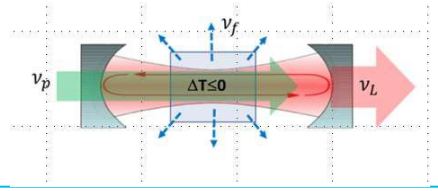


Image from Sheik-Bahea

EM-Matter Interaction

- Fundamental EM-matter interaction
- critical for high-power/energy optics and beam propagation

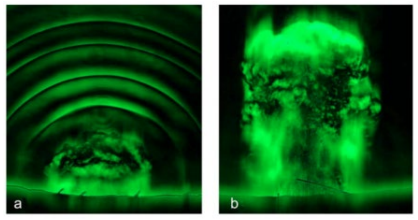
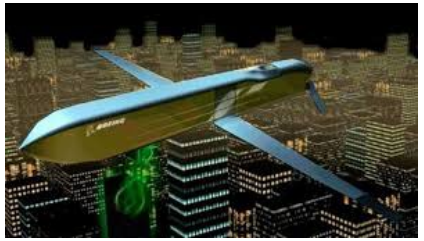


Image from Vogel

High-Power EM (HPEM)

- Production of coherent "long-wavelength" high-power electromagnetic signals
- Typically classical physics


Image from Wikipedia

Non-equilibrium Thermodynamics

- Track the flow of energy, charge, and information through a system
- Coupling of light with neutral and charged matter

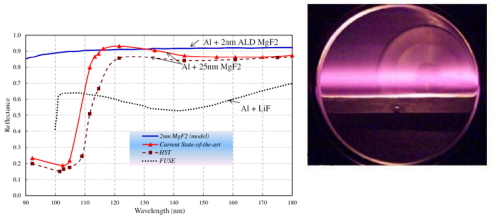


Image from Walton

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Directed Energy NSP Topic

- **Extreme Light, Heat and Sound: New Vistas in Controlling Brillouin, Raman, and Thermal Instabilities in Novel Lasing Mater**
  - **Background**
    - Our understanding of the complex interaction of light and matter has dramatically advanced in the last decade. With applications as diverse as remote sensing, manufacturing, high-precision metrology, and directed energy, the next-generation of high-power and high-energy lasers must manage the nonlinear interactions of light, sound, and heat to produce spatially and temporally coherent sources of bright light across the electromagnetic spectrum.
    - The Department of the Air Force routinely requires robust high-power and high-energy laser systems with highly consistent output to perform various missions, including long-range sensing, additive manufacturing including in-orbit systems, and long-range directed energy sources that combine range with the deep magazine of a laser system. These requirements create requirements for materials that can support both high peak and average power operations with narrow linewidth and good spatial beam quality across the range of the electromagnetic spectrum. This effort is particularly focused at extending and enhancing our understanding of nonlinear laser instabilities to new wavelengths and lasing materials.

Directed Energy NSP Topic

- **Extreme Light, Heat and Sound: New Vistas in Controlling Brillouin, Raman, and Thermal Instabilities in Novel Lasing Mater**
  - **Objective:**
    - we seek to identify both mechanisms and materials that can be used to produce high-power/energy coherent sources of electromagnetic radiation at wavelengths of interests for such uses as directed energy missions, manufacturing, and long-range remote sensing, imaging, and ranging.
    - Figures of merit such as high-power/energy output, narrow linewidth, and high beam quality can all be enhanced through mitigation and control of phenomena such as Stimulated Brillouin Scattering (SBS), Stimulated Raman Scattering (SRS), and Transverse Mode Instability (TMI).
    - Techniques that develop new advanced materials and exploit novel spatial and temporal pumping are especially encouraged under this call. It is anticipated that co-designing the material system with aspects of instability control will speed the development of new lasers for a wide variety of U.S. Air and Space Forces missions.

Directed Energy NSP Topic

- **Extreme Light, Heat and Sound: New Vistas in Controlling Brillouin, Raman, and Thermal Instabilities in Novel Lasing Mater**
  - **Research Concentration Areas (suggested, but not limited to):**
    - Novel theoretical approaches to modeling multi-scale laser-matter instabilities.
    - Modeling and engineering of novel pumping schemes for instability control
    - Identification of specific materials features that promote or inhibit instability grown (examples include intrinsic material phonon energy, scattering losses, etc)
    - Assessment of laser system design using novel materials
    - Development of novel laser-quality materials
    - Construction and laboratory demonstration of novel lasing systems
    - Verification, validation, and uncertainty quantification of novel lasing systems

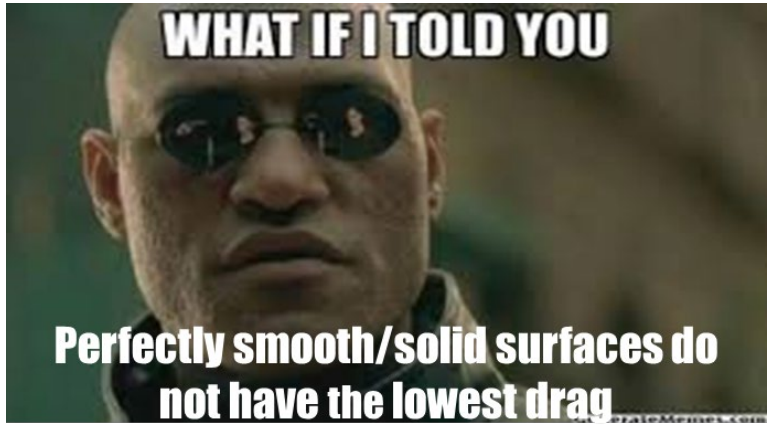
  - Stand-alone experimental, theoretical, or simulation proposal are acceptable and mixed theory, simulation, and experimental proposals are encouraged.

Technical Topic:
Fluid Surface Material Interaction

Dr. Gregg Abate
AFRL/AFOSR Program Officer, Unsteady Aerodynamics and Turbulent Flow

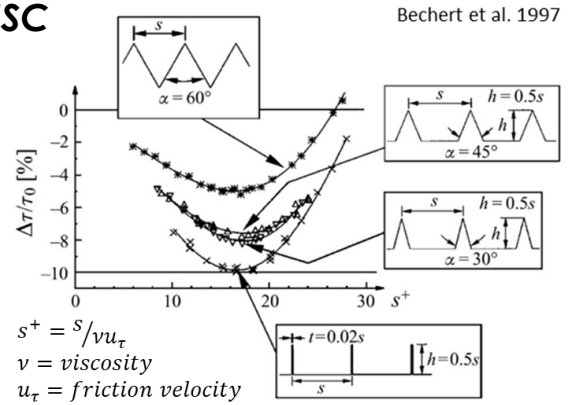
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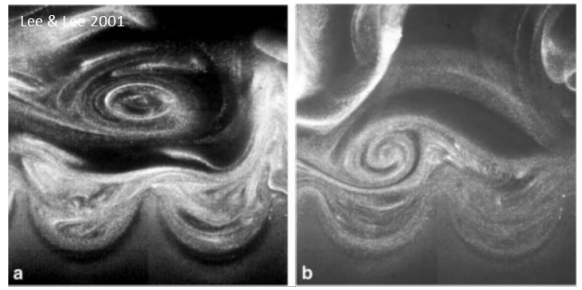
Unsteady Aerodynamics and Turbulent Flow



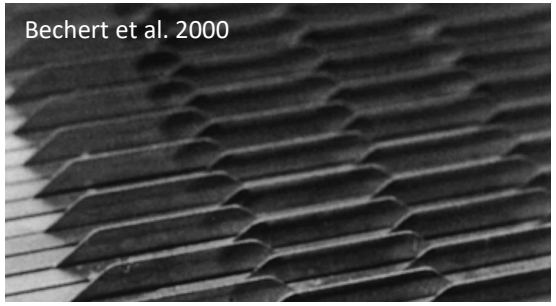
Tunable porous and patterned surfaces for turbulence control

(YIP) Luhar, USC



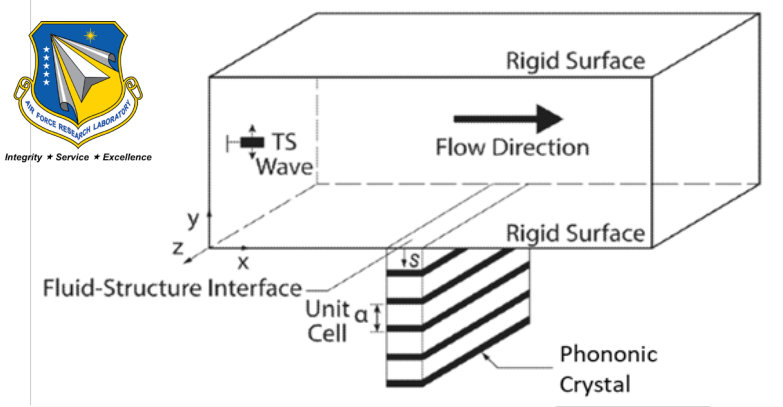


Drag decrease Drag increase



Resonant Metamaterials for Laminar Flow Control

(LRIR) Juhl (RX), Barnes (RQ), Medina (RQ)

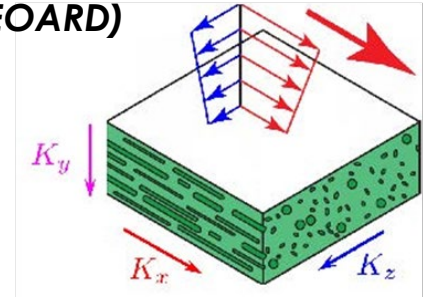


Proceeding of the Royal Society A 471: 20140928

Permeable Coatings for Turbulent Drag Reduction

Ricardo Garcia-Mayoral, Cambridge Univ.

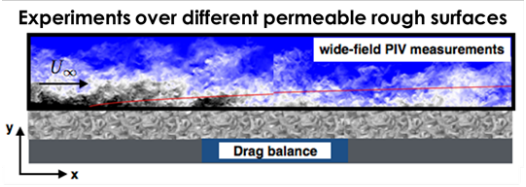
(EOARD)



1. Obtain homogenized parameters K_x, K_z, K_y for real anisotropic, fibrous layouts and validate homogenized models (pressure & shear driven).
2. Perform DNS fully-resolving fluid & coating.

Turbulent Flow Over Permeable Rough Surfaces

Bharath Ganapathisubramani, SOTON



1. Determine mean flow similarity
2. Identify relationship between permeability and roughness length
3. Examine flow mechanisms and similarities to rough surfaces

Morpheus image from meme-arsenal.com

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Background:

- Challenges remain in understanding how an engineered surface texture, or sub-surface phononic structure, can couple to the fluid dynamics and improve performance.
- There is very limited understanding in how heterogeneity in texture scale, or inhomogeneity in spatial distribution, or porosity and permeability affect the very near wall flow.
- There is only a nascent understanding for how sub-surface phononic structures can couple to turbulent flow unsteadiness
- Advances in materials and additive manufacturing technologies…now make it possible to imagine bespoke surfaces with textures and sub-structures tailored to interact with the wall flow.

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Objectives:

- To make foundational advancements in our understanding and predictive capabilities of fluid-material interfaces to enable the development of novel surface treatments, architected subsurface structures, and/or metamaterials to improve air vehicle performance over a broad range of flight conditions.
- The research should exploit advances in flow field measurement capabilities, emerging concepts in digital manufacturing, passive meta-surface/structure design, and sophisticated data-driven analysis.

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Research Concentration Areas:

1. fluid physics research focused on wall-bounded shear flows over novel surface interfaces (i.e., porosity/patterning/texturing) and architected materials.
2. materials and manufacturing research and development focused on resonant/metastable/metamaterials and their coupling to fluid interactions.
3. elucidation of the effect of scale (i.e., Reynolds number), imposed pressure gradients and surface curvature, and three-dimensionality (i.e., finite span wing) on the fluid-surface interactions over a range of flow field conditions (angle of attack, unsteadiness, etc.)
4. understanding of the effects of engineered surfaces and/or surfaces texturing on surface obstacles and features such as cavities, protuberances, corners, etc.
5. development of models and tools that will lead to engineering approaches for design.
6. understanding the complex 3D topologies spanning multiple length scales in polymers and metals.

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Technical Topic: Data, Models: Machine Learning for Scientific Discovery

Dr. Fariba Fahroo
AFRL/AFOSR Program Officer, Computational Mathematics

Dr. Ali Sayir
AFRL/AFOSR Program Officer, Materials with Extreme Properties

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Technical Focus Areas of Computational Mathematics

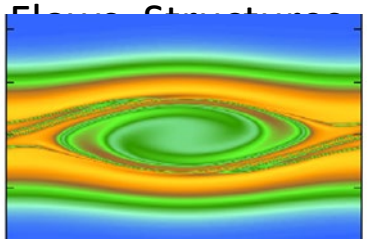
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Mission Statement: Discover and Develop Mathematical Algorithms and Computational Techniques that Provide *Accurate*, *Reliable*, and *Efficient* Algorithms for Modeling & Simulation, Design and Decision Making for Complex Systems for the DAF with radical cost and turn-time improvements.

Applications: Fluids, Structures, Plasmas, Materials, Quantum Systems, Biology, Social Systems, (and this year Space Systems)

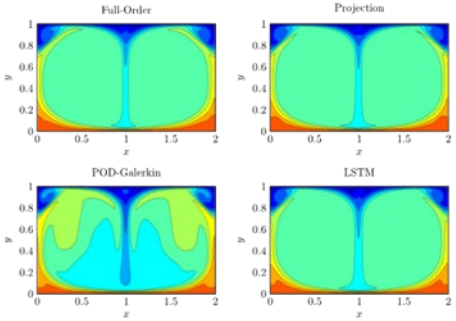
High-Order, High-Fidelity Numerical Methods

- Numerical Schemes of Order Accuracy Higher than 2 for Simulating Multiscale, Multi-Physics phenomena
- Turbulent High Speed Flows, Structures, Plasma



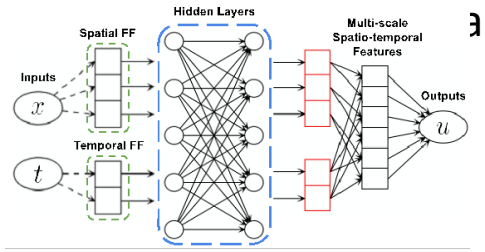
Dimensionality and Complexity Reduction

- Reduced Order Modeling for Analysis And Design
- Uncertainty Quantification – Model Error



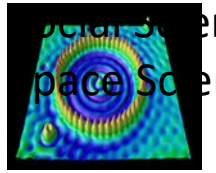
Data, Models, Learning

- Machine Learning, Deep Learning for Modeling Physical Systems
- Mean-Field Games, Optimal Transport
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Emerging Applications

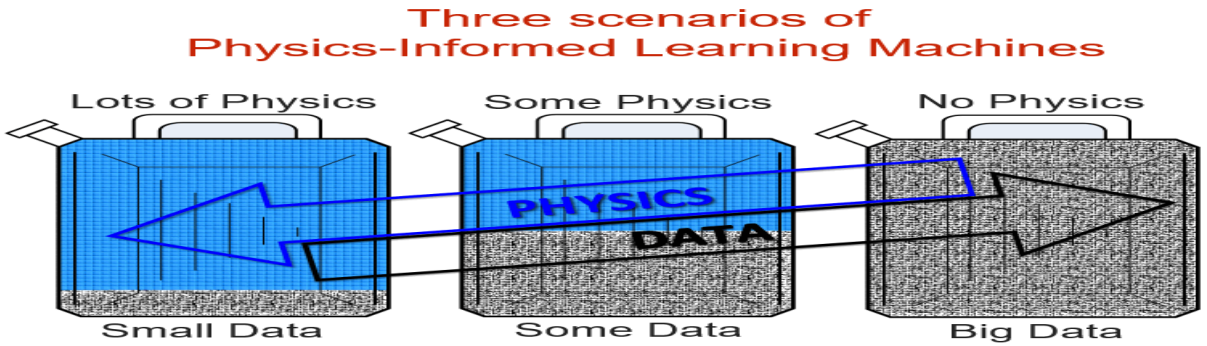
- Quantum Many-Body Systems
- Synthetic Biology
- Computational [illegible]ence
- [illegible]pace Sc[illegible]ence



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Scientific Machine Learning Topic

- **Data-Models: Machine Learning for Scientific Discovery**
- **Background:** Emergence of Scientific Machine Learning as a multidisciplinary field within the data science community --- the field brings together expertise in computational science for modeling complex physical systems with computer and data scientists to develop new methods in machine learning that merges data with physics-based models.
- **Examples:** Physics-Informed Machine Learning, (PIML), or the Physics-Informed- Neural Networks (PINNs)
- **Key Challenges:** Early success with these frameworks, but lots of challenges remain:
  - Given partial information about the physics or constraints in the model, and noisy, sparse data, how we can develop reliable and predictive models.



From an existing MURI project on PINNs

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Research Concentration Areas;

- Motivation of this topic is not to just use existing codes and ideas to new unexplored physical sciences, but to give an opportunity to the participating teams to explore and develop new mathematical and computational frameworks that could enhance existing methodologies for scalable, predictive modeling.
- **Uncertainty Quantification** to account for different sources of uncertainty (data, models, parameters), model fidelity quantification in the case of reduced order modeling, or multi- fidelity models and errors and uncertainties due to neural network computing (if NNs are used for computing).
- **Computational cost, training cost, scalability, formulation of proper computing architectures** (as in neural networks or other computing networks) should be seriously considered.
- Depending on the particular scientific field, developing and checking the efficiency and accuracy of the methods on these benchmark problems will be quite beneficial.
- Also, while the methods developed are application-aware, generalizability and applicability of the methods to other scientific and engineering fields should be explored and addressed.

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Possible Applications and the General Motivation for the topic:

- Since SciML as a hybrid (data, physics-based) predictive modeling field is multidisciplinary, this topic presents an excellent opportunity for enhancing the research capabilities within the HBCU/MIs Universities which have strong mathematics and data science departments and allows these researchers in close collaboration with science and engineering departments to fundamentally transform the engineering and science research at these institutions.
- **Possible Application Areas but not limited to :** Material Science , Environmental and Life Sciences, Chemistry, or Physics. Various engineering disciplines are also encouraged. The choice of application areas and domain scientists is dependent on the strength of the particular participating institutions.

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Final Remarks

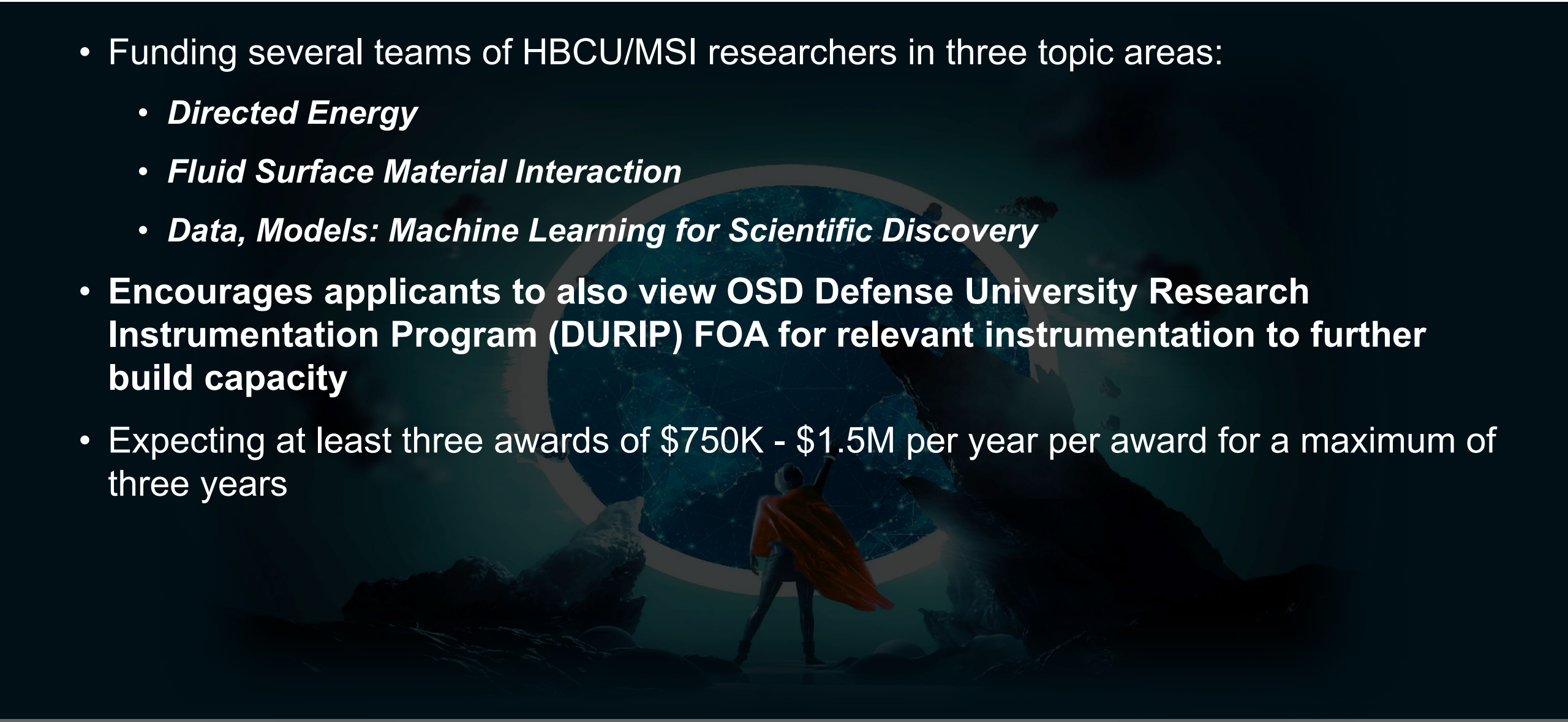
Dr. Irina Pala
AFRL/AFOSR Division Chief (Acting), Science & Engineering Division

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AFRL Basic Research National Science Portal Pilot

AFRL

- Funding several teams of HBCU/MSI researchers in three topic areas:
  - ***Directed Energy***
  - ***Fluid Surface Material Interaction***
  - ***Data, Models: Machine Learning for Scientific Discovery***
- **Encourages applicants to also view OSD Defense University Research Instrumentation Program (DURIP) FOA for relevant instrumentation to further build capacity**
- Expecting at least three awards of $750K - $1.5M per year per award for a maximum of three years



Bolstering MSIs will attract more students to STEM and increase U.S. minority STEM graduates
FLOODING THE U.S. WITH DIVERSE STEM TALENT

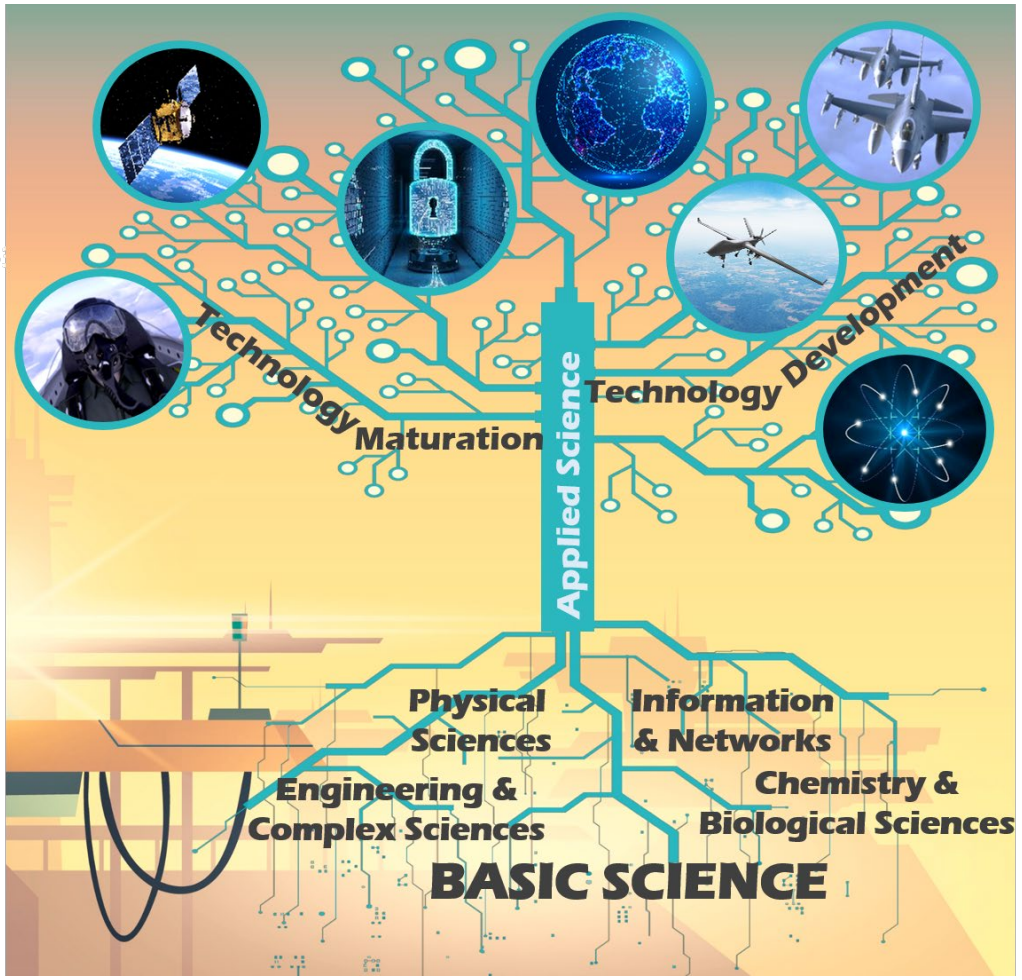
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Agency Point of Contacts

Topic Area	Primary POC
Topic 1: Directed Energy	DR. JOHN LUGINSLAND, AFOSR/RTB Email: john.luginsland@us.af.mil
Topic 2: Fluid Surface Material Interaction	DR. GREGG ABATE, AFOSR/RTA Email: gregg.abate@us.af.mil
Topic 3: Data, Models: Machine Learning for Scientific Discovery	DR. FARIBA FAHROO, AFOSR/RTA Email: fariba.fahroo@us.af.mil
General Inquiries and Questions	MS. DENISE M. JOHNSON Email: denise.johnson.19@us.af.mil

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"BASIC RESEARCH LEADS TO NEW KNOWLEDGE. IT PROVIDES THE SCIENTIFIC CAPITAL. IT CREATES THE FUND FROM WHICH THE PRACTICAL APPLICATIONS OF KNOWLEDGE MUST BE DRAWN.

NEW PRODUCTS AND NEW PROCESSES DO NOT APPEAR FULL-GROWN. THEY ARE FOUNDED ON NEW PRINCIPLES AND NEW CONCEPTIONS, WHICH IN TURN ARE PAINSTAKINGLY DEVELOPED BY RESEARCH IN THE PUREST REALMS OF SCIENCE."

— SCIENCE, THE ENDLESS FRONTIER

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THANK YOU!

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