



# Air Force Office of Scientific Research (AFOSR)

11 March 2015

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Chief, Basic Research Division (RT)  
Air Force Office of Scientific Research  
Air Force Research Laboratory

*Integrity ★ Service ★ Excellence*



# 60+ Years of Basic Research





# AFOSR Vision & Mission



- **Vision**

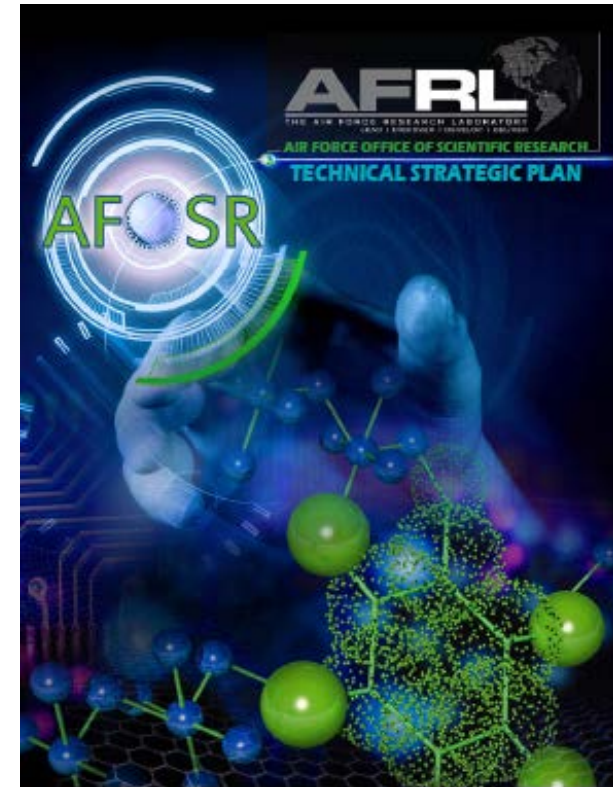
- The U.S. Air Force dominates air, space, and cyberspace because of revolutionary basic research

- **Mission**

- Discover, shape, and champion basic science that profoundly impacts the future Air Force

- **Scope**

- AF basic research program: \$390M
- AF part of the OSD University Research Initiative program - \$147M

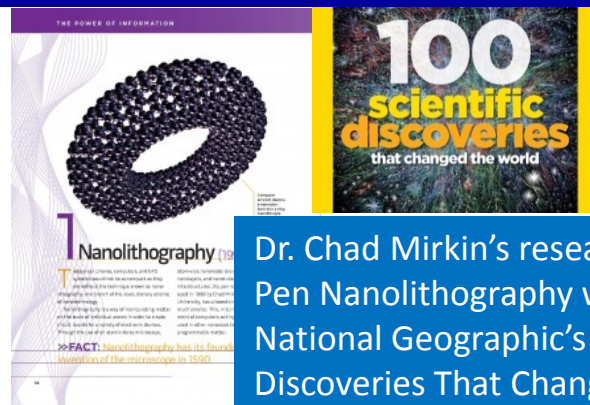




# Why does the Air Force Invest in Basic Research?



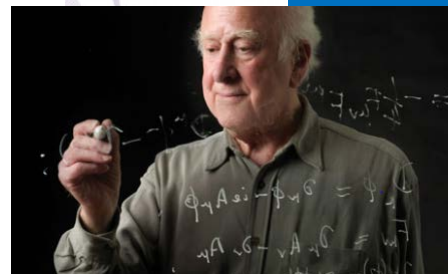
- To probe today's technology limits and ultimately lead to future technologies with DoD relevance
- Attract the most creative minds to fields of critical DoD interest
- Create a knowledgeable workforce in fields of critical DoD interest



Dr. Chad Mirkin's research on Dip Pen Nanolithography was featured in National Geographic's '100 Scientific Discoveries That Changed the World'



AFOSR Sponsored 73 Nobel Laureates



2013 Nobel Prize in Physics – Dr. Peter Higgs, Univ of Edinburgh



2012 Nobel Prize in Physics Dr. David Wineland, Univ of Colorado/NIST



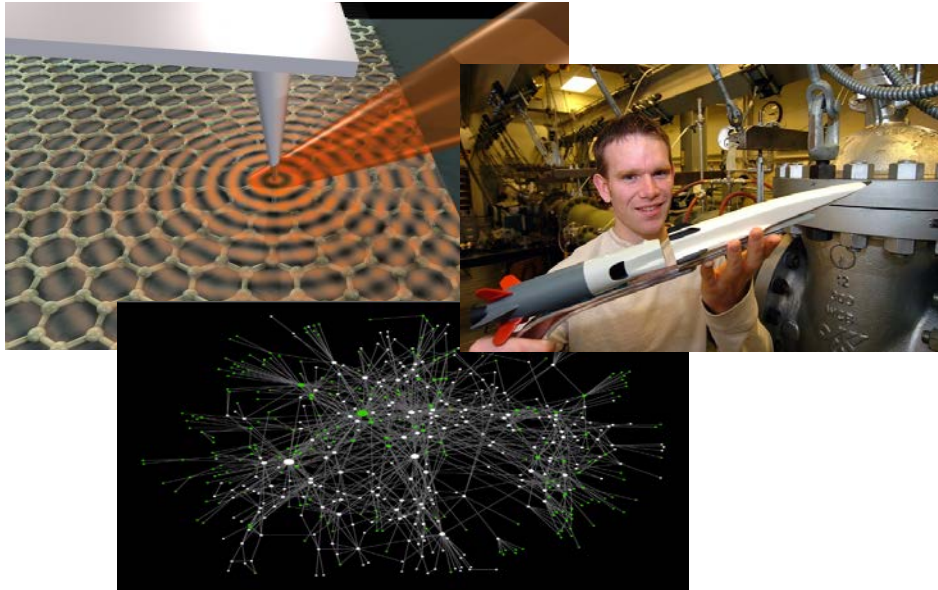
Dr. Greg Pitz & Dr. Onome Scott-Emuakpor, AFRL scientists, received 2013 PECASE awards.



# Executing Our Mission



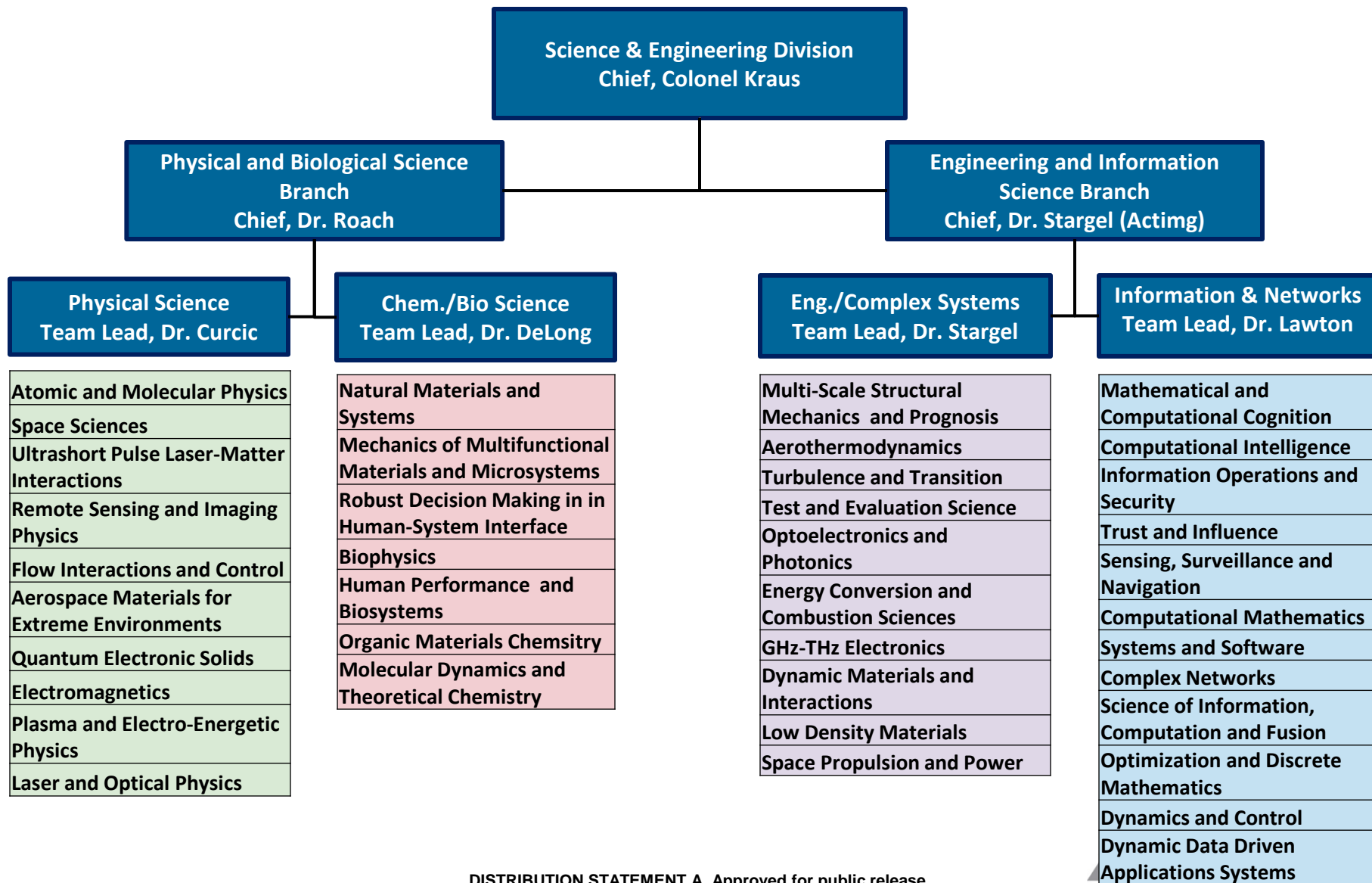
- **Intramural (AFRL) program**
  - Lab tasks
  - Academic connections
  - International opportunities



- **Extramural (university and industry) programs**
  - Grants
  - Young Investigators
  - STTR contracts

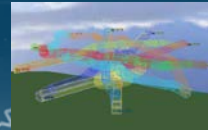


# Basic Research Division

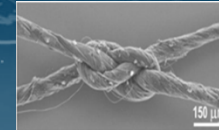




# International Outreach



Autonomous Agents for Air Traffic Control:  
Czech Technical University



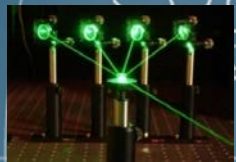
US-Korea Nano-Bio-Info Technology Program

**Arlington**

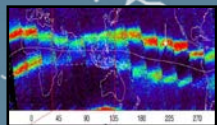
**London**

**Tokyo**

- Accelerating S&T transitions and achievements to the U.S.
- Avoiding technological surprise
- Strengthening partnerships
- Building international goodwill

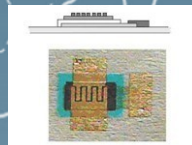


Photorefractive Polymers - Mexico

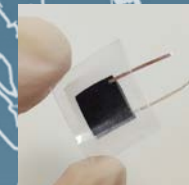


Ionospheric Prediction - Brazil

**Santiago**



Nanoparticle Solutions for Printed Electronics - S. Africa



Flexible Supercapacitor Singapore



HyShot scramjet - Australia

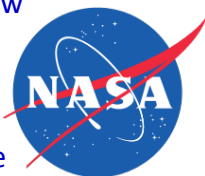
Awareness of, and access to, international basic research



# Scientific Partnerships



- Hypersonics Research
- Non-equilibrium flow
- Digital Twin
- Nanocomposites
- Living With a Star Steering Committee



- Ultracold atoms, Quantum sensor-magnetometry
- Microplasma for counter HPM
- Plasma-based logic circuits for rad-hard applications
- Photonics, High-power energy,
- Many more...



- Complex Networks OSTP/NITRD committee member

- Quantum computing, transducers project
- Info ops and security



- National Institutes of Health
- Cognition



- Nanophotonics



- Partnership for Research in Optical Technology
- Multi-agency Materials Genome Initiative



- Combustion Working Group
- Multi-Agent Sys.



- Origami Structures, aero
- Solar and heliospheric physics
- Decision Making, Social and Behavioral Science, plasma chemistry, and others



- Alternative energy Interagency
- Pulse Power Energy
- High temperature superconductors



- Nanoenergetics: co-crystallization
- Combustion Chemistry



- Many joint reviews
- Metamaterials research
- Laser propagation
- Graphene research
- Alt Navigation
- Other areas



Space Weather



Working with many industry and international teams on various research topics

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Approved for public release







# OSD University Research Initiatives



- **Multidisciplinary Univ Res Init (MURI) :**

- 5-year grants, \$500K 1<sup>st</sup> year, \$1.5M each in years 2-5

## FY15 Air Force MURI Topics

- *Exploiting Biological Electromechanics: Using Electromagnetic Energy to Control Biological Systems*
- *Large Scale Nano-Architecture Formation*
- *Membrane-Based Electronics: Foldable & Adaptable Integrated Circuits*
- *Semantics and Structures for Higher-level Quantum Programming Languages*
- *Strong Field Laser Matter Interactions at Mid-Infrared Wavelength*

- **Defense Univ Res Instrumentation Program (DURIP):**

- 1-year grants, up to \$1.5M
- Improve the capabilities of U.S. institutions of higher education to conduct research and to educate scientists and engineers in areas important to national defense by providing funds for acquisition of research equipment.



# Develop Next Generation S&Es (AFOSR STEM Programs)



- **National Defense Science and Engineering Graduate Fellowship (NDSEG)**
  - Full tuition assistance + \$31K/per year stipend
  - Fellows do not incur any service obligation
  - Supports over 550 PhD-track graduate students
- **Awards to Stimulate and Support Undergraduate Research Experience (ASSURE)**
  - Provide undergraduates with research opportunities in S&E fields of DoD interest
  - Supports over 500 undergraduate students during summer months – managed by National Science Foundation
- **Junior Science and Humanities Symposia (JSHS)**
  - Provide high school students opportunities to conduct an original research investigation in the STEM field



ASSURE site at Fort Johnson, NY



USA Science & Engineering Festival, DC



# University Centers of Excellence



- Flexibility and continuous quality assurance
- Perform excellent research in high priority Air Force interest areas
- Strengthen AFRL in-house technical capabilities by providing frequent substantive professional interchanges between AFRL and university personnel
- Educate students in vital technology areas and offer opportunities for AFRL new employee recruitment
- Jointly managed and funded by AFOSR and AFRL TDs

## Current Centers of Excellence (CoEs):

- Assured Cloud Computing (RI/Univ. of Illinois)
- High-rate Deformation Physics of Heterogeneous Materials (RW/Cal Tech)
- Integrated Computational Material Science and Engineering of Structural Materials (RX/Johns Hopkins)
- Guided Wave Infrared Sources (RY/Univ. of Wisconsin/Penn State)
- Nature-inspired Sciences (RW/Univ. of Washington)
- Advanced Bioprogrammable Nanomaterials (RX/Univ. TBD)
- Electromagnetic Interference for Extreme Electromagnetic Environments (RD/ Univ. TBD)



# Resident Researcher Programs



## National Research Council Resident Research Associate Program

- Provides Postdoctoral Scientist and Engineers to work at
  - AFRL Technical Directorates, AFIT, Air Force Academy
  - Renewable up to 3 years

## Summer Faculty Fellowship Program (SFFP)

- 8-12 weeks of research experience for up to 150 faculty members
- AFRL Technical Directorates, AFIT, Air Force Academy
- Faculty can bring graduate students (up to 80)



# HBCU/MI Program



## Historically Black Colleges and Universities / Minority Institutions

- Enhance defense-related research at covered educational institutions
- Provides grants for research and instrumentation
  - \$200,000 per year for three years (\$600,000 max)
  - \$4.5M expected to be awarded in 2015



# Young Investigator Research Program (YIP)



- Supports scientists and engineers who have received Ph.D. or equivalent degrees in the last five years and show exceptional ability and promise for conducting basic research.
  - *Foster creative basic research in science and engineering*
  - *Enhance early career development of outstanding young investigator*
  - *Increase opportunities for the young investigator to learn about AF research interests*
- **\$120K/yr x 3 years (up to 5) each**
- **FY14: 39 New YIPs**
- **FY15: 57 New YIPs (Just Announced!)**



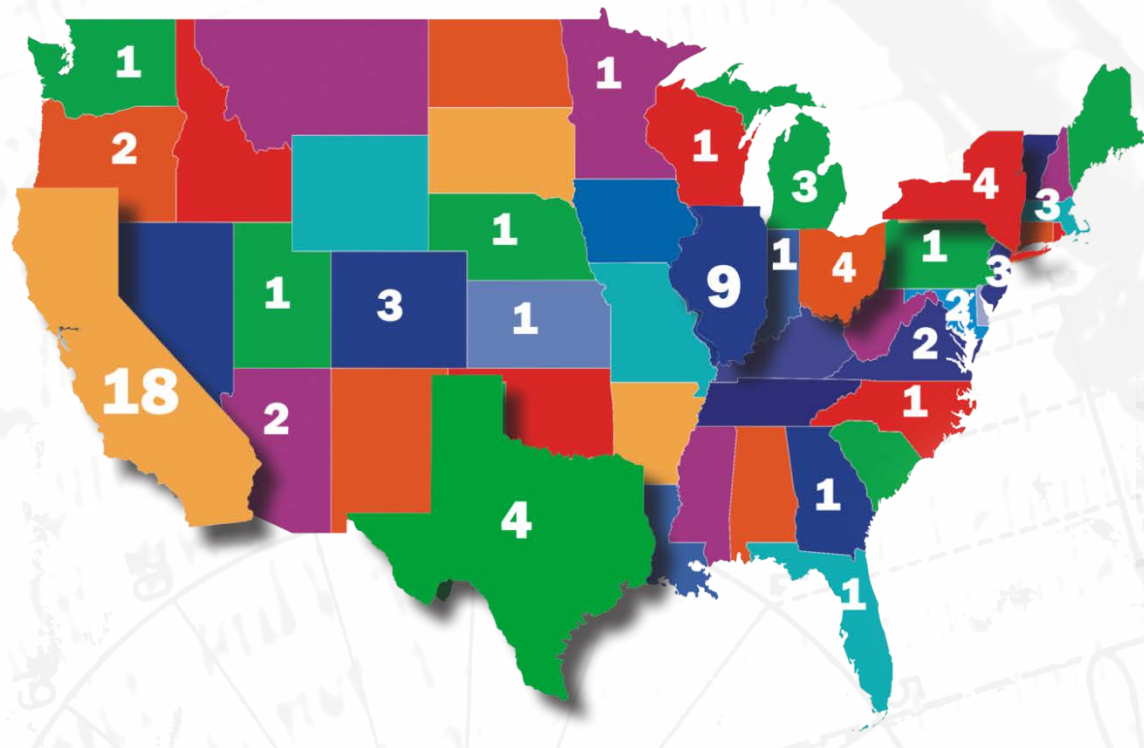
# Small Business (University-Industry) Collaborations (STTR)



- **Small Business Technology Transfer (STTR) contracts provide up to \$850,000 for early-stage R&D directly to small companies working cooperatively with U.S. research institutions**
  - Company must be U.S. for-profit small business
  - Research institution must be a U.S. college or university, FFRDC, or non-profit research institution
  - Principal investigator may be employed at small business or research institution
- **Support in FY14: 26 STTR awards**
  - \$10.3M total funds
- **More information**
  - <http://www.afsbirsttr.com/>
  - <http://www.acq.osd.mil/osbp/sbir/>



# AFOSR's Entrepreneurial Impact



AFOSR funding has resulted in or significantly contributed to the establishment of 72 cutting-edge startup companies.

- Critical innovative technologies
- 24 states with new industries & new jobs
- Future scientists trained
- Sharing in foreign technology







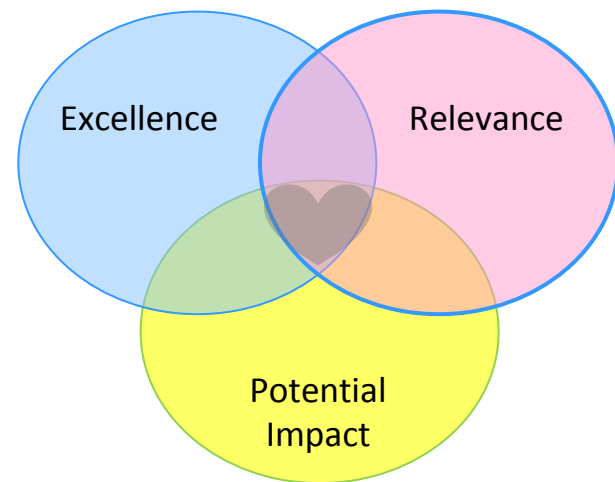
# How To Do Business With AFOSR



- **General GRANT Submission Process**
  - Researchers submit white papers to AFOSR program officers (PO)
  - Promising white papers lead to request for full proposals
  - Individual grants awarded for up to 5-years in duration
- **POs weighs several factors in selecting proposals for funding**
  - White paper process to identify overlap with program interests
  - Encourage proposals with high potential for breakthroughs
  - Peer review to gauge scientific merit
  - Programmatic issues
    - Strategic directions
    - Portfolio coverage
    - Budget realities

Broad Agency Announcement (BAA) open at all times to innovative ideas

<http://www.wpafb.af.mil/afri/afosr/>



# Social Media



AIR FORCE OFFICE OF SCIENTIFIC RESEARCH 1951 - 2011 AFRL

[www.facebook.com/afosr](http://www.facebook.com/afosr)



[www.twitter.com/afosr](http://www.twitter.com/afosr)



[www.youtube.com/TheAFOSR](http://www.youtube.com/TheAFOSR)





# AFOSR

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH



# AFOSR Supports AFRL “Game Changers”



- **Autonomy**



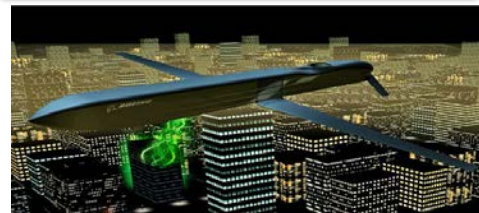
Research includes decision and control theories, and how to co-ordinate the collective management of adaptive sensors

- **Hypersonics**



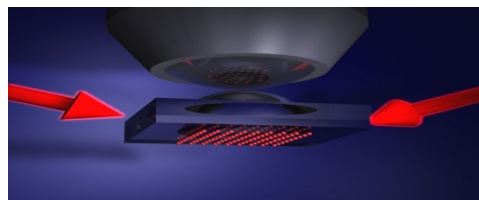
Research on characterization, modeling and interactions between unsteady aerodynamic flow field, thermal science, and structures.

- **Directed Energy**



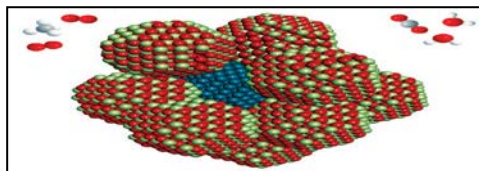
Develop relativistic plasma physics tools for high power/energy coherent electromagnetic signal generation.

- **Alternative Navigation**



Enhanced capabilities in precision navigation, cold chemistry, ultracold plasmas, metrology, and negative index materials.

- **Fuel Efficiency**



Create advanced fuel/propellants that can enable new mission capabilities or longer duration mission.

- **Big Data**



Understand relevant information from high-dimensional heterogeneous, or streaming data with quantifiable & provable performance.



# AFOSR-Supported Nobel Prize Winners



**1950's**

**1955 PHYSICS**  
Polykarp Kusch, Willis Lamb  
"precision determination of the magnetic moment of the electron and discoveries concerning the fine structure of the hydrogen spectrum"

**1956 PHYSICS**  
John Bardeen  
"co-invention of the transistor"

**1960 CHEMISTRY**  
Willard Libby  
"method to use carbon-14 for age determination in archaeology, geology, geophysics, and other branches of science"

**1961 PHYSICS**  
Robert Hofstadter  
"pioneering studies of electron scattering in atomic nuclei and for his thereby achieved discoveries concerning the structure of the nucleons"

**1963 PHYSICS**  
Eugene Wigner  
"contributions to the theory of hot atomic nucleus and the elementary particles, particularly through the discovery and application of fundamental symmetry principles"

**1964 PHYSICS**  
Charles Townes  
"fundamental work in the field of quantum electronics, which has led to the construction of oscillators and amplifiers based on the maser-laser principle"

**1966 CHEMISTRY**  
Robert Mulliken  
"fundamental work concerning chemical bonds and the electronic structure of molecules by the molecular orbital method"

**1967 MEDICINE**  
Ragnar Granit  
"discoveries concerning the primary physiological and anatomical processes in the eye"

**1969 PHYSICS**  
Murray Gell-Mann  
"contributions and discoveries concerning the classification of elementary particles and their interactions"

**1970 MEDICINE**  
Ulf von Euler  
"discoveries concerning the humoral transmitters in the nerve terminals and the mechanism for their storage, release and inactivation"

**1972 PHYSICS**  
John Bardeen, John Schrieffer  
"theory of superconductivity, usually called the BCS theory"

**1973 PHYSIOLOGY/MEDICINE**  
Nikolass Tinbergen  
"discoveries concerning organization elicitation of individual and social patterns"

**1973 PHYSICS**  
Brian Josephson  
"theoretical predictions of the supercurrent through a tunnel barrier, particular those phenomena that are known as the Josephson effects"

**1974 CHEMISTRY**  
Paul Flory  
"fundamental achievements in the physical chemistry of macromolecules"

**1976 CHEMISTRY**  
William Lipscomb  
"studies on the structure of boranes illuminating problems of chemical bonding"

**1977 PHYSICS**  
Philip Anderson, John Van Vleck  
"fundamental theoretical investigations of the electronic structure of magnetic disordered systems"

**1977 CHEMISTRY**  
Ilya Prigogine  
"contributions to the theory of chemical dynamics, particularly concerning structures"

**1978 ECONOMICS**  
Herbert A. Simon  
"for his pioneering work on the organization of decision-making process within organizations"

**1979 PHYSICS**  
Sheldon Glashow, Steven Weinberg, Abdus Salam  
"contributions to the theory of the unified weak and electromagnetic interaction between elementary particles, including, inter alia, the prediction of the weak neutral current"

**1980 CHEMISTRY**  
Walter Gilbert  
"contributions concerning the determination of base sequences in nucleic acids"

**1981 CHEMISTRY**  
Kenichi Fukui, Ryoji Noyori  
"theories concerning course of chemical reactions"

**1981 MEDICINE**  
David Hubel, Thorstein Sjöstrand  
"discoveries concerning the visual system"

**1983 PHYSICS**  
Subramanyam Chandrasekhar, William Fowler  
"theoretical studies of the physical processes important to the structure and evolution of the stars" and "theoretical and experimental studies of the nuclear reactions of importance in the formation of the chemical elements in the universe"

**1986 CHEMISTRY**  
An Lee, Dudley Herschbach, John Polanyi  
"contributions concerning the chemical element processes"

**1988 CHEMISTRY**  
Kurt Wüthrich  
"development and use of molecules with structure-specific interactions of high selectivity"

**1989 PHYSICS**  
Melvin Schwartz  
"neutrino beam method and the demonstration of the doublet structure of the leptons through the discovery of the muon neutrino"

**1990 CHEMISTRY**  
Elias Corey  
"development of the theory and methodology of organic synthesis"

**1990 PHYSICS**  
Jerome Friedman, Henry Kendall  
"pioneering investigations concerning deep inelastic scattering of electrons on protons and bound neutrons"

**1991 PHYSICS**  
Nicolas Bloembergen, Arthur Schawlow, Kai Siegfried  
"contributions to the development of laser spectroscopy"

**1996 CHEMISTRY**  
Richard E. Smalley  
"shared award for the discovery of fullerenes"

**1997 PHYSICS**  
Steven Chu  
"development of method to cool and trap atoms with laser light"

**1998 PHYSICS**  
Daniel Tsui  
"discovery of a new form of quantum fluid fractionally charged excitations"

**1999 CHEMISTRY**  
Ahmed Zewail  
"studies of the transition of chemical reactions using femtosecond spectroscopy"

**2000 CHEMISTRY**  
Alan Heeger, Alan G. MacDiarmid  
"discovery and development of conductive polymers"

**2000 PHYSICS**  
Herbert Kroemer  
"developing semiconductor heterostructures used in high-speed and optoelectronics"

**2000 MEDICINE**  
Eric R. Kandel, Paul Greengard  
"signal transduction in the nervous system"

**2000 PHYSICS**  
Jack Kilby  
"invention of the integrated circuit"

**2001 PHYSICS**  
Wolfgang Ketterle  
"jointly for the achievement of Bose-Einstein condensation in dilute gases of alkali atoms, and for early fundamental studies of the properties of the condensates"

**2002 ECONOMICS**  
Daniel Kahneman, Amos Tversky  
"for their pioneering work on psychological research into decision-making, particularly concerning human judgment and uncertainty"

**2005 PHYSICS**  
John Hall, Roy Glauber, Theodor W. Hansch  
"contribution to the quantum theory of optical coherence and jointly for development of laser precision spectroscopy"

**2005 CHEMISTRY**  
Robert Bergbreiter  
"development of the method in organic synthesis"

**2005 PHYSICS**  
Thomas Schelling  
"for his pioneering work on understanding of conflict and cooperation"

**2006 MEDICINE**  
George Palade  
"discoveries concerning the structure and anisotropy of the collagen"

**2008 PHYSICS**  
Yoichiro Nambu  
"discovery of the mechanism of spontaneous broken symmetry in subatomic physics"

**2010's**

**2010 PHYSICS**  
Andre Geim, Konstantin Novoselov  
"groundbreaking experiments regarding the two-dimensional material graphene"

**2011 CHEMISTRY**  
Daniel Schechtman  
"discovery of quasicrystals"

**2012 PHYSICS**  
David Wineland  
"for ground-breaking experimental methods that enable measuring and manipulation of individual quantum systems"

AFOSR provided sole seminal/initial funding

