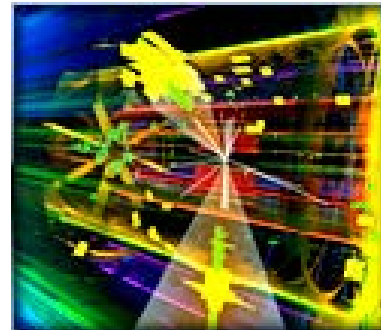
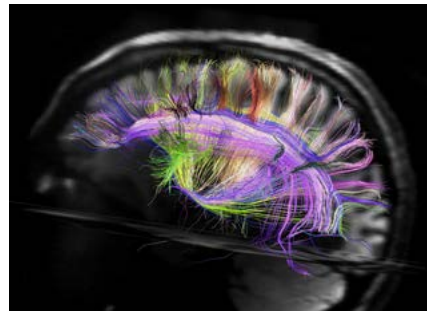
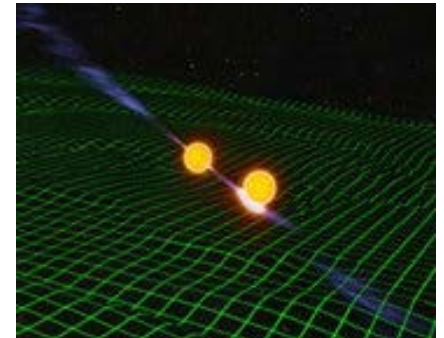




NSF Mathematical and Physical Sciences Division of Physics



Denise Caldwell
Division Director





Supports Experiment and Theory in Six Major Sub-Areas of Physics

Gravitational Physics (Includes LIGO Research Support)

Atomic, Molecular, and Optical Physics; Quantum
Information Science and Revolutionary Computing

Nuclear Physics

Particle Physics (Elementary Particle Physics and
Particle Astrophysics)

Physics of Living Systems

Plasma Physics

Plus Cross-Cutting Programs in Accelerator Science, Computational
Physics, Other Integrative Activities (REU, Outreach, BP)

(Note that Condensed Matter Physics is **NOT** included – Housed in DMR)



PHY Funding Modalities

Individual Investigator Awards – Direct Research Support

Infrastructure Awards – Tools Needed for Research

Centers and Institutes – Large Groups of Investigators with Topic Focus

Individual Investigator Awards

Individuals or Small Groups (3-5 PI's) – The Major Component of PHY Funding (ca. 55%)

Awards to Universities to Support Faculty-Directed Research Projects

Awards selected based on peer review of submitted proposals

Infrastructure Awards (Facilities)

IceCube (Neutrino Detector at South Pole, funded jointly with Polar Programs in GEO)

Large Hadron Collider (Support for ATLAS and CMS M&O, funded jointly with DOE/HEP)

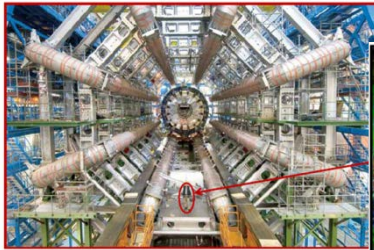
Laser Interferometer Gravitational Wave Observatory (LIGO)

National Superconducting Cyclotron Laboratory (Nuclear Physics Laboratory at Michigan State)

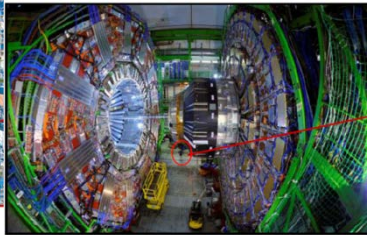


Facilities in Physics Division

Laser Interferometer Gravitational
Wave Observatory (LIGO)



ATLAS



CMS

Typical
Scientist

ATLAS and CMS Detectors at
Large Hadron Collider (LHC)

National Superconducting
Cyclotron Laboratory (NSCL)



IceCube





PHY Funding Modalities (cont'd)

Centers and Institutes (Physics Frontiers Centers)

Kavli Institute for Cosmological Physics – U Chicago

Center for Ultracold Atoms – MIT/Harvard

PFC@JILA – UC Boulder

Kavli Institute for Theoretical Physics – UCSB

Center for Theoretical Biological Physics – Rice

Joint Institute for Nuclear Astrophysics – Michigan State

PFC@Joint Quantum Institute – U Maryland

Center for the Physics of Living Cells – UIUC

Institute for Quantum Information and Matter – CalTech

North America Nanohertz Observatory for Gravitational Waves – UW Milwaukee

Center for the Physics of Biological Function – CUNY/Princeton

Centers and Institutes (Science and Technology Center)

Center for Bright Beams – Cornell



Physics Division Portfolio

The portfolio of awards made through the Physics Division has as primary goal “to promote the progress of science”, as expressed in the NSF act. Awards in the portfolio support the research needed to address a scientific question that is at the frontier of knowledge as it is currently known, while at the same time extending and redefining that frontier. Inherent in the implementation of this portfolio, which includes significant support for students and junior scientists, is the preparation of the next generation of the advanced high tech workforce and the development of innovative new technologies that arise in the quest to answer some of the hardest questions that Nature can pose.

Implementation:

Begin with new ideas generated by the physics community
Inform the process through workshops, input from advisory committees,
proposal reviews, and the scientific expertise of the Program Directors



Pushing the Frontiers of Physics

Major Scientific Drivers

Controlling the Quantum World— Electromagnetic radiation in the non-classical limit, Entanglement, Cavity QED, QIS, Optomechanics

Complex Systems and Collective Behavior — Living cells, biological systems, ultracold fermions and bosons, quark-gluon liquid, plasmas

Neutrinos and Beyond the Higgs — Neutrino mass, new particles, unification of quantum mechanics and gravity, electron and neutron dipole moments

Origin and Structure of the Universe — Star formation and creation of the elements, dark matter and dark energy, modeling of black holes, gravitational waves

Strongly-Interacting Systems— QCD computations, quark structure of baryons, high-field laser-matter interactions, supernovae, strong gravity



Questions Cut Across Disciplinary Programs

Controlling the Quantum World: Optical Physics; Quantum Information Science; Gravitational Physics

Complex Systems and Collective Behavior: Physics of Living Systems; Atomic and Molecular Dynamics; Nuclear Physics

Neutrinos and Beyond the Higgs: Particle Astrophysics; Gravitational Physics; Nuclear Physics; Precision Measurements; Elementary Particle Physics

Origin and Structure of the Universe: Gravitational Physics; Nuclear Physics; Particle Astrophysics

Strongly-Interacting Systems: Nuclear Physics; Gravitational Physics; Plasma Physics



Major Thrust – Fostering Connections

Focus on Science Question, not Discipline or Subarea

Partner with Others whenever Possible to Promote Science

Partnering within Division – AMO-Nuclear, AMO-Particle, AMO-Gravity

Partnering with other NSF divisions on individual awards and centers –
MPS/AST,CHE,DMR,DMS; BIO/MCB,IOS,DBI; GEO/PLR,AGS;
ENG/ECCS,CBET; CISE/CCF,OAC

Participation in NSF priority areas jointly with other Directorates/Divisions -
e.g. Understanding the Brain, CIF21, CDS&E

Partnering with DOE in Particle Physics, Nuclear Physics, Plasma Physics

Partnering with NASA in Gravitational Physics and Plasma Physics

Partnering with SU2C in PoLS and Gordon & Betty Moore Foundation in Gravity



International Activities in Division of Physics

Major Large Scale Efforts

CERN – Joint with US DoE in US Support of ATLAS and CMS
Funding for Nuclear Physics Experiments on ALICE
Sole US Support for Research on LHCb
Support for ATRAP Antihydrogen Experiment

Laboratori Nazionali del Gran Sasso (LNGS) –
XENON-1T, DarkSide-50, SABRE, BOREXINO, CUORE

LIGO - VIRGO and LIGO Scientific Collaboration

International Involvement at Other Major Facilities – IceCube, NSCL

Interactions at Individual Investigator Level

**NSF 14-099 Dear Colleague Letter - International Activities within the Physics Division –
Potential International Co-Review**

Gravitational Physics - Lead-Agency Agreement with DFG in Germany



Looking Ahead: Ten Big Ideas



**Navigating the
New Arctic**

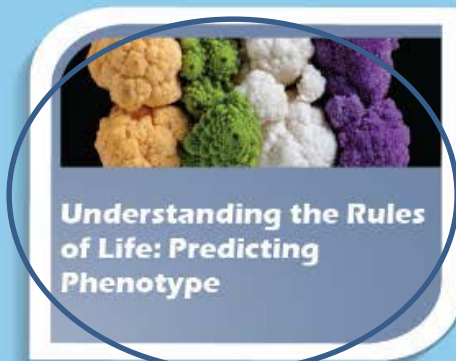


**Harnessing Data for 21st
Century Science and
Engineering**



**Work at the Human-
Technology Frontier:
Shaping the Future**

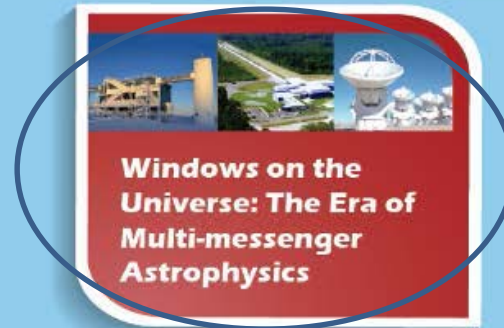
RESEARCH IDEAS



**Understanding the Rules
of Life: Predicting
Phenotype**



**The Quantum
Leap: Leading
the Next
Quantum
Revolution**



**Windows on the
Universe: The Era of
Multi-messenger
Astrophysics**

PROCESS IDEAS



**Growing Convergent
Research at NSF**



**NSF-Includes: Enhancing
Science and Engineering
through Diversity**



**Mid-scale Research
Infrastructure**



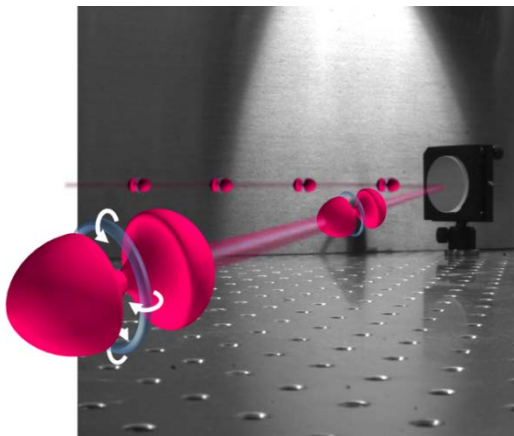
**NSF 2050: Seeding
Innovation**



BACK – UP



20 years of the NSF/DOE Partnership in Basic Plasma Science and Engineering



Observation and modeling of
“spatiotemporal optical vortices” by
the Milchberg research group at U. of
Maryland (*PRX*, 9 September, 2016)

Image Credit: H. Milchberg

ALPHA collaboration at CERN has
succeeded in observing the $1s \rightarrow 2s$
transition in antihydrogen (*Nature*,
19 December, 2016)

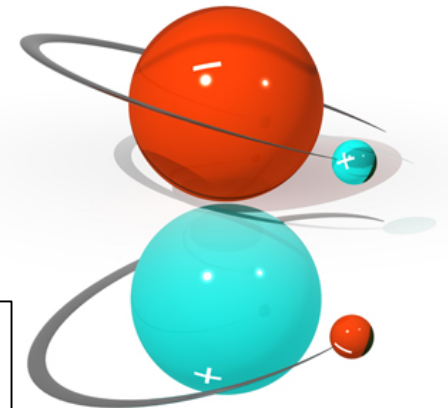


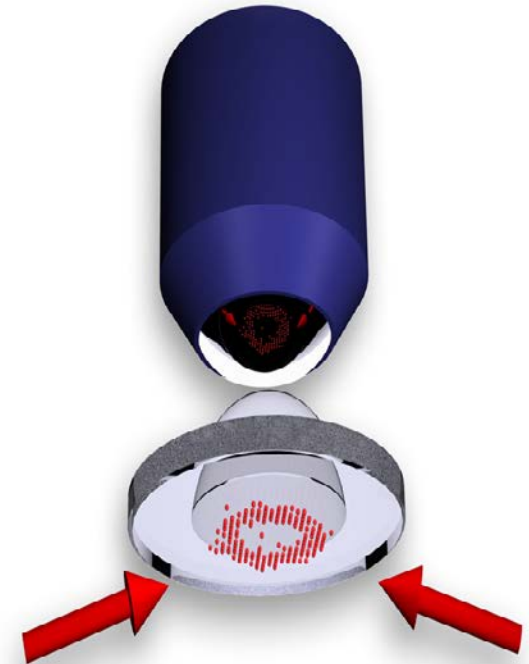
Image Credit: Chukman So,
Wurtele Research Group



Ultracold Quantum Gas Microscopy

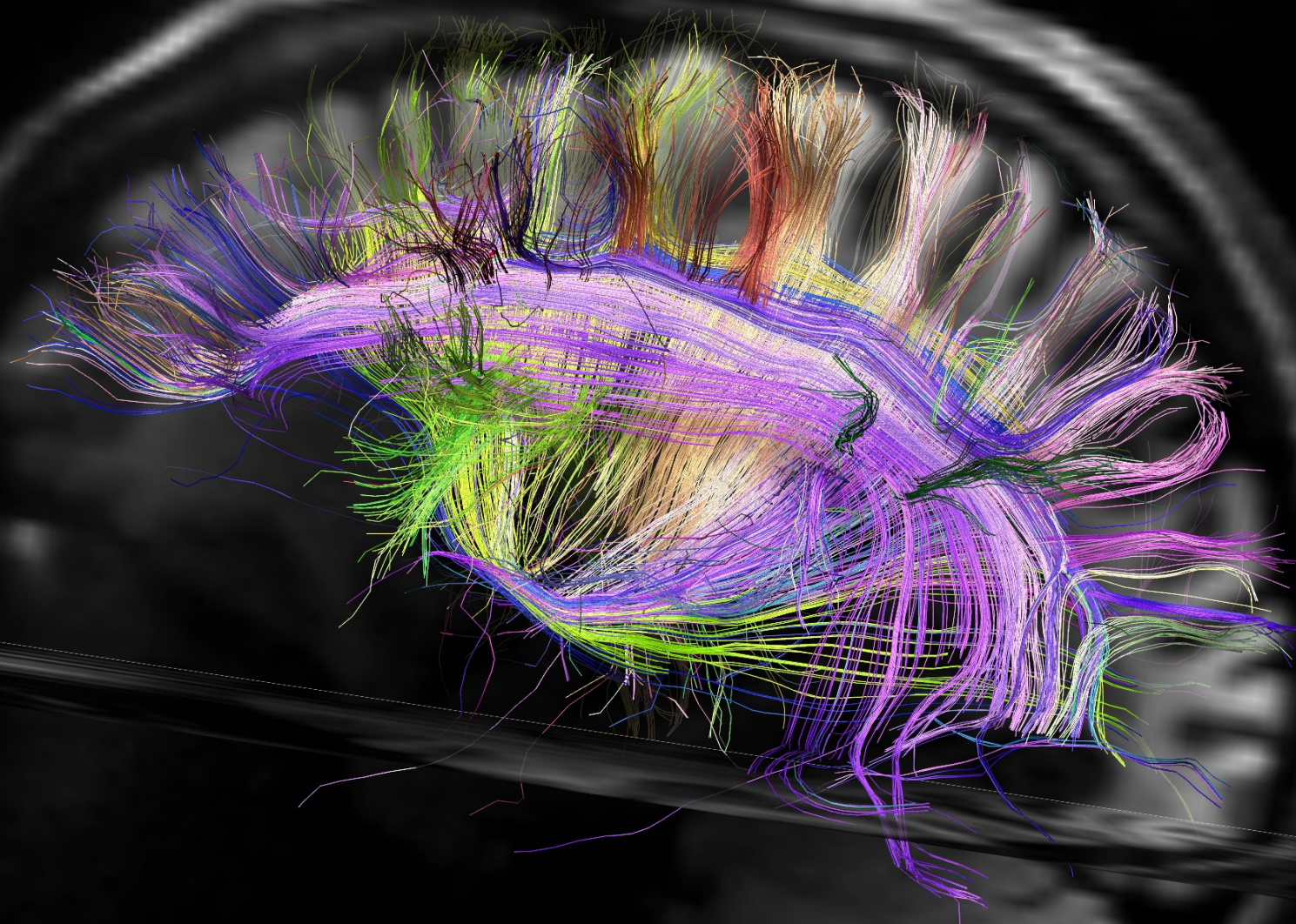
Ideal platform to explore many-body quantum mechanics

- Control and detection of individual atoms
- Adjustable interactions
- Study Bosons, Fermions, spins
- Testbed for many-body physics
- Pioneered at Center for Ultracold Atoms
by M. Greiner et al.,
- Now in many labs worldwide



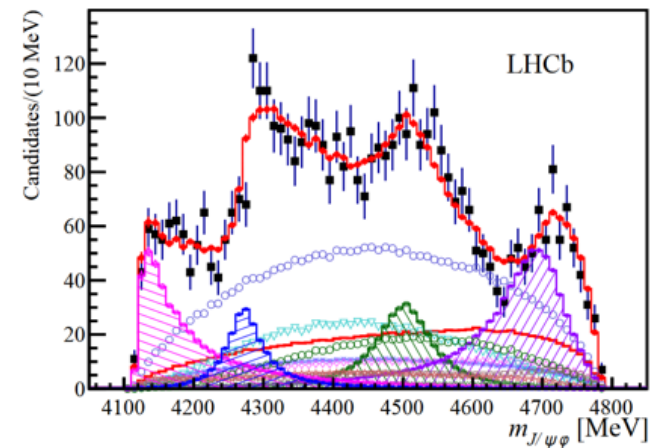
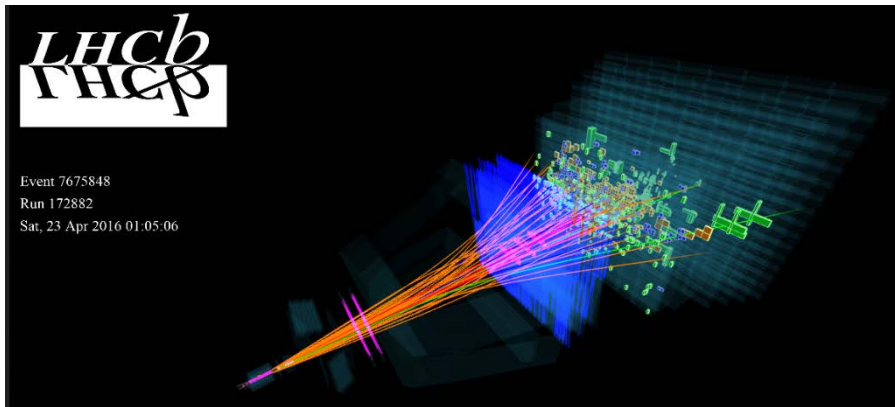
Atoms, in a lattice,
under a microscope

Grid structure of human brain in vivo DSI; orthogonal crossing of longitudinal fasciculus and corona radiata





EPP Highlights: US led highlights at LHCb



- Recent physics highlights from US groups:
 - Observation of exotic-like particles (Tetraquarks)
 - B^+ meson decays into J/ψ , ϕ and K^+ mesons.
 - The plot shows the J/ψ , ϕ mass spectrum which can only be fit with the inclusion of the four exotic particles at 4140, 4274, 4500 and 4700 MeV. See <https://arxiv.org/abs/1606.07898>
 - Ongoing Lepton Universality test probes physics beyond the Standard Model
 - Recent Science article: <http://www.sciencemag.org/news/2017/04/physicists-detect-whiff-new-particle-large-hadron-collider>



Did Einstein have the last word on gravity?

Black Holes of Known Mass

