

# NSF's Mathematical and Physical Sciences: Priorities

Anne Kinney

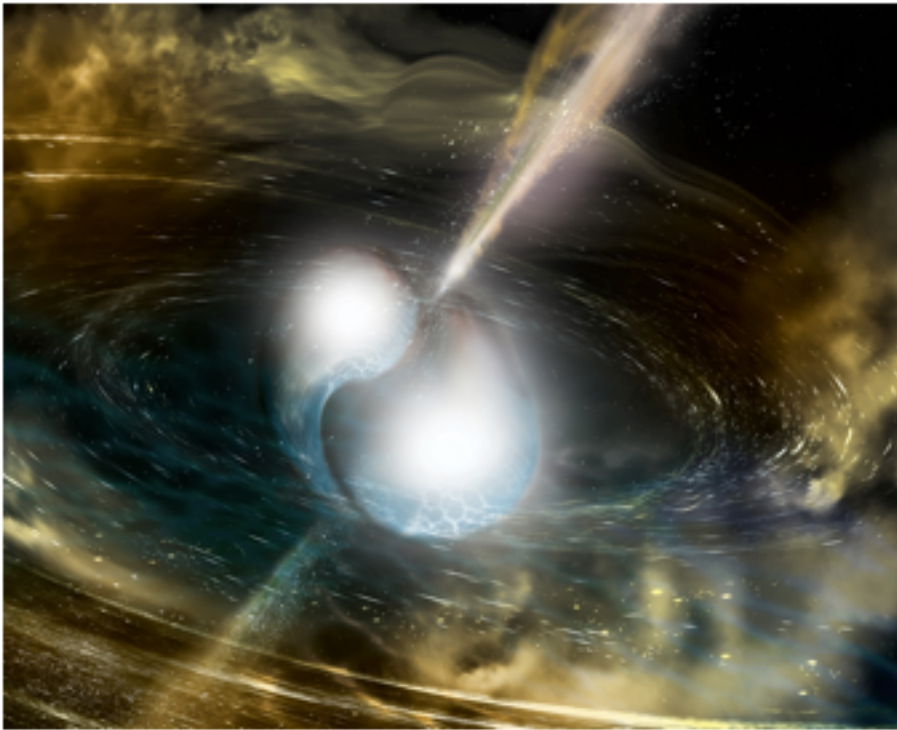
Assistant Director, Mathematical and Physical Sciences

ASEE Engineering Research Council

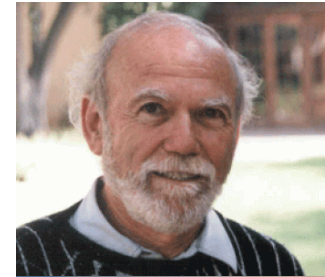
March 14, 2018



# LIGO Pioneers Win 2017 Nobel Prize in Physics for Detecting Gravitational Waves



August 2017: LIGO and Virgo make first detection of gravitational waves produced by colliding neutron stars



# NSF's 10 Big Ideas

## RESEARCH IDEAS

- Harnessing the Data Revolution**  
MATHEMATICAL, STATISTICAL, OPEN, RESEARCH, EDUCATIONAL, FOUNDATIONS, COMPUTATIONAL, ANALYTICS, DATA SCIENCE, WORKFORCE, FUNDAMENTAL, MACHINE, LEARNING, SCIENCE, CHALLENGES, CYBERINFRASTRUCTURE, MODELING, DATA MINING, INTERNET OF THINGS, HUMAN DATA INTERFACE
- Work at the Human-Technology Frontier: Shaping the Future**
- Windows on the Universe: The Era of Multi-messenger Astrophysics**
- The Quantum Leap: Leading the Next Quantum Revolution**
- Harnessing Data for 21st Century Science and Engineering**
- Navigating the New Arctic**
- Understanding the Rules of Life: Predicting Phenotype**

## PROCESS IDEAS

- Mid-scale Research Infrastructure**
- NSF 2026**
- Growing Convergence Research at NSF**
- NSF INCLUDES: Enhancing STEM through Diversity and Inclusion**



# Windows on the Universe: The Era of Multi-Messenger Astrophysics



The goal of “*Windows on the Universe*” is to bring **electromagnetic waves**, **high-energy particles**, and **gravitational waves** together to study the universe and probe events in real time in a way that was previously impossible.

# Windows on the Universe: Science Questions

- How did the universe begin?
- Why is the universe accelerating?
- What is the unseen matter that constitutes much of the universe?
- How does gravity work under the most extreme conditions?
- What are the properties of the most exotic objects in the universe?
- How do matter and energy evolve to produce the universe around us?



# The Quantum Leap

Can we go fully quantum?

Can we overcome decoherence?

*If you are not completely confused by quantum mechanics, you do not understand it.* -John Wheeler

*Spooky action at a distance.* -Albert Einstein



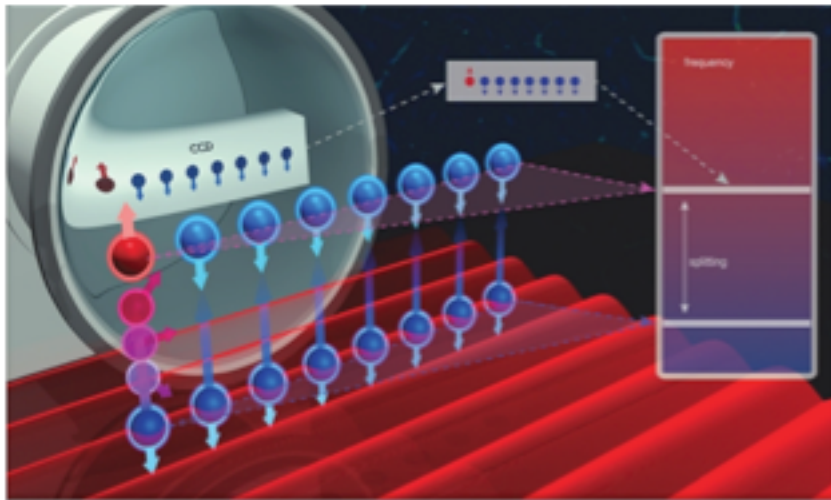
*I do not like it, and I am sorry I ever had anything to do with it.* -Erwin Schrödinger

*It is safe to say that nobody understands quantum mechanics.* -Richard Feynman

$$i\hbar \frac{\partial}{\partial t} |\Psi(\mathbf{r}, t)\rangle = \hat{H} |\Psi(\mathbf{r}, t)\rangle$$



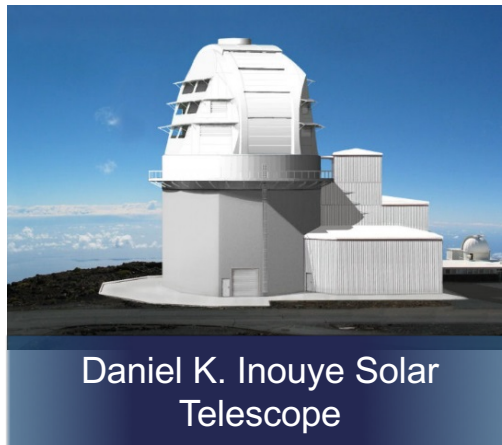
# Leading the Next Quantum Revolution



Quantum Leap Summer School: Students learned to program the IBM Quantum Experience computer

*“A cross-NSF approach to identifying and supporting research that **answers deep questions about quantum behavior and develops the means of accessing and manipulating quantum systems** ... couple together experiment, computation, and theory to attack fundamental questions”*

# Continued Investment in NSF Research Infrastructure





# Picture Credits

- Slide 2:
  - Thorne: <http://mashable.com/2014/11/11/interstellar-kip-thornes-book/#wOchnwdw0iq6>
  - Barish: Caltech
  - Weiss: Physics Today
  - NSF/LIGO/Sonoma State University/A. Simonnet
- Slide 3: NSF
- Slide 4:
  - Left: F. Fleming Crim, NSF
  - Center: LIGO Scientific Collaboration
  - Right: F. Fleming Crim, NSF
- Slide 7:
  - Left: Joint Quantum Institute, University of Maryland
  - Right: Joseph Checkelsky, Materials Research Lab, MIT
- Slide 8:
  - DKIST: Tom Kekona, K.C. Environmental, Inc
  - LSST: <https://www.lsst.org/gallery/lsst-and-calypto>
  - LIGO: LIGO Scientific Collaboration
  - ALMA: ALMA
  - NSCL: Gary Westfall, Michigan State, NSCL

