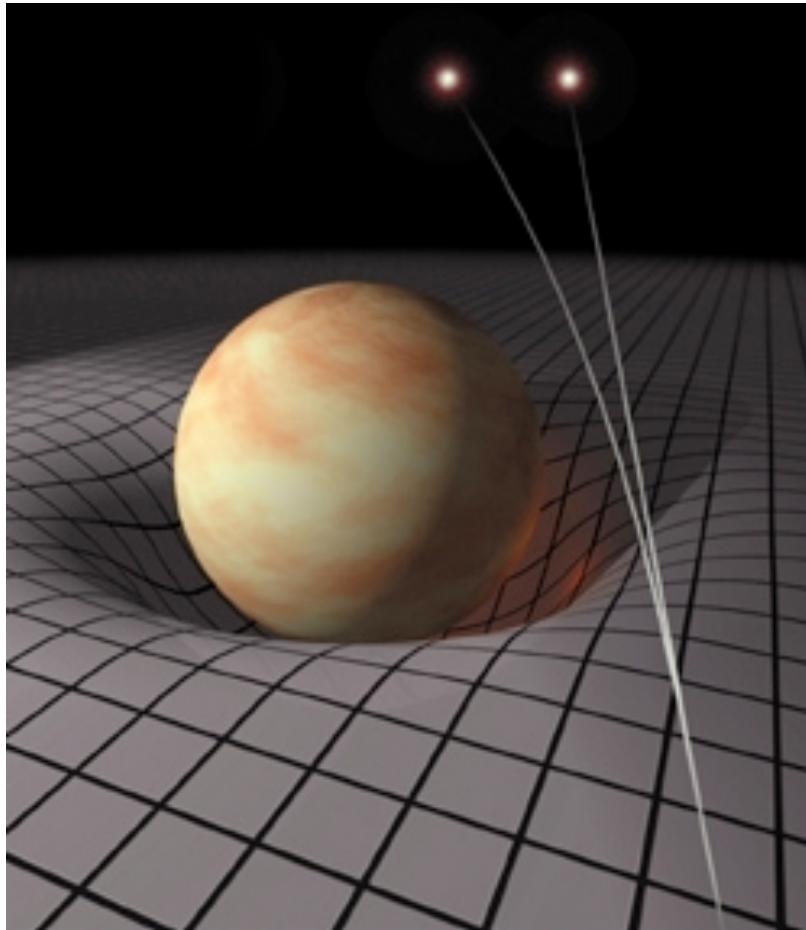


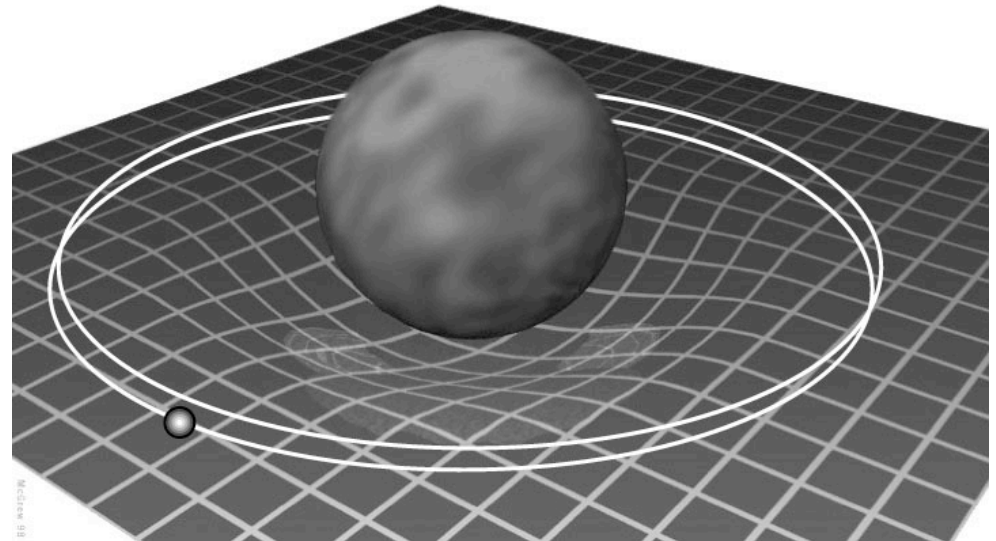


LIGO's First Measurement of Gravitational Waves

Tiffany Summerscales
Andrews University



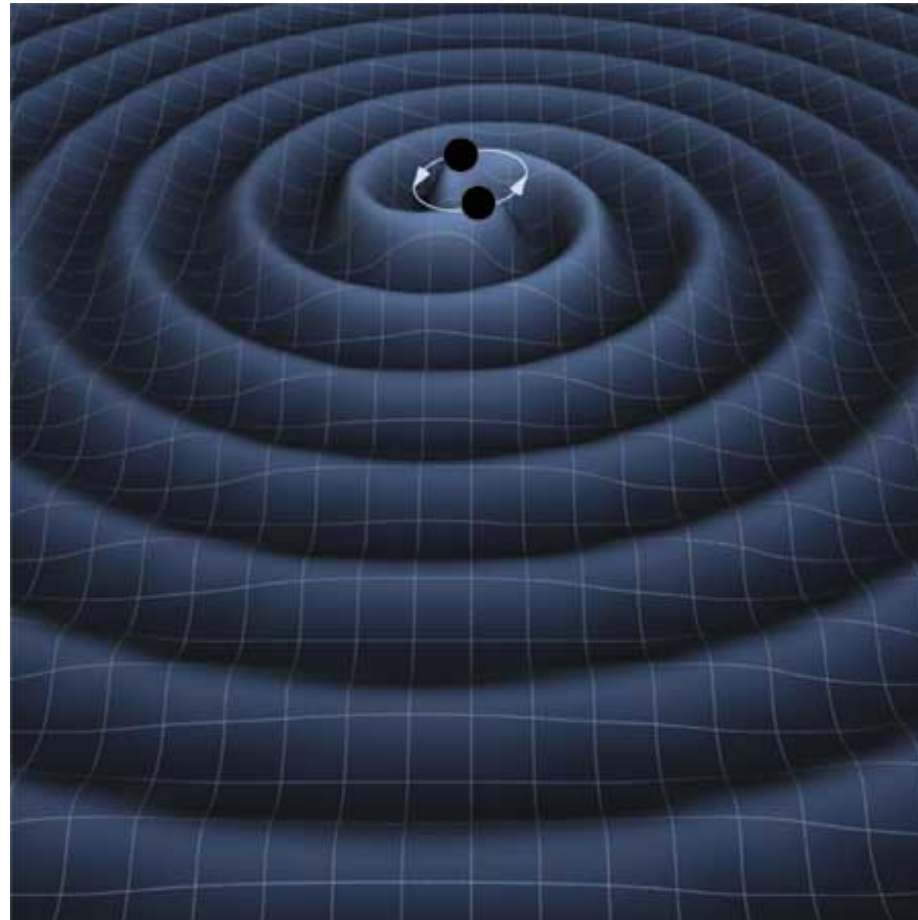
Space tells matter how to move.
Matter tells space how to curve.
– John A. Wheeler



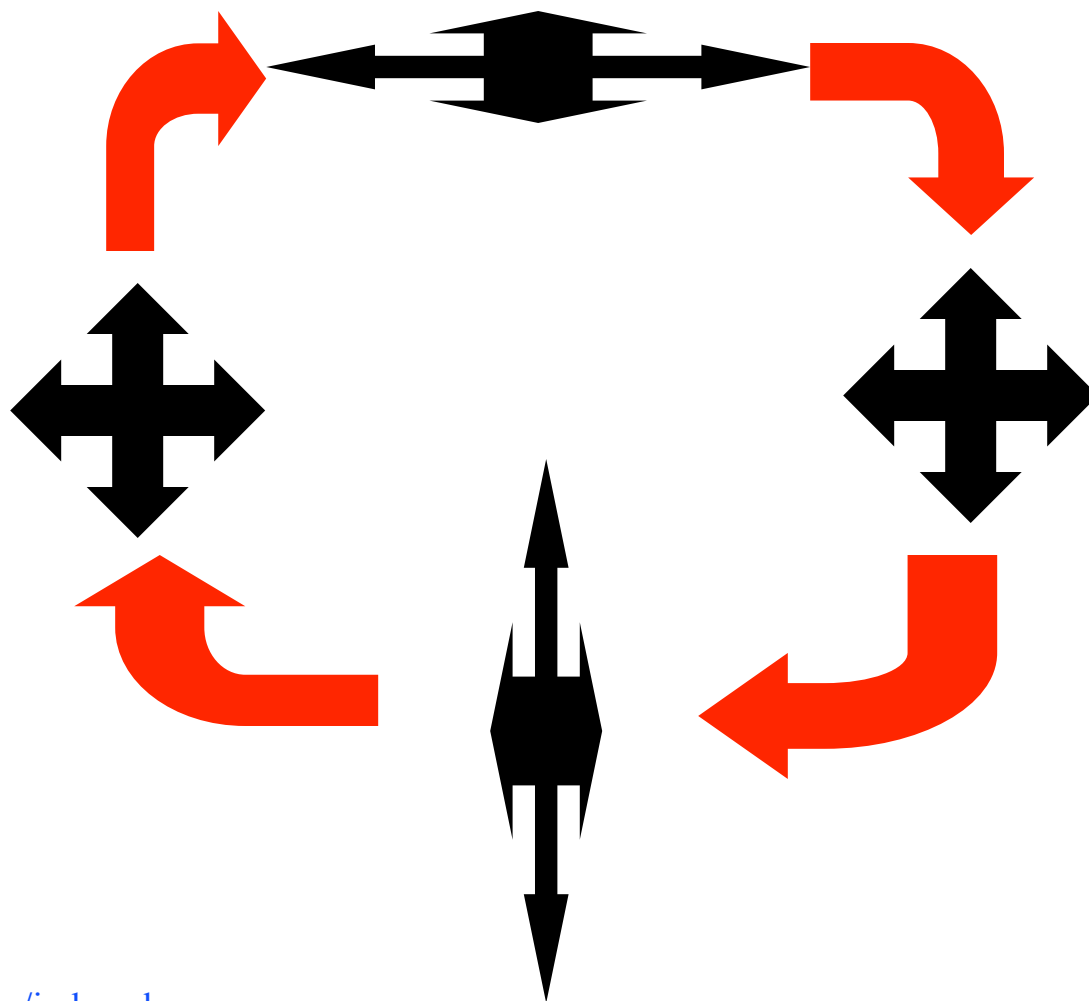
<http://preposterousuniverse.com/spacetimeandgeometry/covercrop.jpg>
<http://zebu.uoregon.edu/ph121/hb/amy/merc.jpg>



- Change in matter distribution = Change in curvature
- Propagating change in curvature = A Gravitational Wave



<http://lisa.jpl.nasa.gov/gallery/binary-wave.html>



Animation from <http://www.ligo-la-caltech.edu/Posters/index.php>



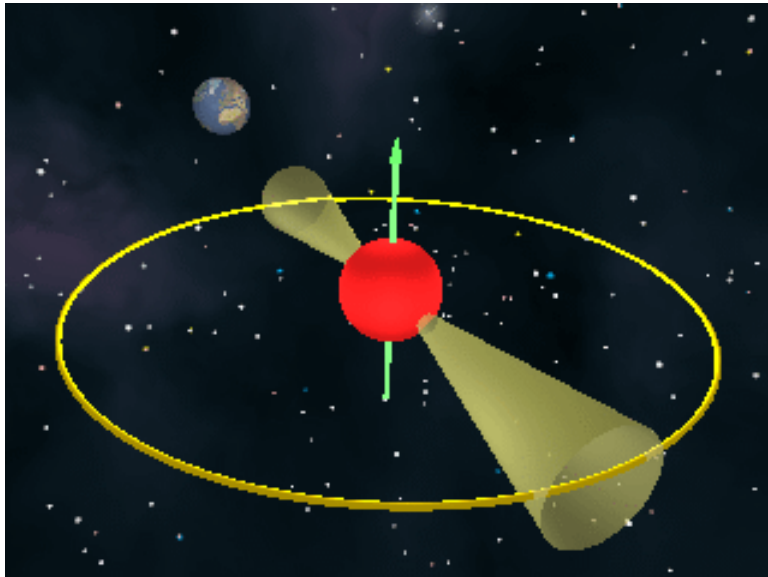
Gravitational Waves Measured in Strain

$$h = \frac{\Delta L}{2L}$$



$$h_{\max} \sim 10^{-21}$$

$$\Delta L = 2D_{\text{Earth}} (10^{-21}) \approx 1 \times 10^{-14}$$



<http://www.jb.man.ac.uk/news/neutronstar/neutronstar.gif>

http://nobelprize.org/nobel_prizes/physics/laureates/1993

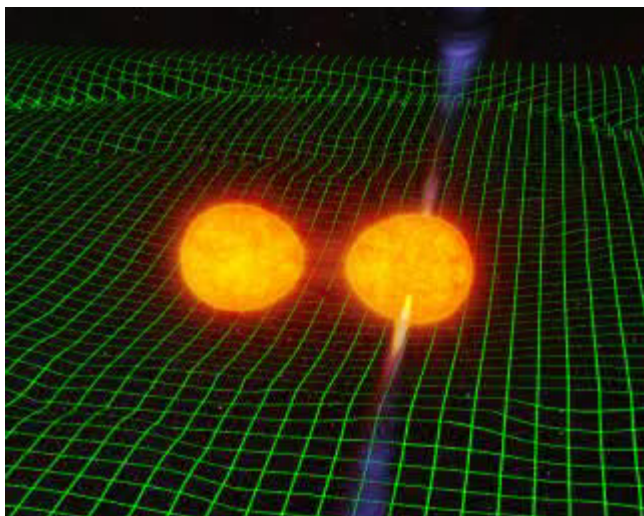
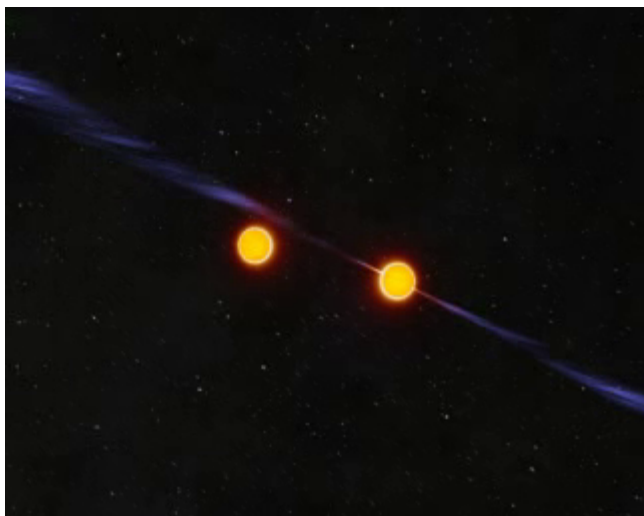


Hulse



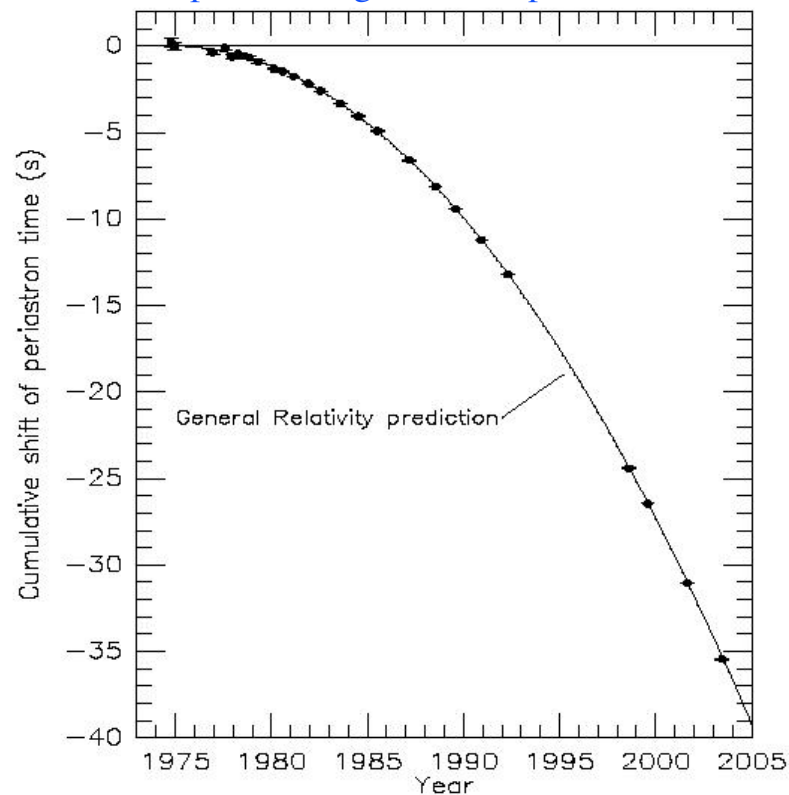
Taylor

In 1974, Russell Hulse and Joseph Taylor discover a new pulsar



http://www.atnf.csiro.au/news/press/neutron_binary/

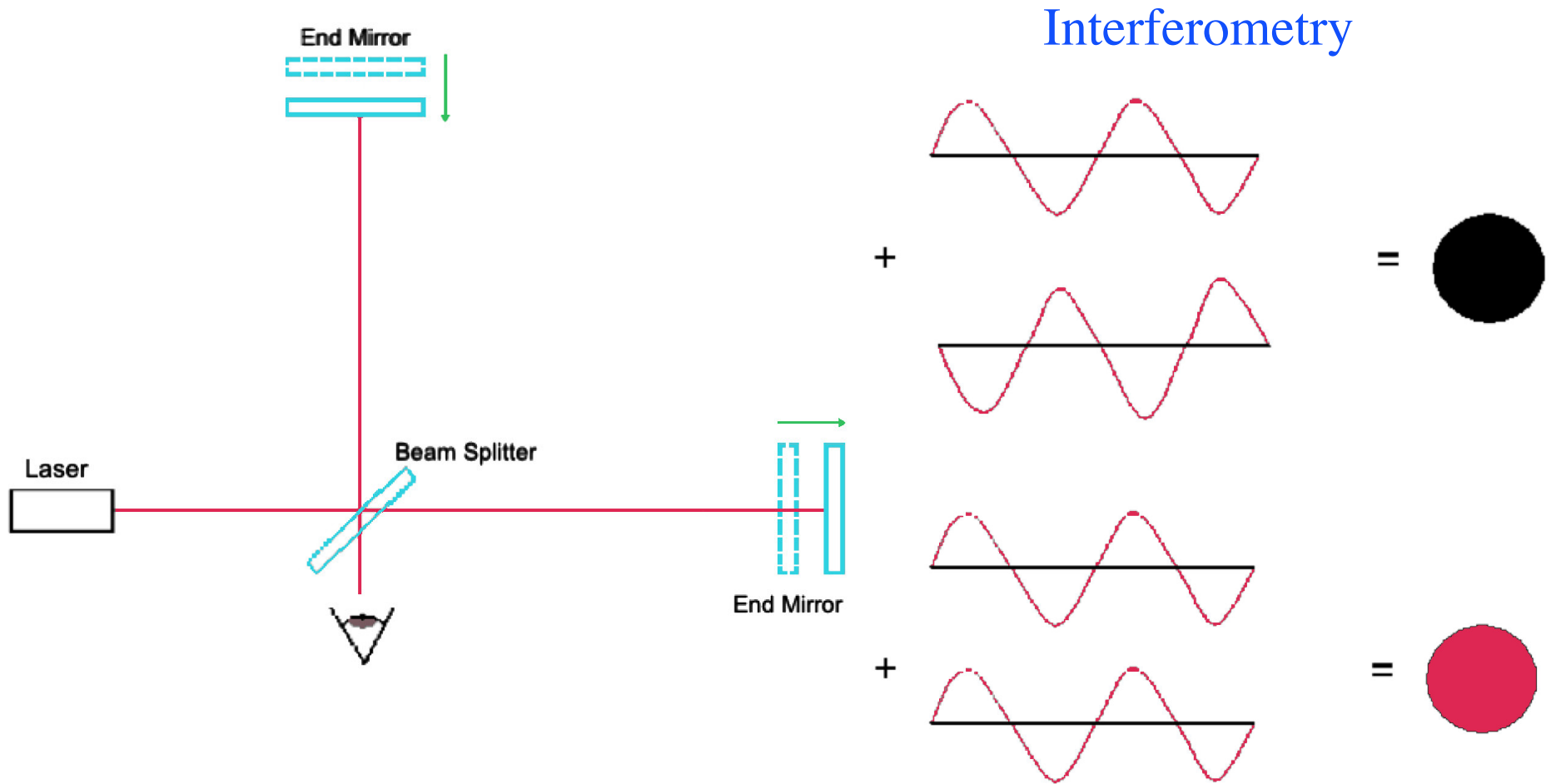
<http://arxiv.org/abs/astro-ph/0407149>





How Do We Detect Gravitational Waves?





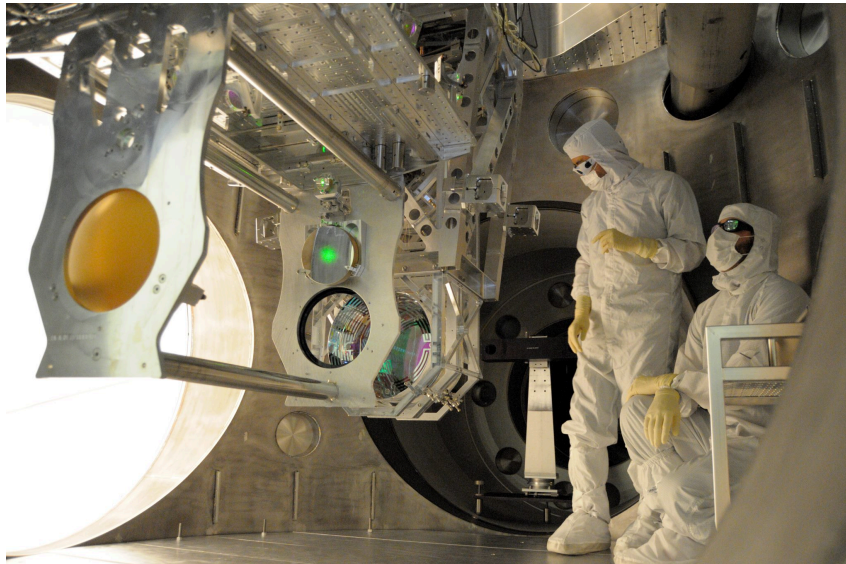
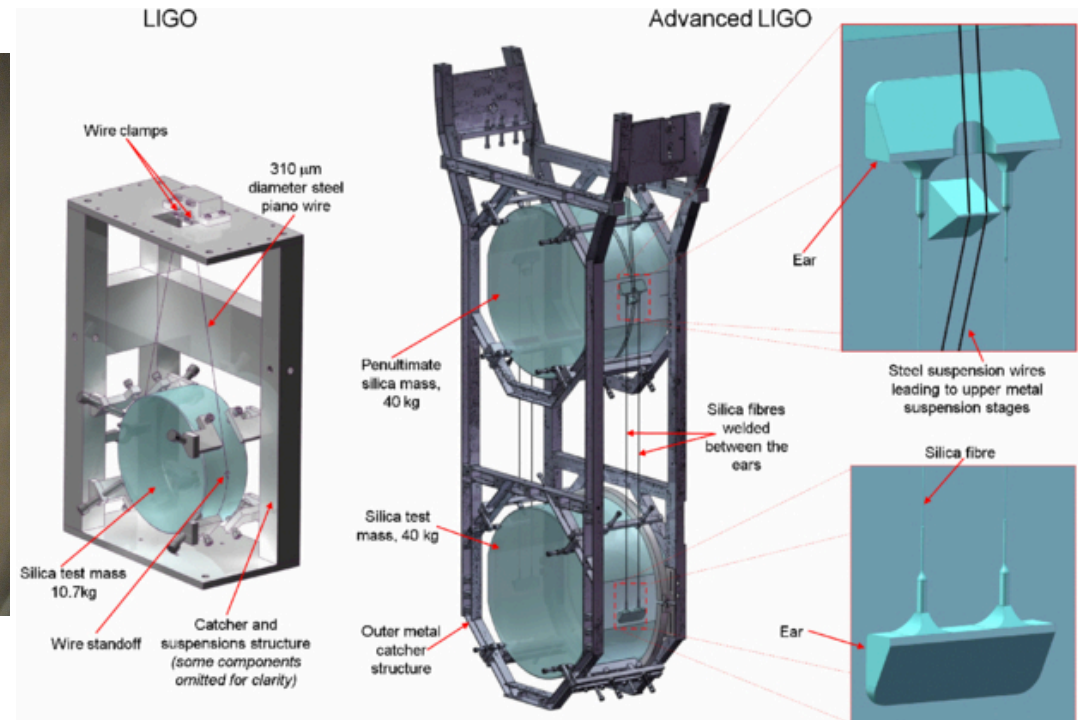


Image Credit: LIGO



Class. Quantum. Grav. 29 (2012) 035003

- Initial detectors (2002 – 2010)
- Upgrades
 - » Laser 4.5 W to 125 W
 - » Mirrors 25 cm diameter, 10.7 kg to 34 cm, 40 kg
 - » More sophisticated suspensions

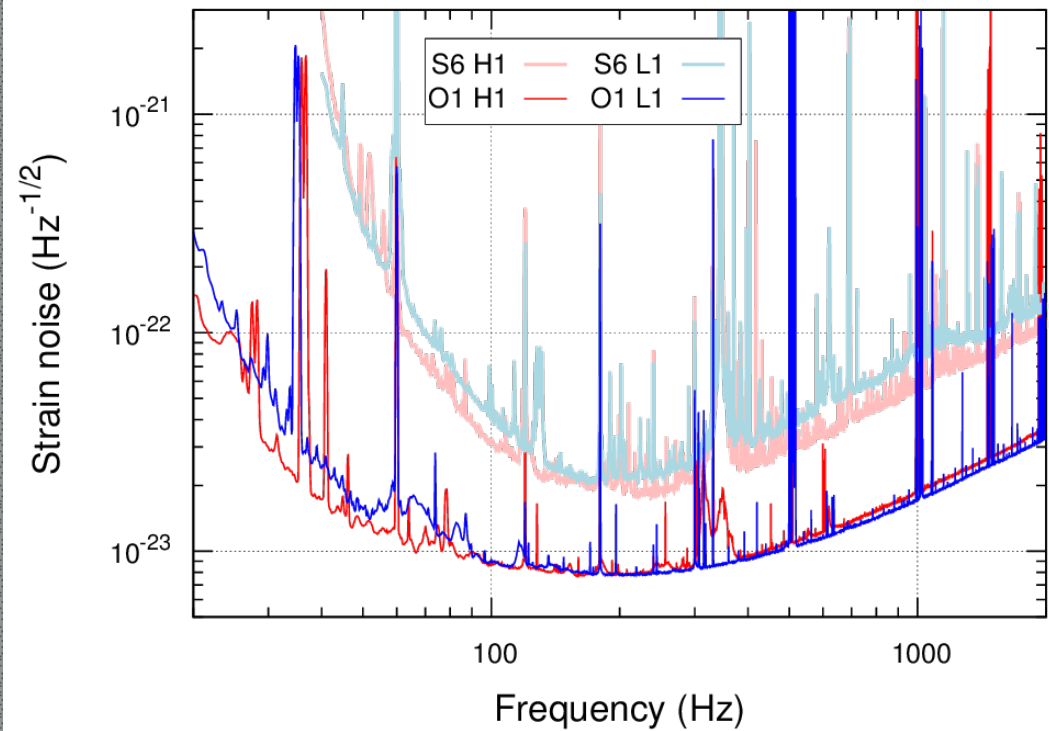
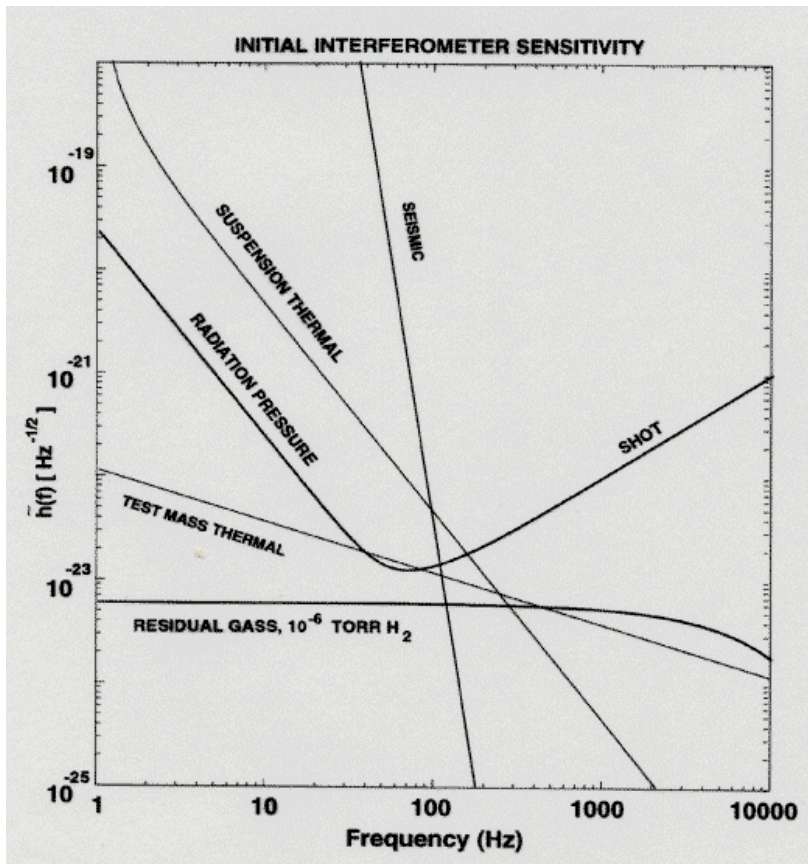
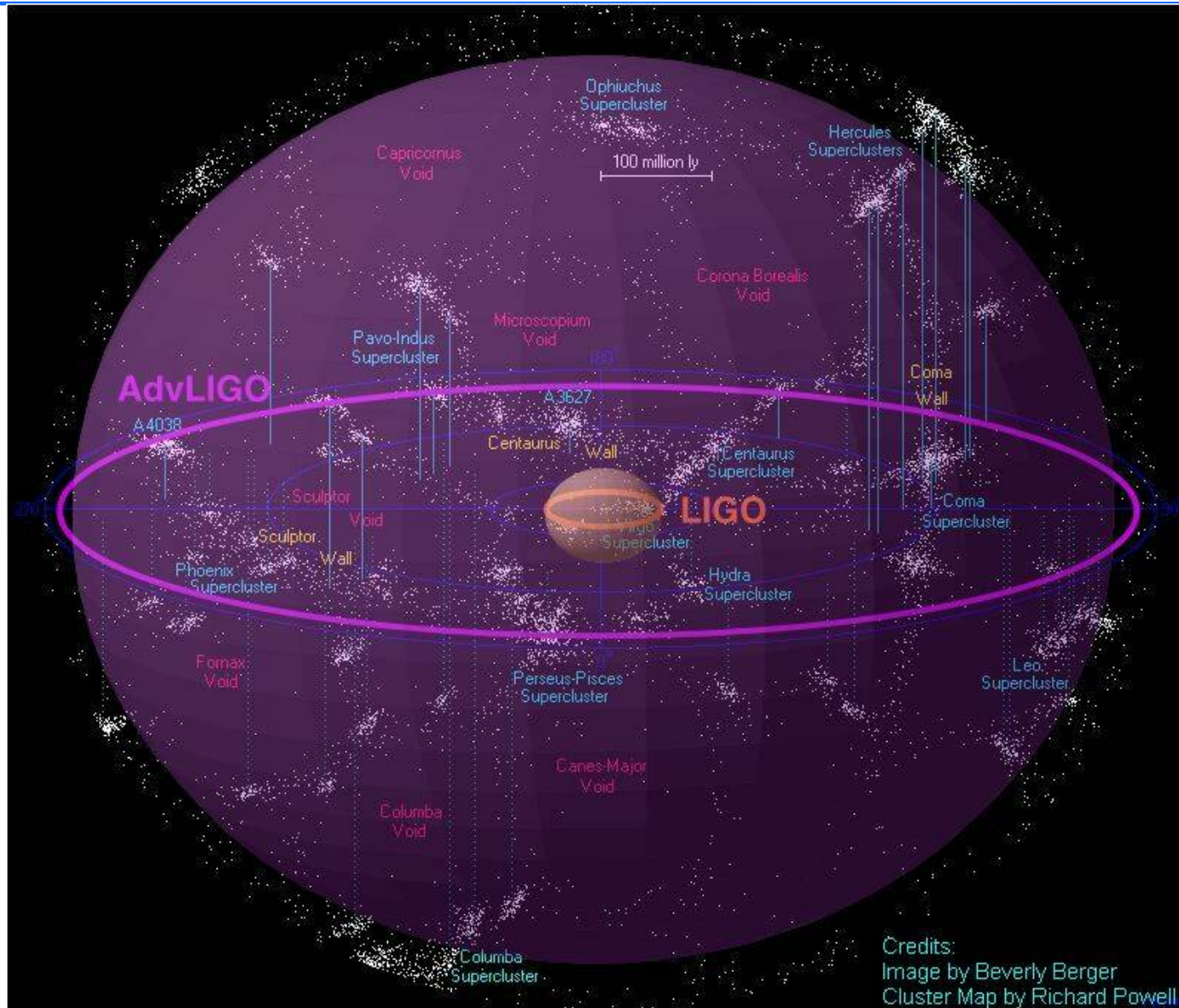


Image Credit: LIGO





A Network of Gravitational Wave Detectors

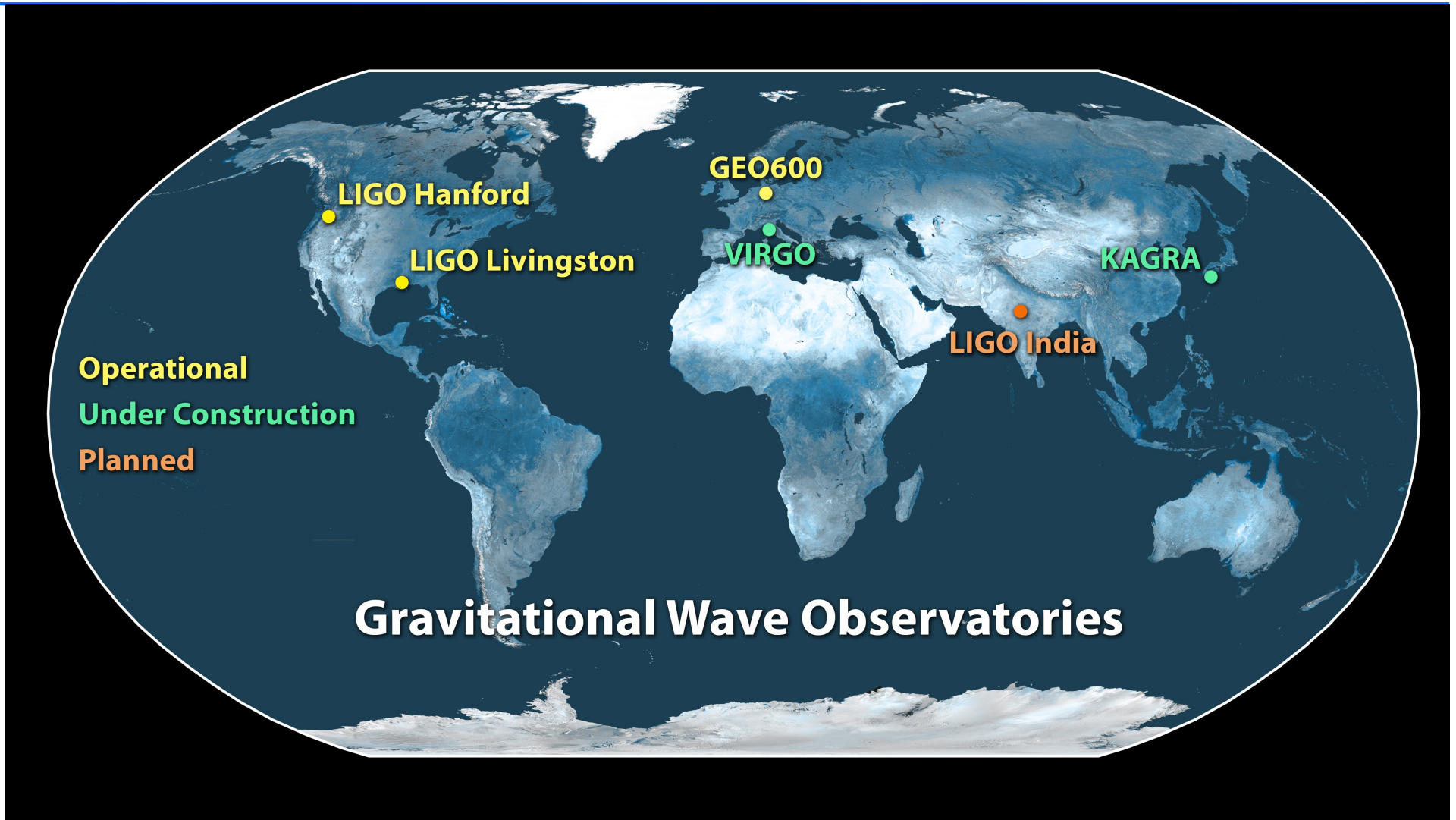


Image Credit: LIGO

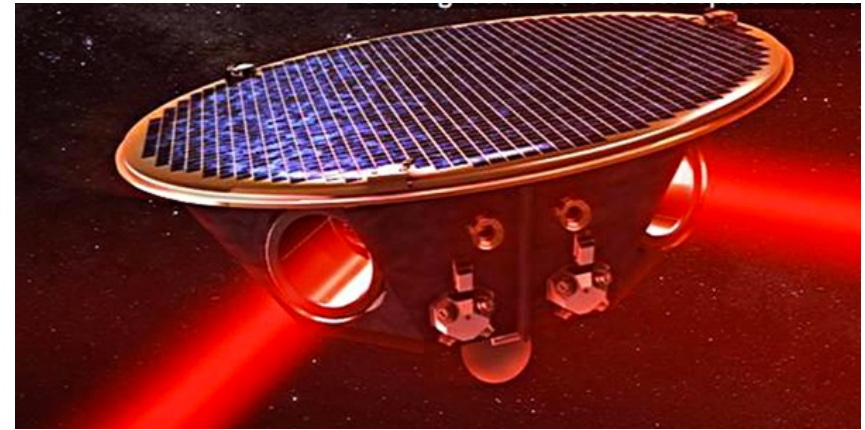
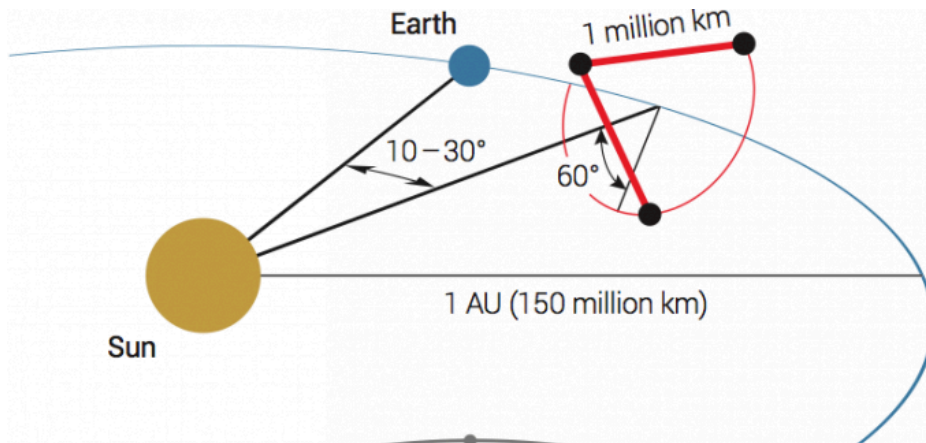


Image Credit: eLISA

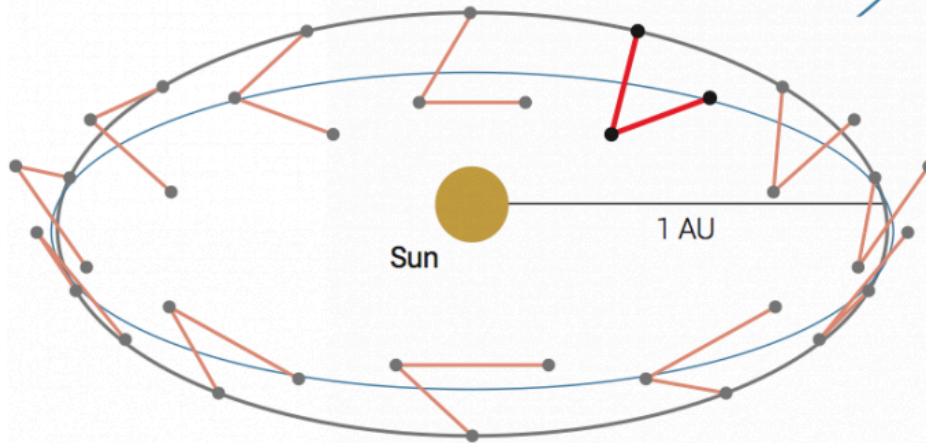
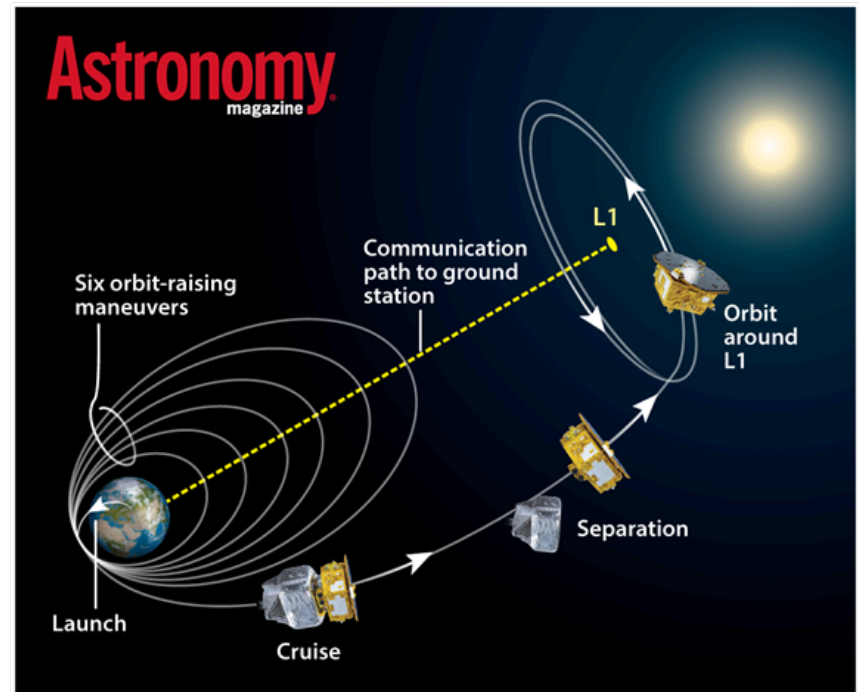


Image Credit: eLISA



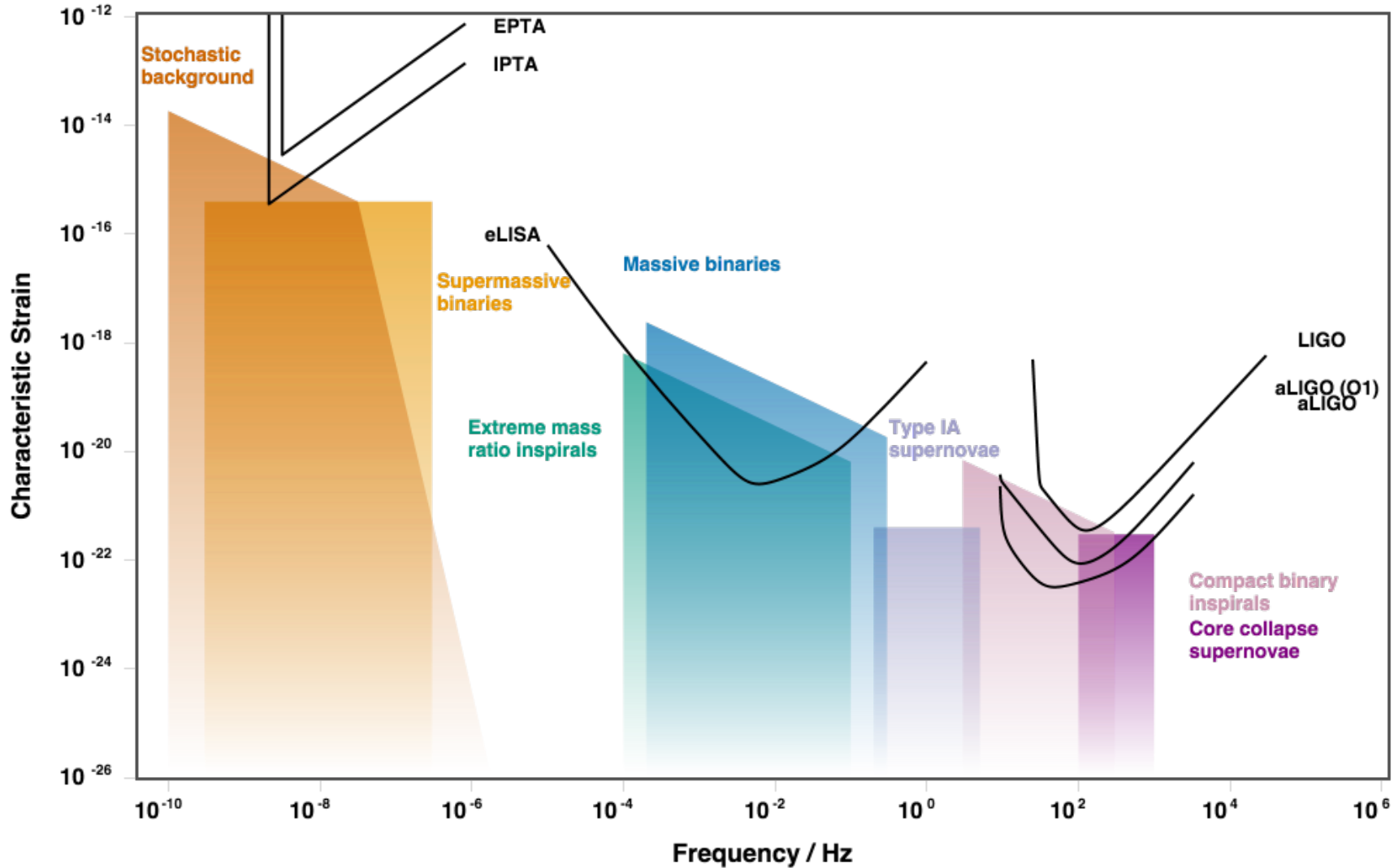
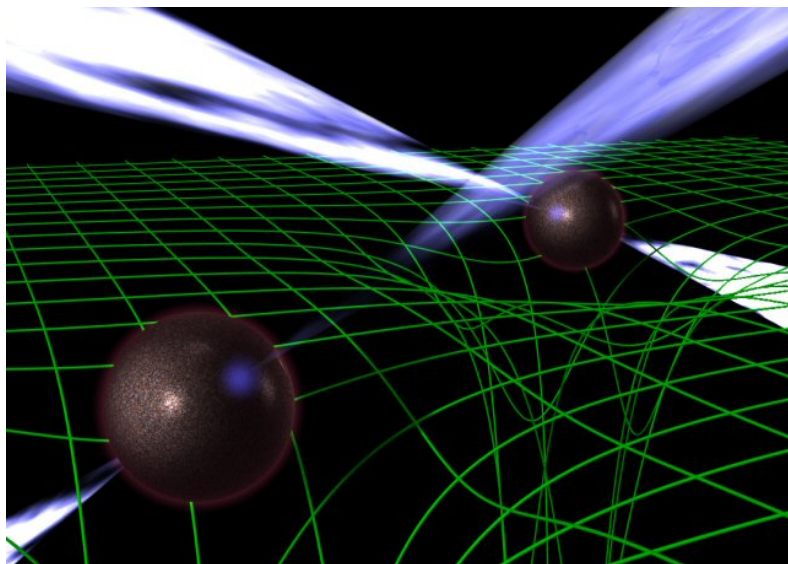


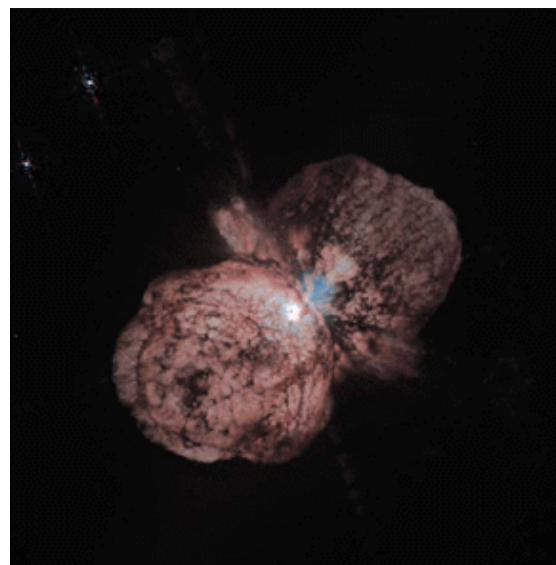
Image from <http://rhcole.com/apps/GWplotter>

- Binary neutron star inspirals and binary black hole inspirals
- Spinning neutron stars
- Bursts from supernovae etc
- Stochastic background from indistinguishable sources and/or the creation of the universe



<http://www.jb.man.ac.uk/research/pulsar/doublepulsarcd/>

http://hubblesite.org/gallery/album/entire_collection/pr1996023a/



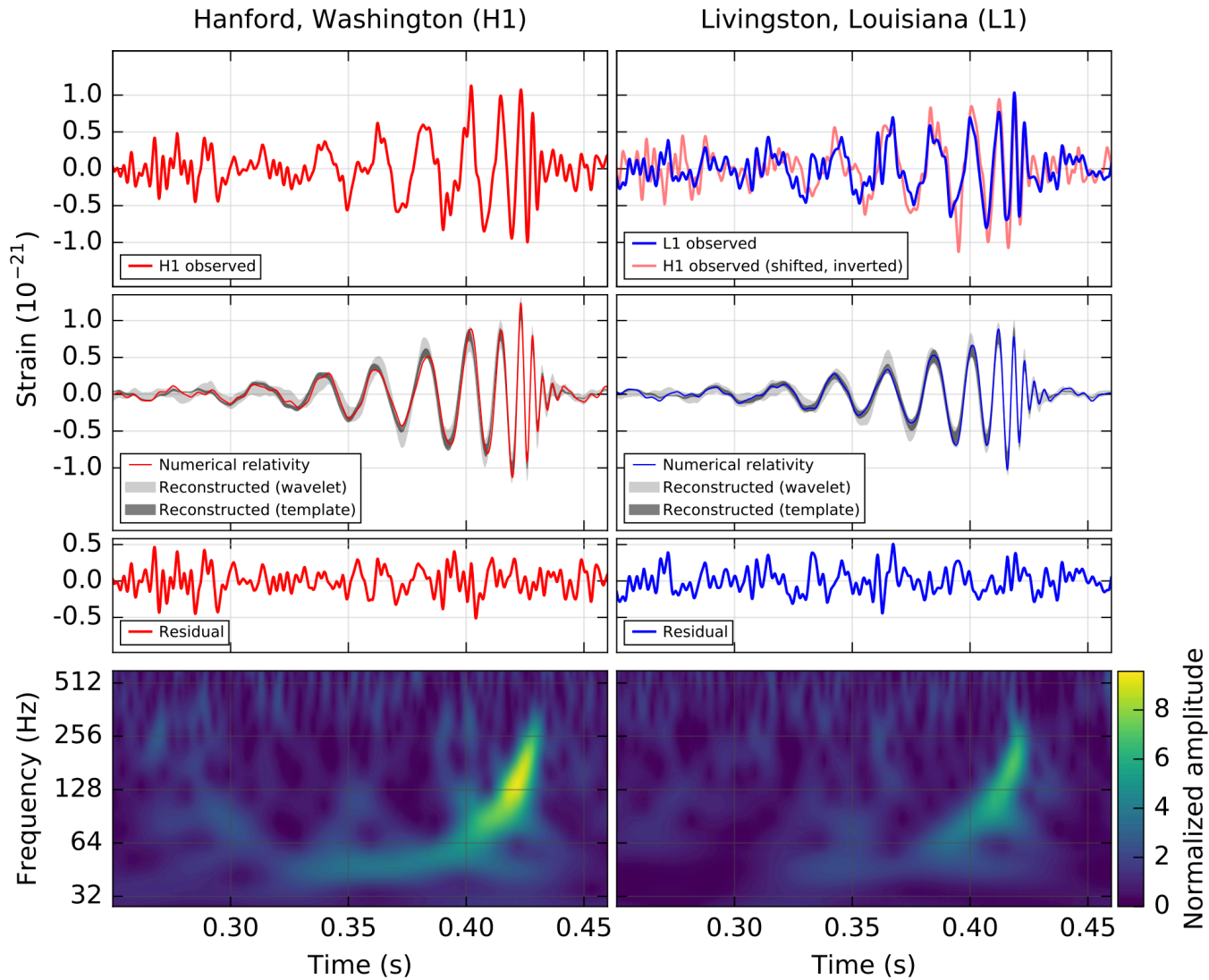


Image Credit: LIGO

*eigen*Talk*



- Binary Black Hole Inspiral
- $29 M_{\odot} + 36 M_{\odot} = 62 M_{\odot}$
- 1.3 billion light years away

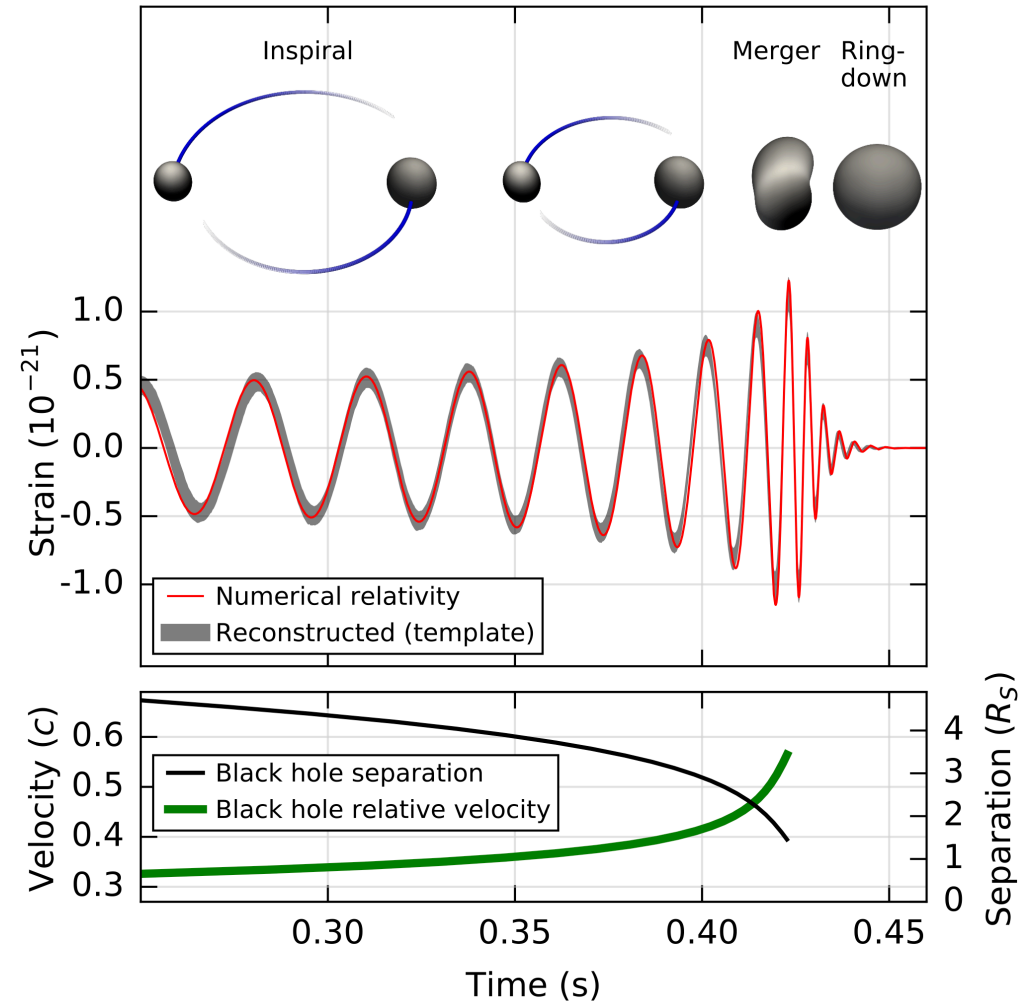


Image Credit: LIGO



GW150914: What did LIGO See?

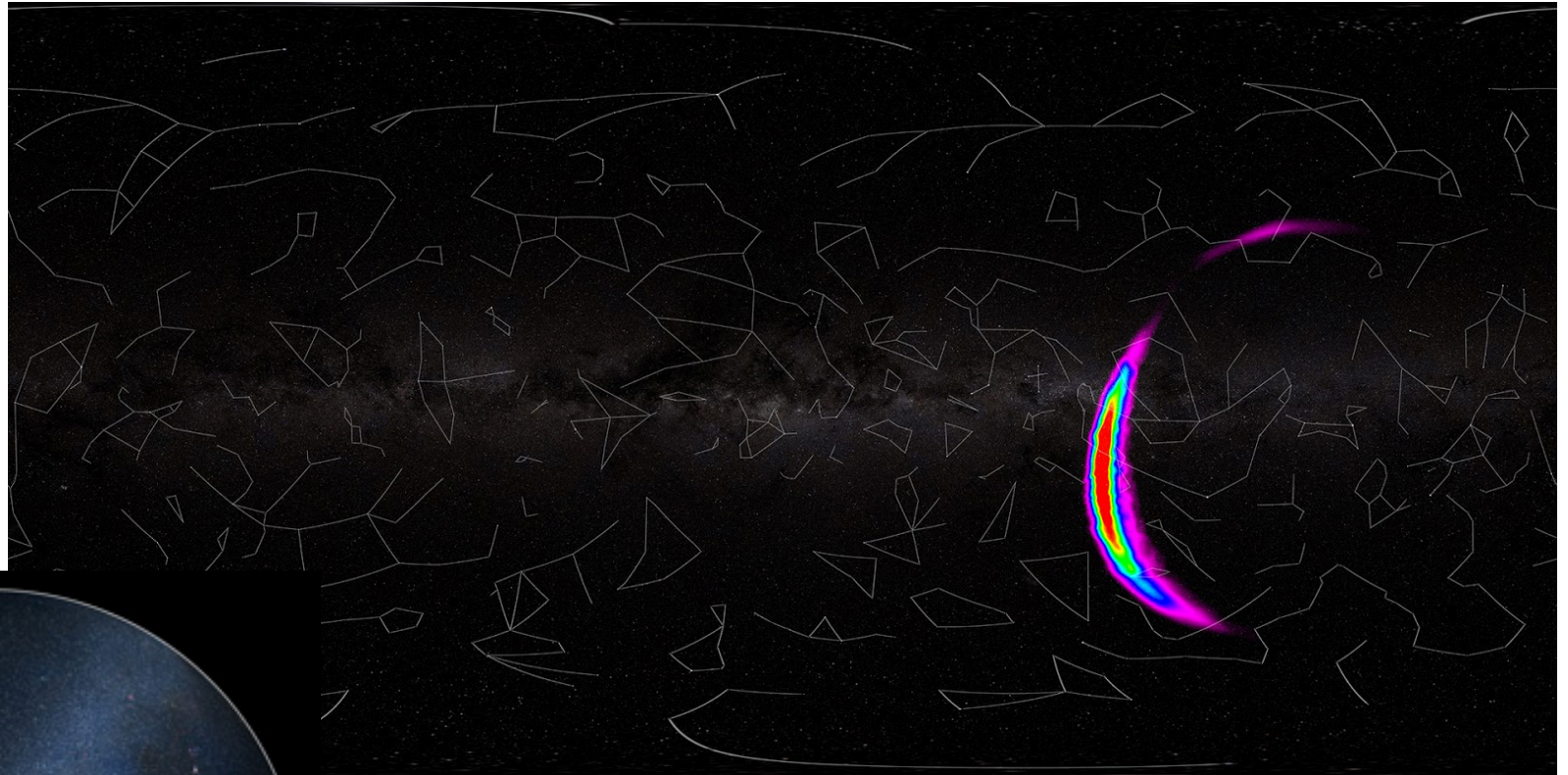


Image Credit: NASA Deep Star Maps and LIGO

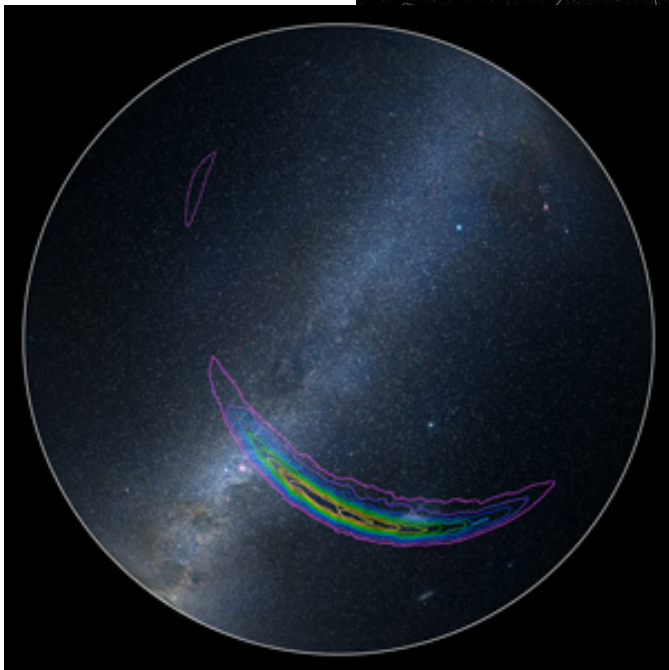
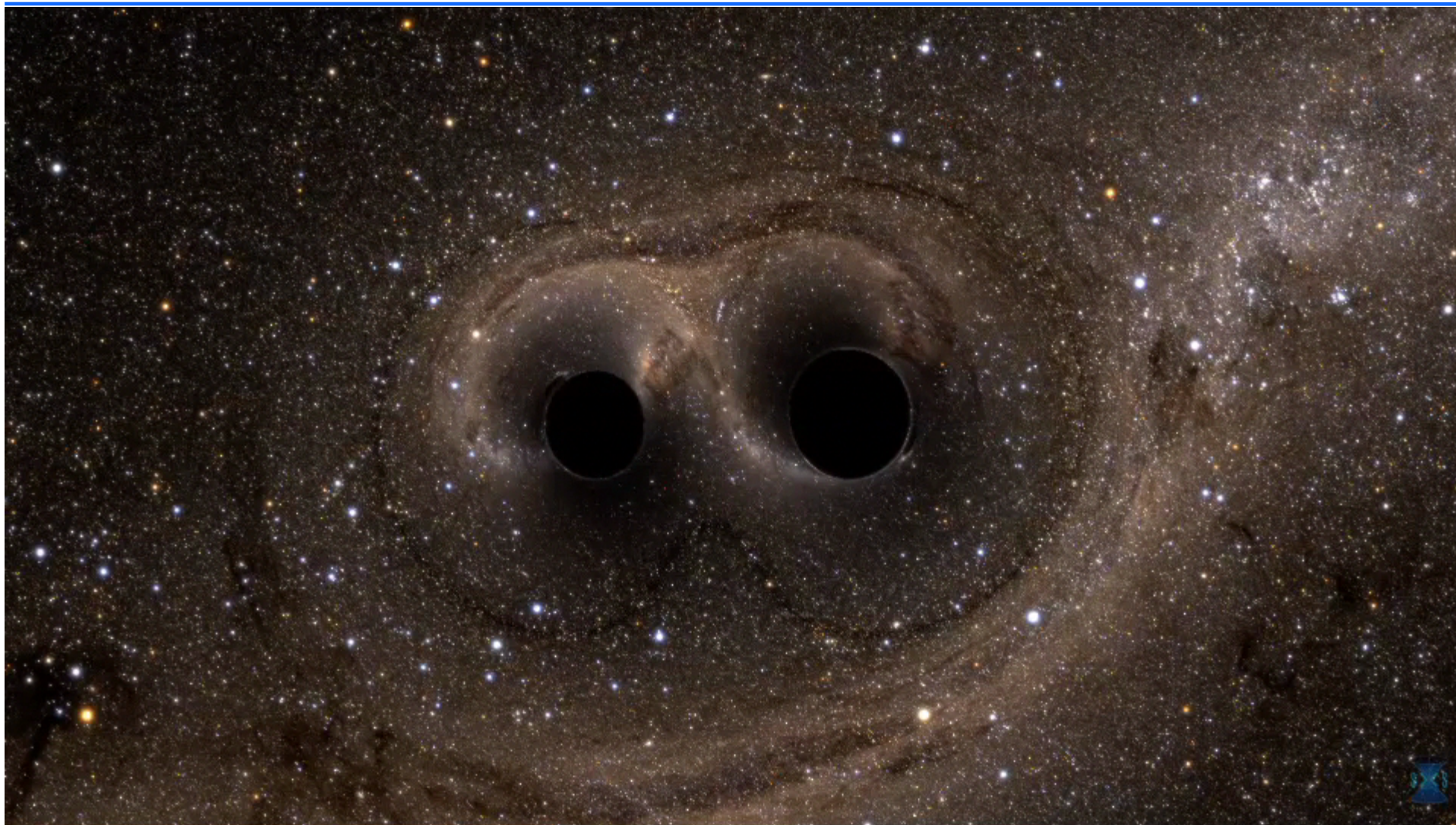


Image Credit: Roy Williams, Caltech and
Thomas Boch, CDS Strasbourg

*eigen*Talk*



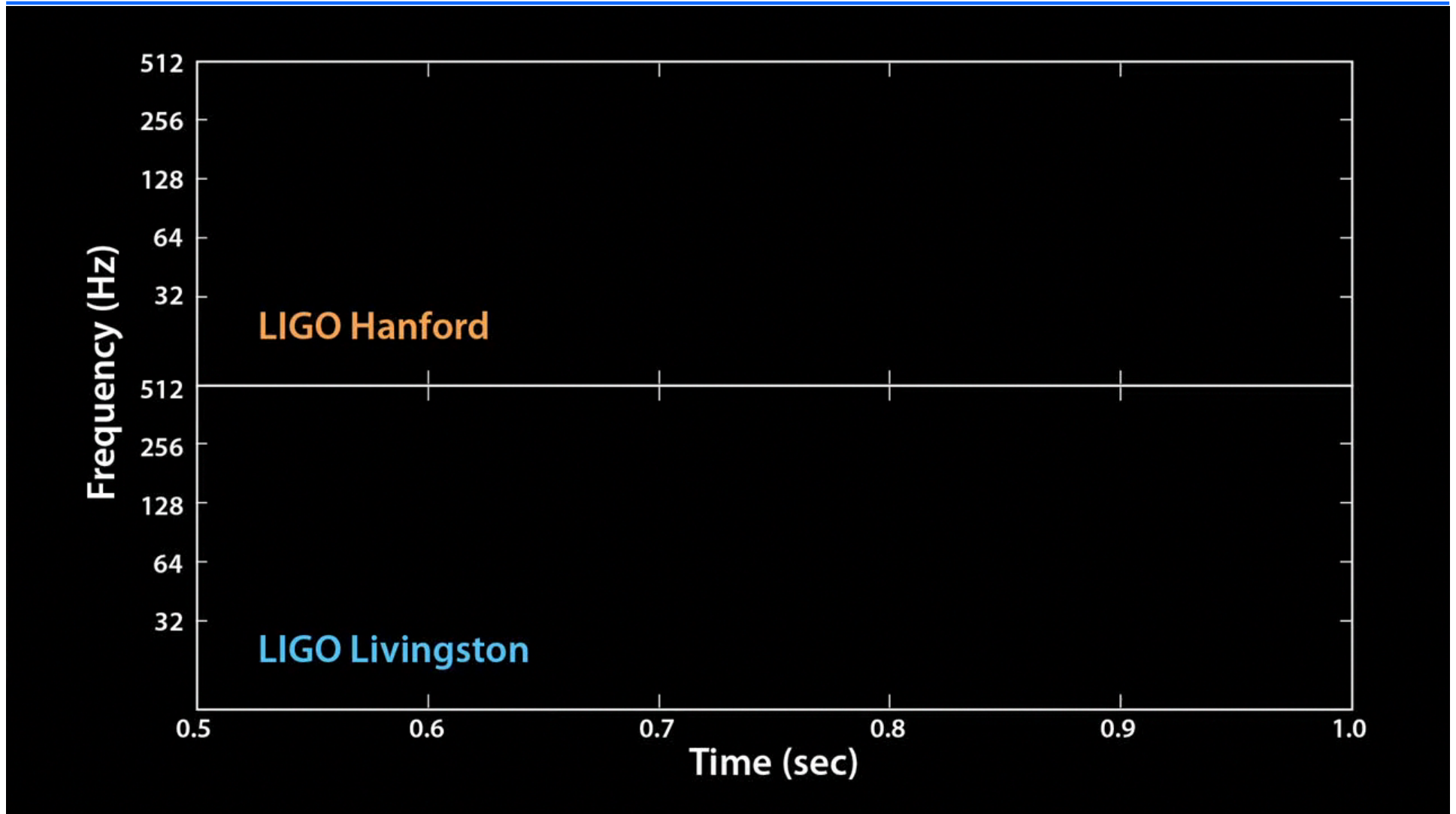
GW150914: What did LIGO See?



Movie Credit: LIGO



The Music of the Spheres



Movie Credit: LIGO

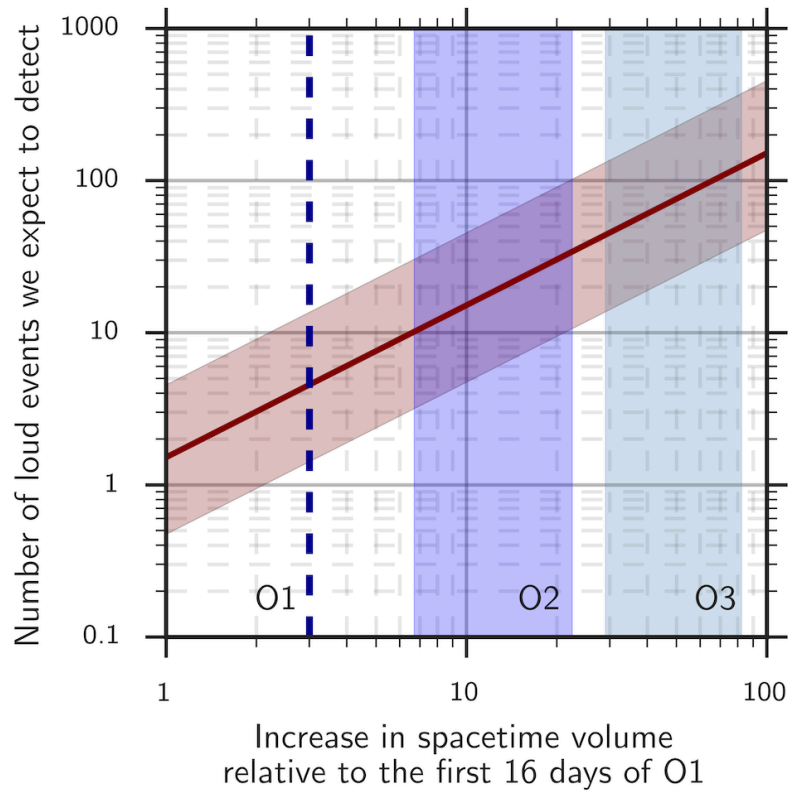


Image from: <https://dcc.ligo.org/LIGO-P1500217>

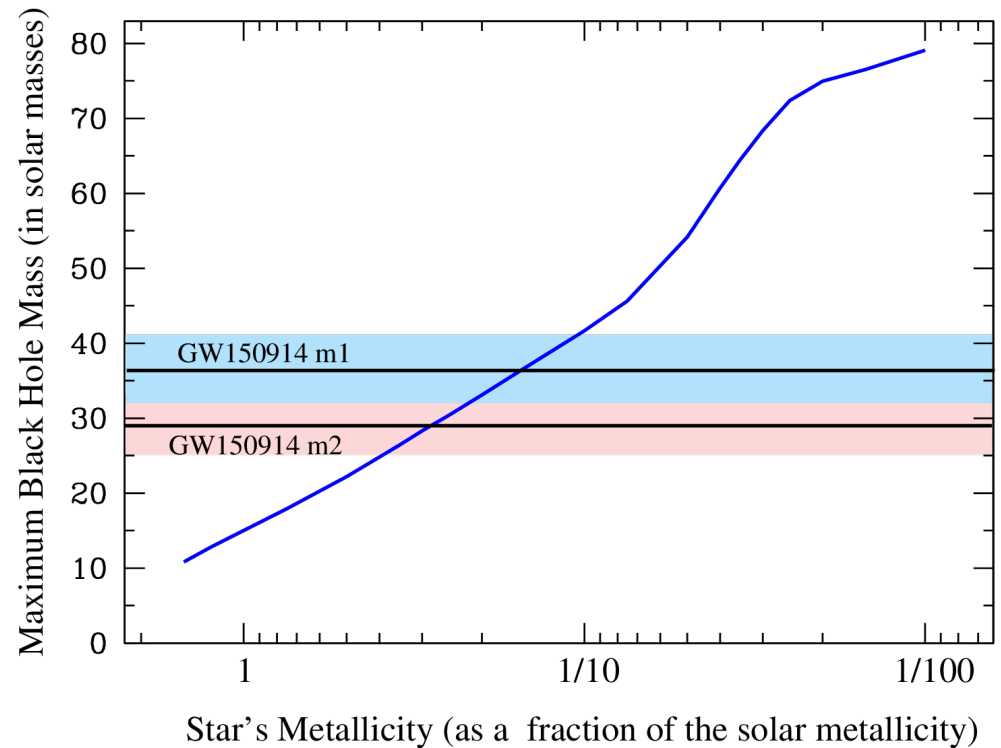
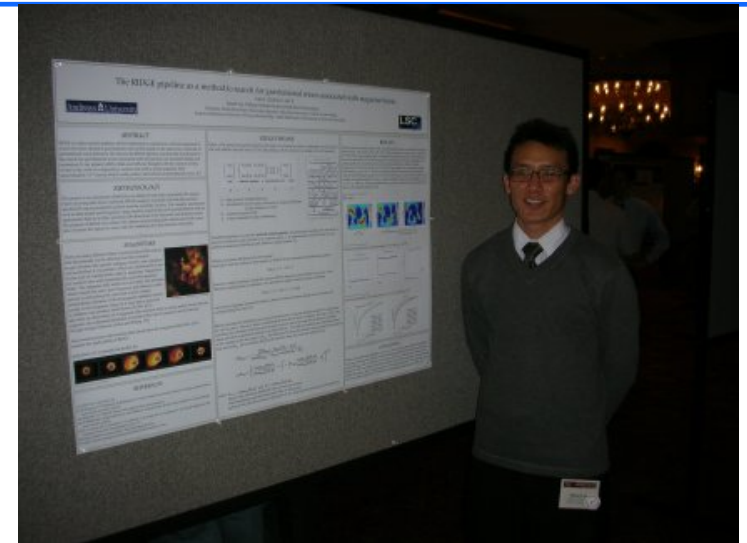
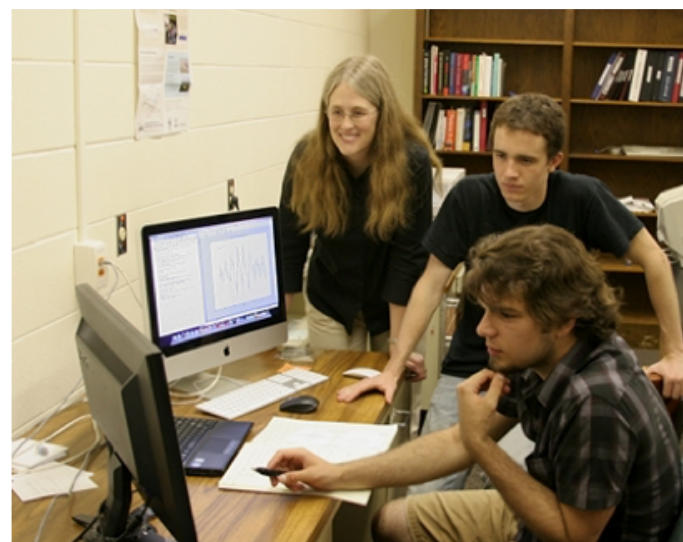
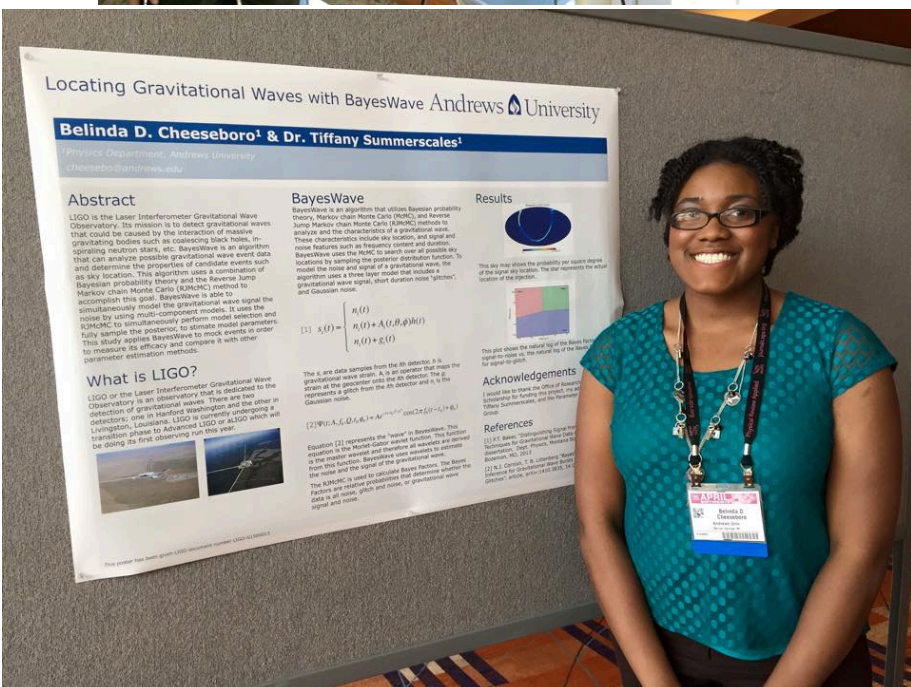
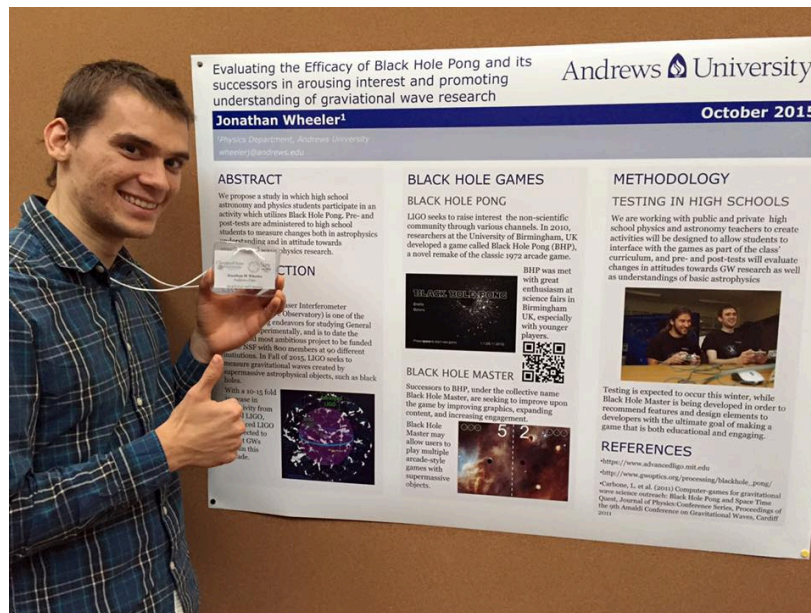
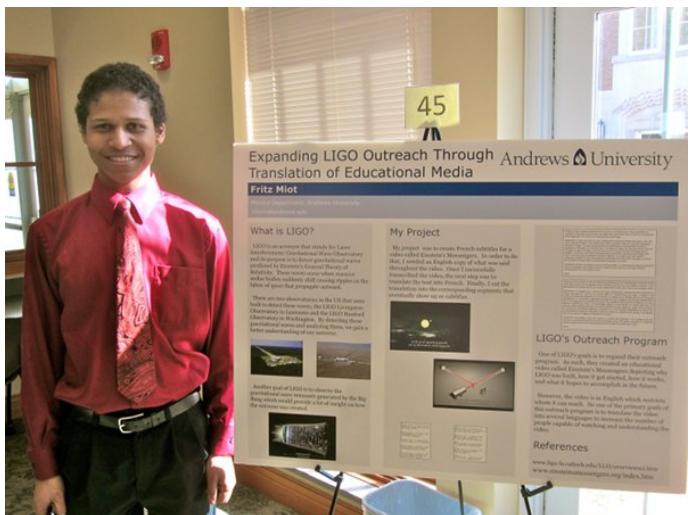


Image from <https://dcc.ligo.org/LIGO-P1500262>







Learn More About It!



- Join the Search for Gravitational Waves
 - » Einstein@Home <http://einstein.phys.uwm.edu/>
- Learn More about LIGO
 - » LIGO website <http://www.ligo.org>
 - » Einstein's Unfinished Symphony by Marcia Bartusiak