

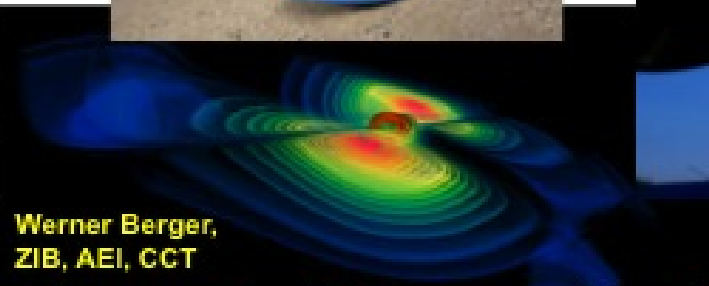
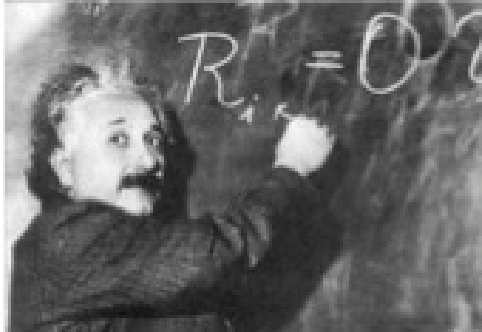
Title: How To Catch Einstein's Wave, and See Black Holes in the Process

Date: Feb 06, 2013 07:00 PM

URL: <http://pirsa.org/13020119>

Abstract: Gravitational waves are "ripples of space-time" that were predicted by Einstein's theory of General Relativity almost a century ago. The Laser Interferometer Gravitational-wave Observatory (LIGO) now pushes the frontiers of science and engineering to try and catch these waves for the first time. This will allow us to explore the last dance of pairs of neutron stars colliding to give birth to a black hole and other astrophysical events in a way humans never have before. Dr. Gonzalez will describe how a worldwide community of scientists is working to open a new window to the Universe searching for Einstein's gravitational waves.





Catching Einstein's waves

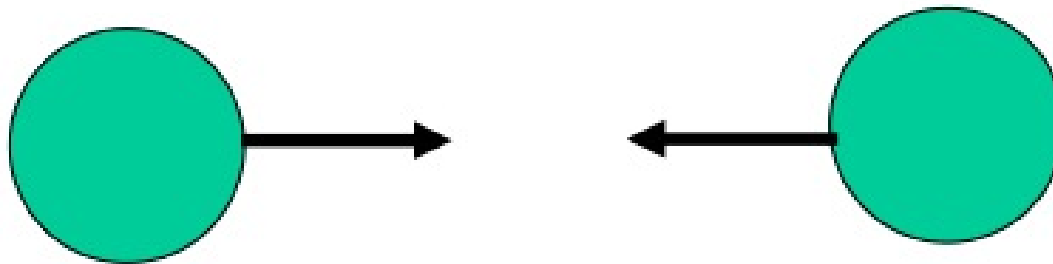


Gabriela González
Louisiana State University
Perimeter Institute
Waterloo, Ontario, Canada
February 6 2013

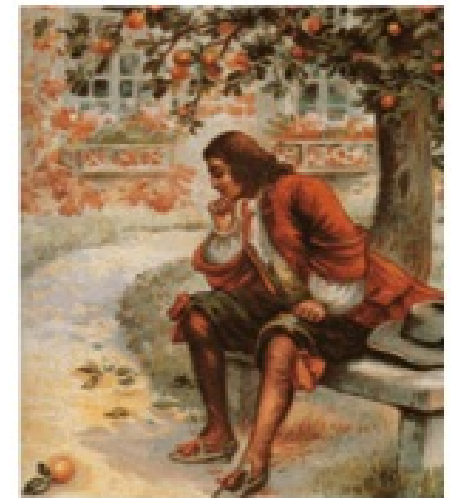


www.ligo.org

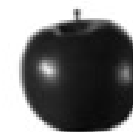
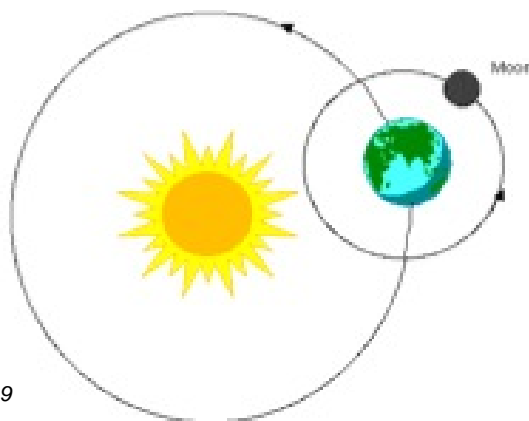
Newton's' gravity



“Newton’s law”: $F = Gm_1m_2/r^2$

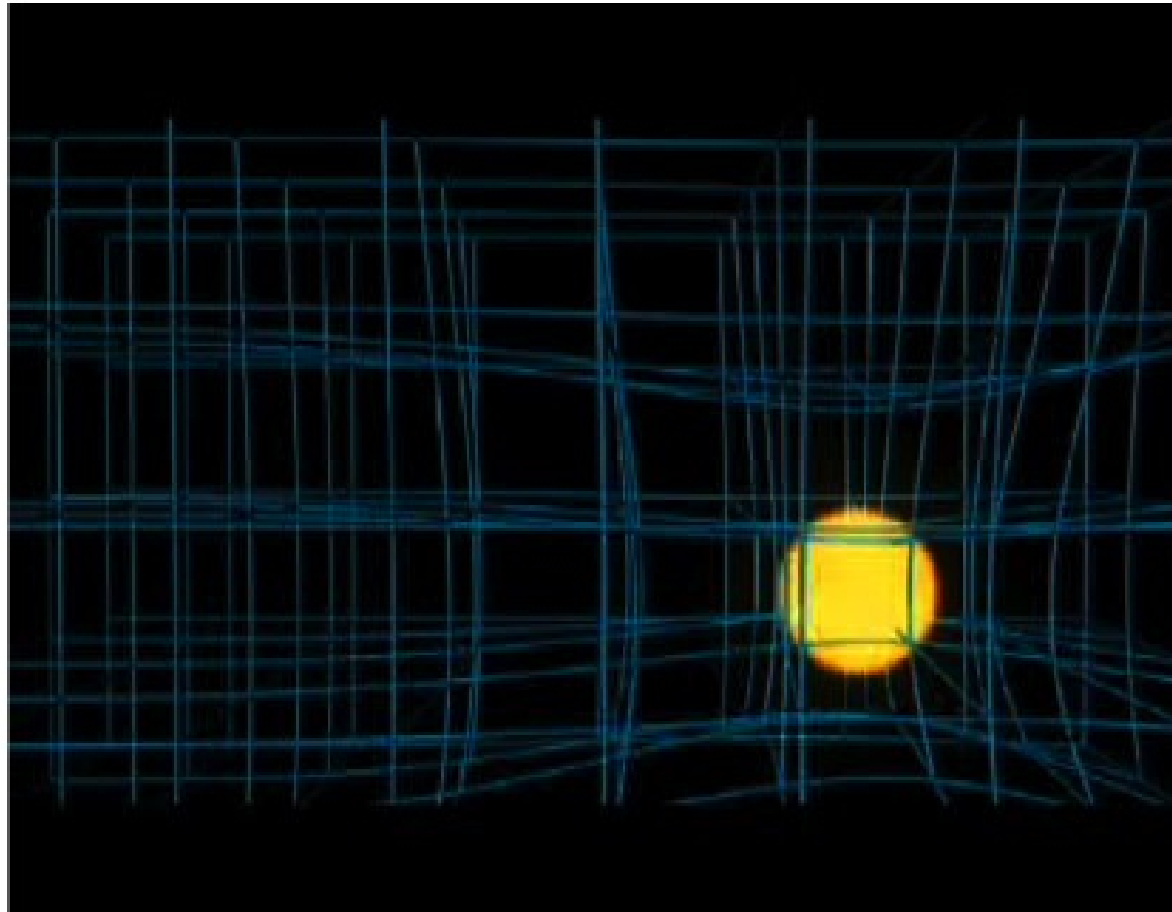
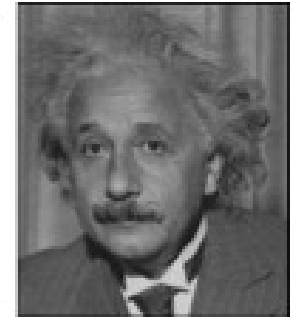


Explains why apples fall, why the planets move around the Sun,...





Einstein's gravity



sciencebulletins.amnh.org
And in YouTube!



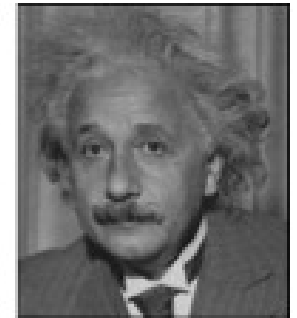
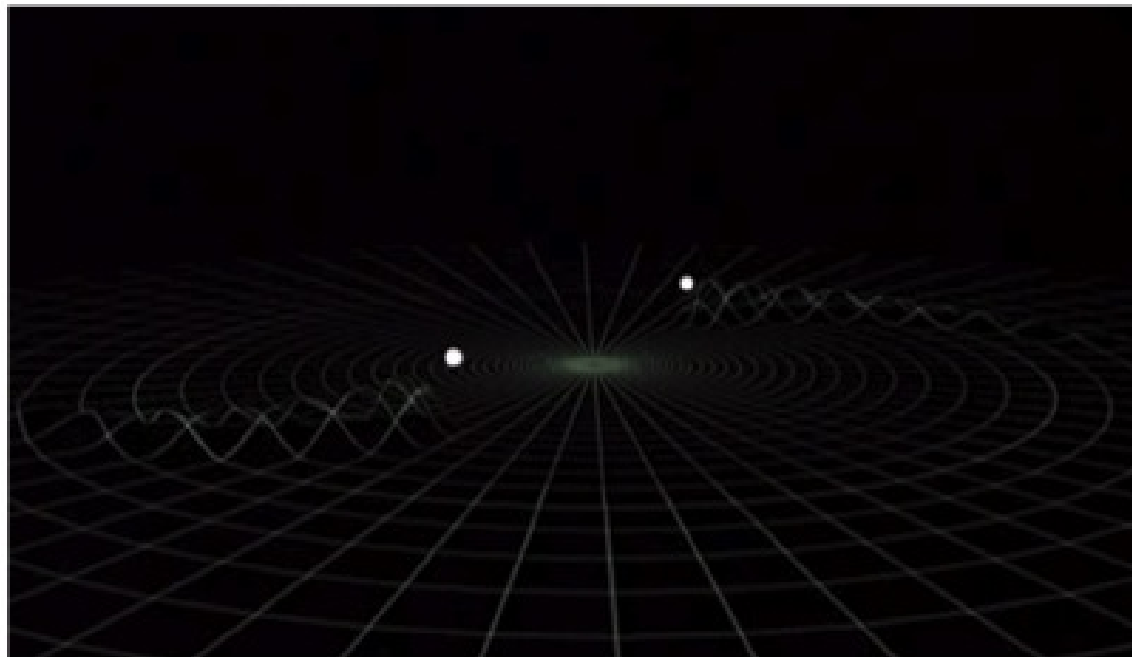
Einstein's gravitation



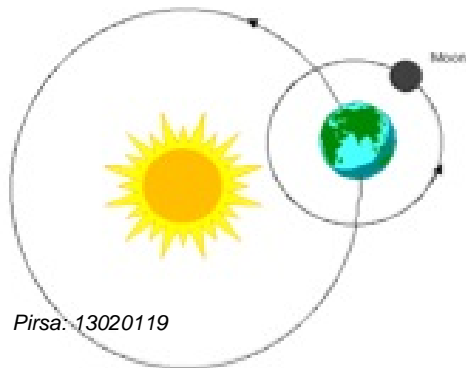
When masses move, they wrinkle the space time fabric, making other masses move...



Explains just as well as Newtons' why things fall and planetary motion...

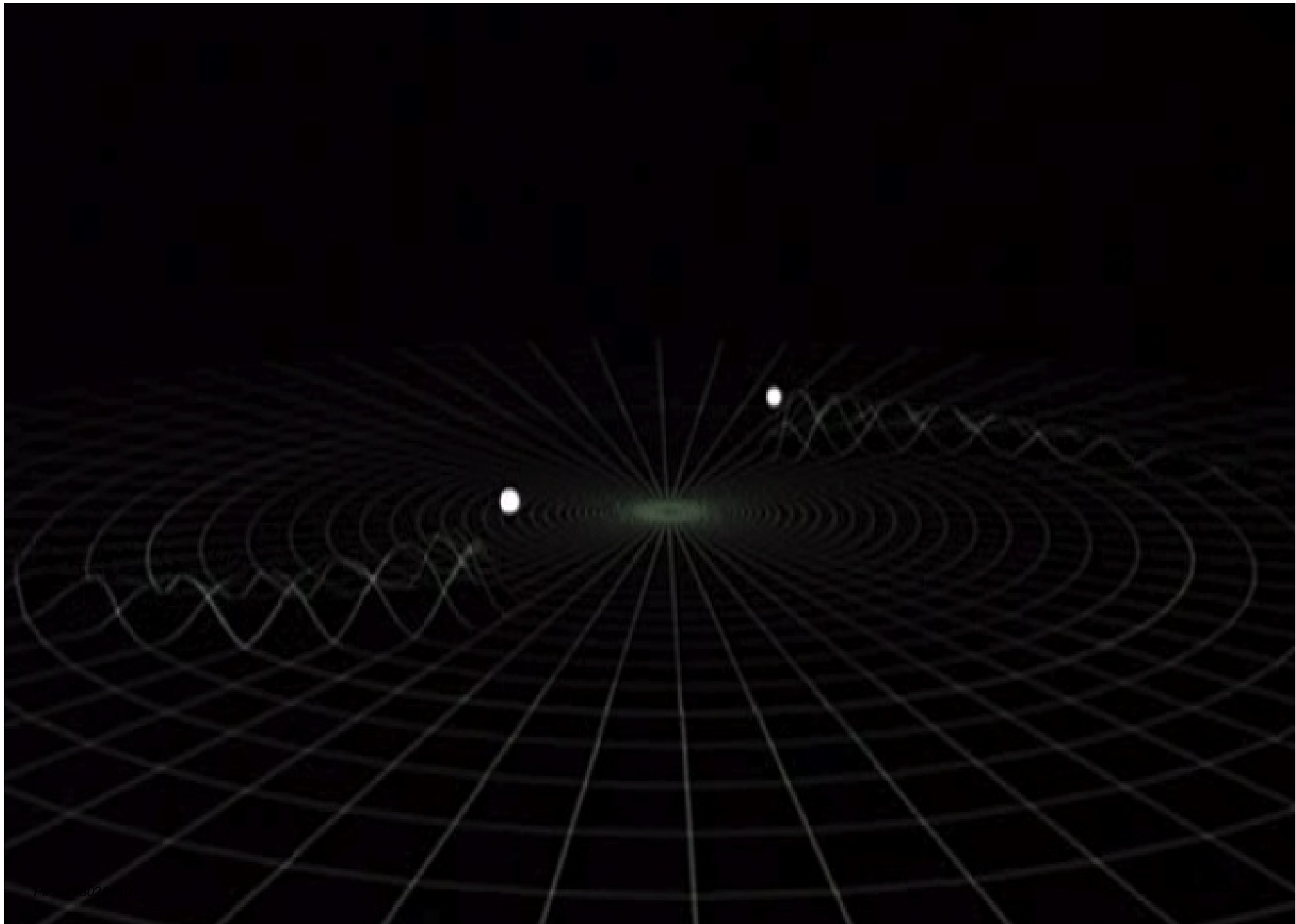


Einstein's messengers,
National Science Foundation video
www.einsteinsmessengers.org

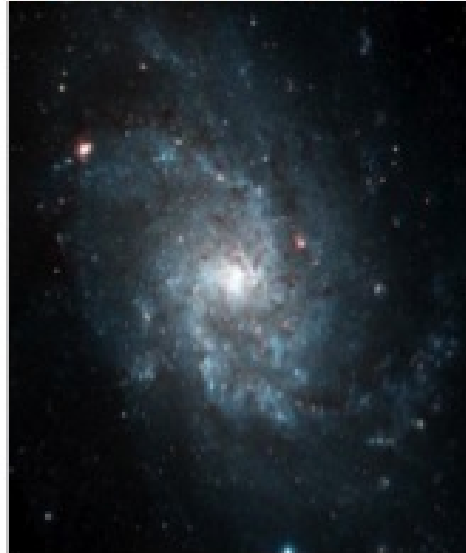


Pirsa: 13020119

.. but it also predicts **gravitational waves** traveling away from moving masses!

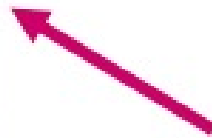
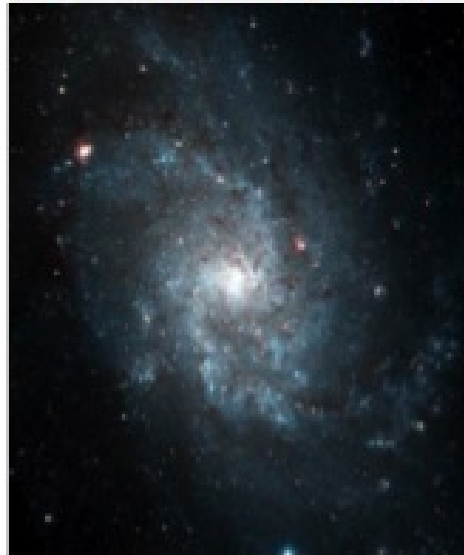


From stars living in galaxies...



**Where do gravitational
waves come from?**

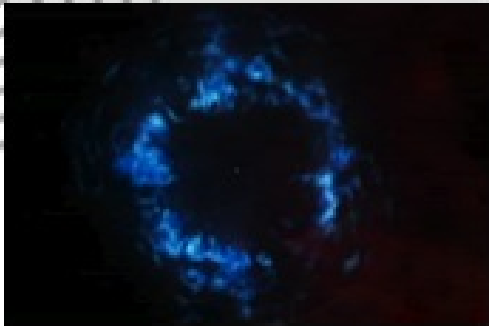
From stars living in galaxies...



Supernova explosions
(that form a BH or a NS)

**Where do gravitational
waves come from?**

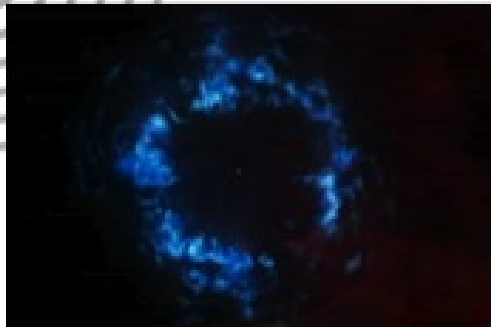
From stars living in galaxies...



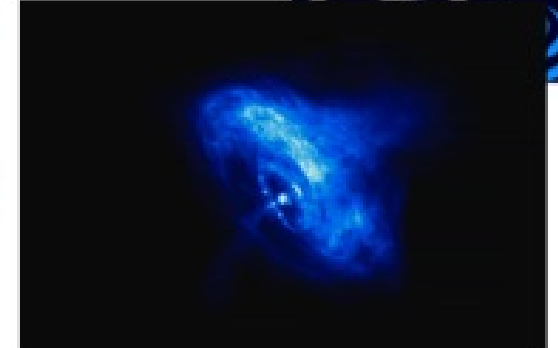
Rotating stars (pulsars)

Where do gravitational waves come from?

From stars living in galaxies...

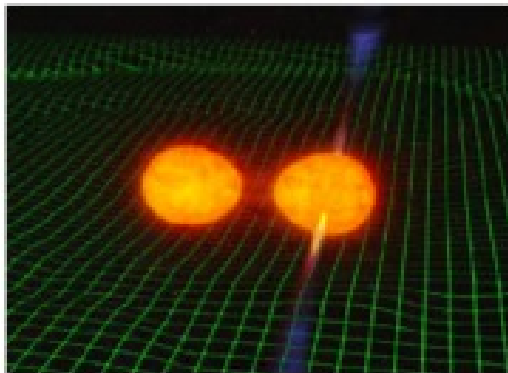


Supernova explosions



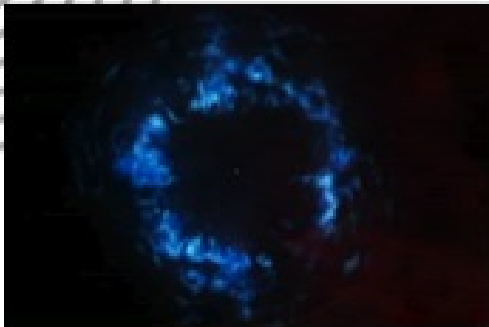
Rotating stars (pulsars)

Where do gravitational waves come from?

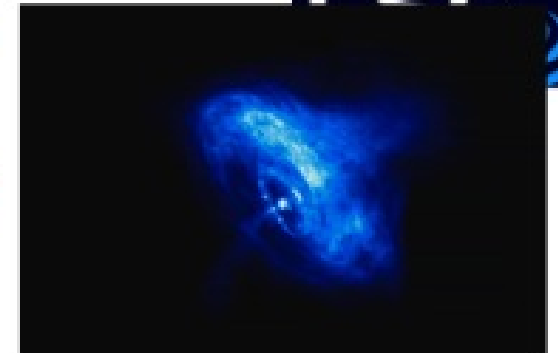


Binary systems coalescing into a black hole

From stars living in galaxies...

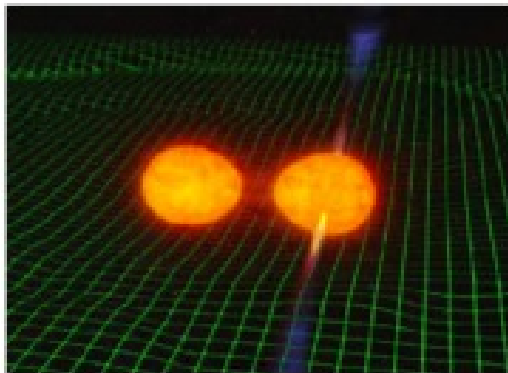


Supernova explosions



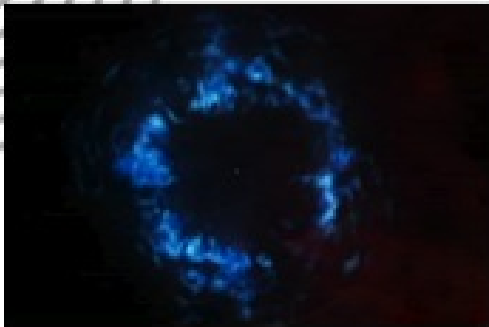
Rotating stars (pulsars)

Where do gravitational waves come from?

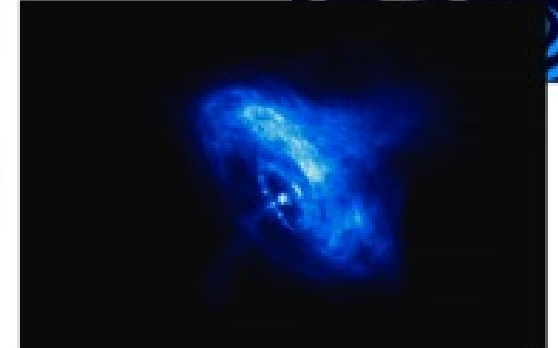


Binary systems coalescing into a black hole

From stars living in galaxies...



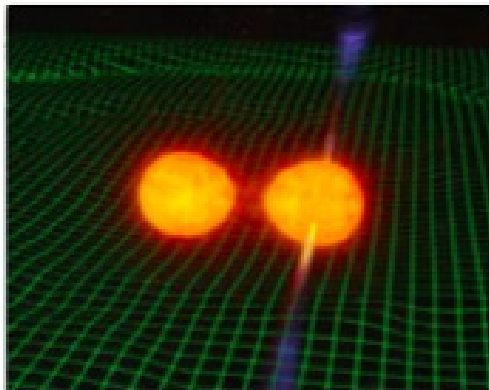
Supernova explosions



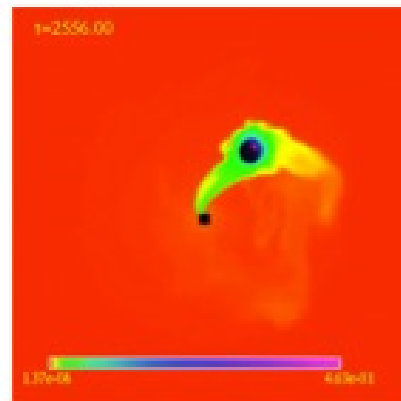
Rotating stars (pulsars)

Where do gravitational waves come from?

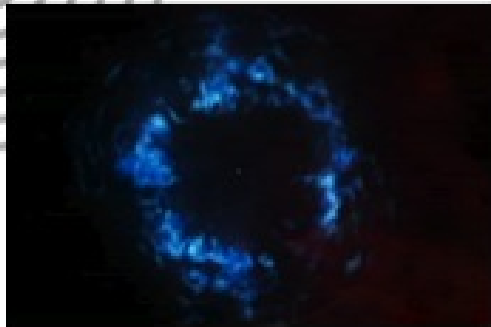
Credit: John Rowe



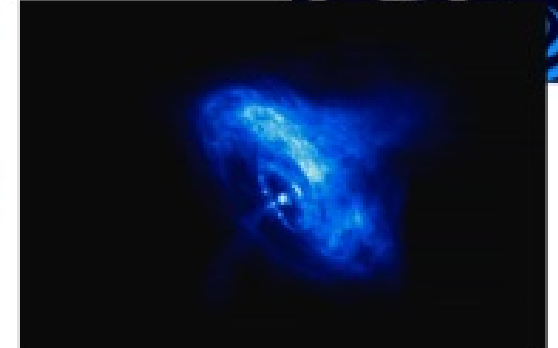
Binary systems coalescing into a black hole



From stars living in galaxies...

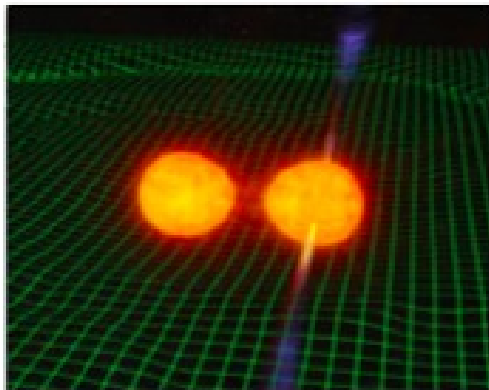


Supernova explosions

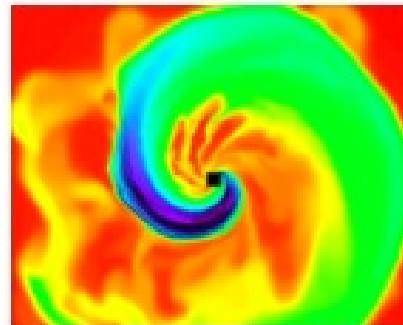


Rotating stars (pulsars)

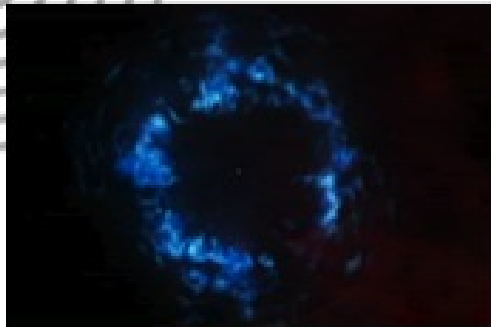
Where do gravitational waves come from?



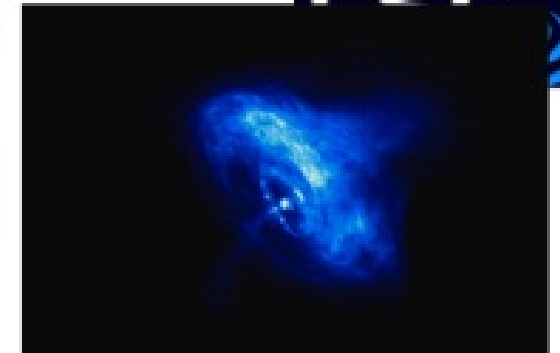
Binary systems coalescing into a black hole



From stars living in galaxies...

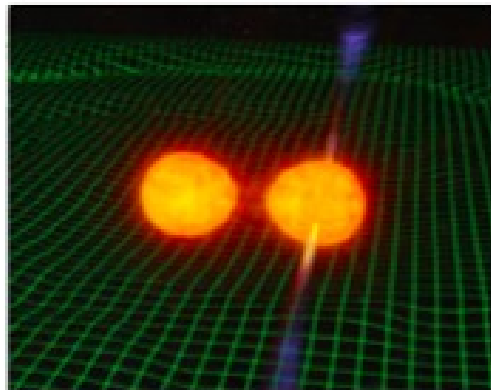


Supernova explosions

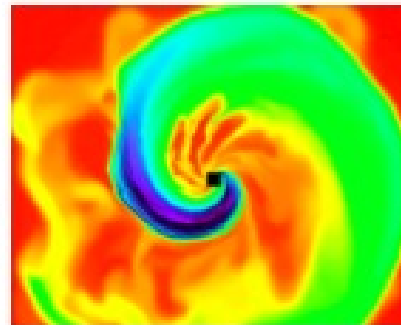


Rotating stars (pulsars)

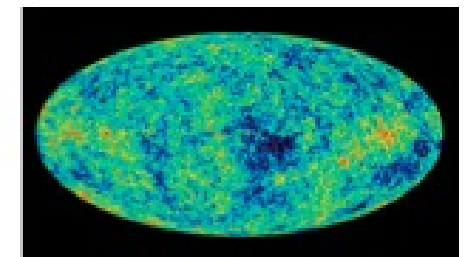
Where do gravitational waves come from?



Binary systems coalescing into a black hole

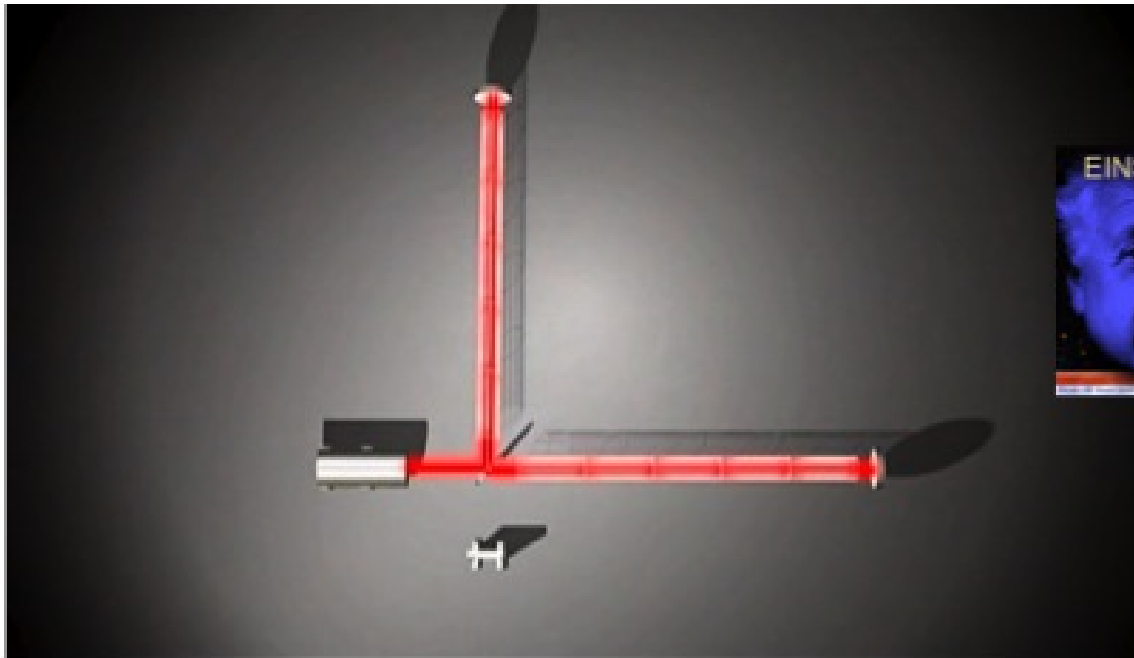


..and from the beginning of the Universe!





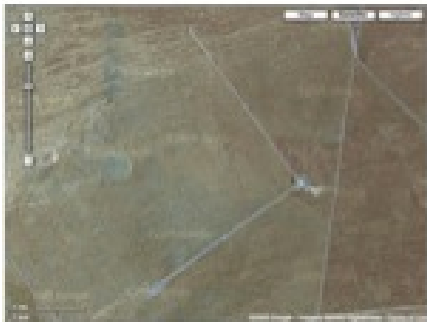
How to detect gravitational waves with an interferometer



Einstein's messengers,
National Science Foundation video



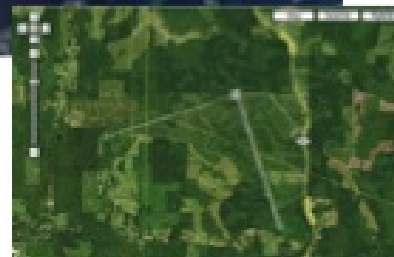
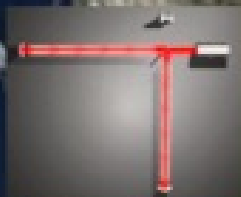
The LIGO Observatories



Hanford, WA



Livingston, LA

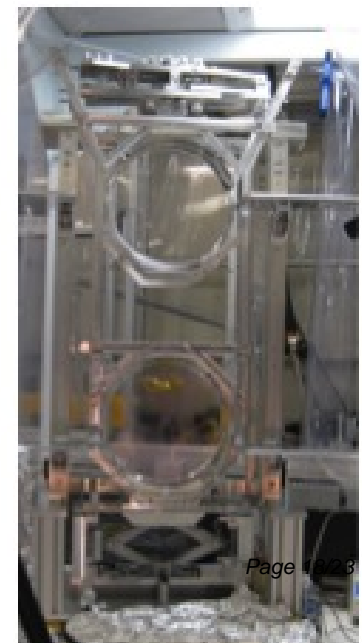
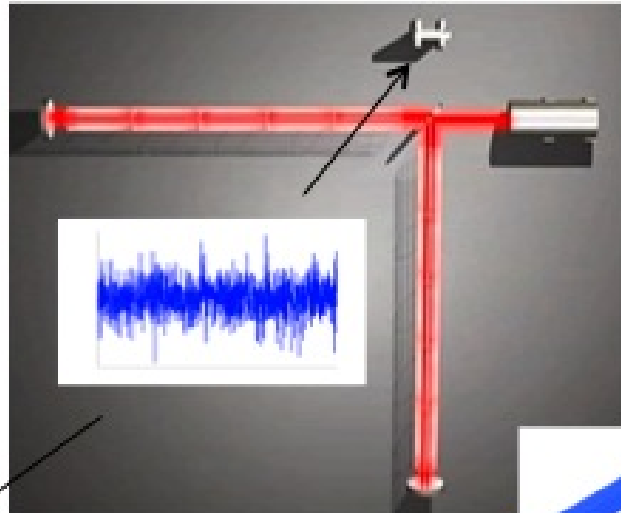




GW Detection:



a difficult and fun experiment





Read more on Advanced LIGO!



www.ligo.org/magazine

LIGO

The Advanced GW Detector Network

Advanced LIGO

Hanford



GEO600

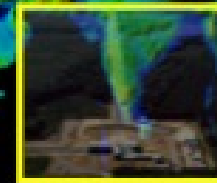


Advanced
Virgo



Advanced LIGO

Livingston



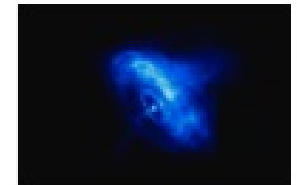
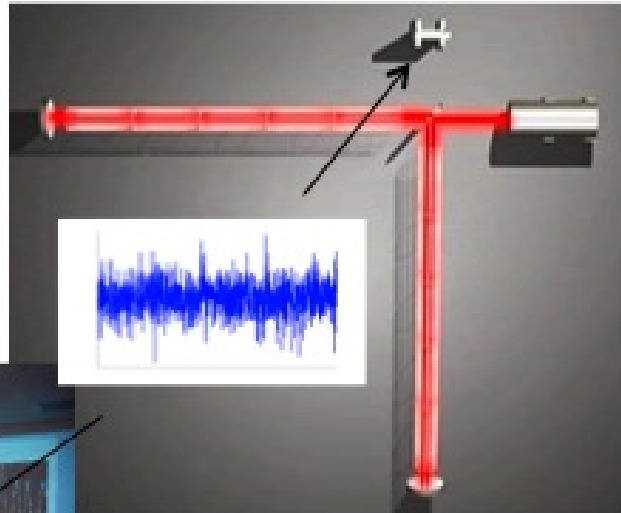
LIGO-India



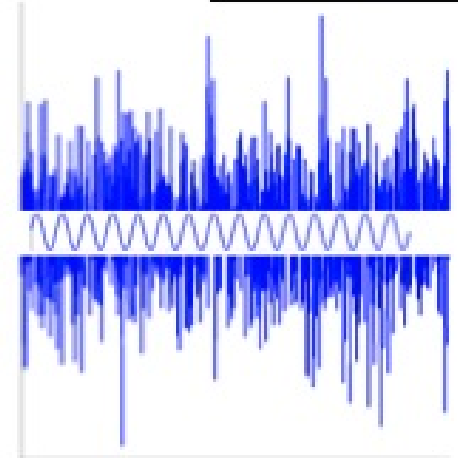
KAGRA



GW Detection: a difficult and fun experiment



Find signal:



In noise:

You can help!





How sensitive are the detectors? (how many signals have we seen?)



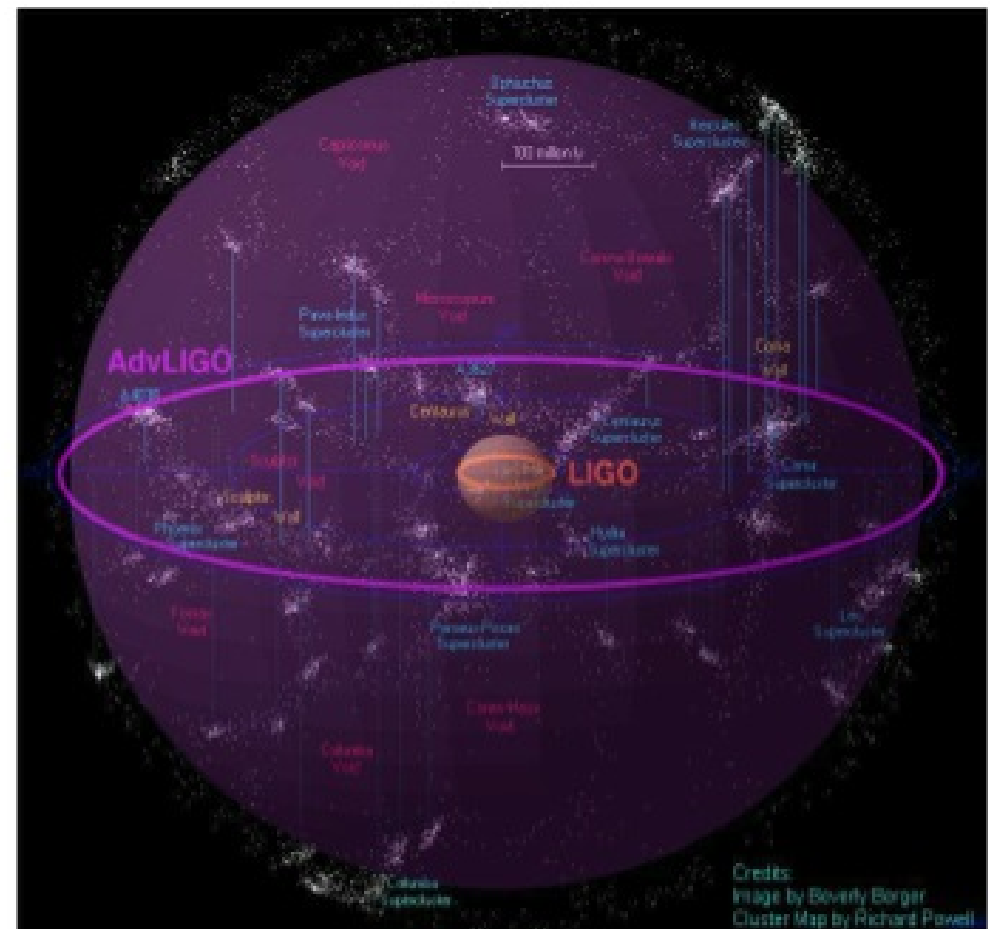
Average reach and rate for Neutron Star Binaries:

“Initial” LIGO detectors (2005-2011):
~50 million light years
→ detection rate ~1 per 50yrs

*No signals have been detected in the
data yet*

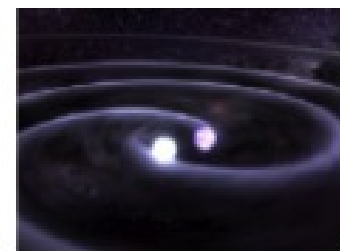
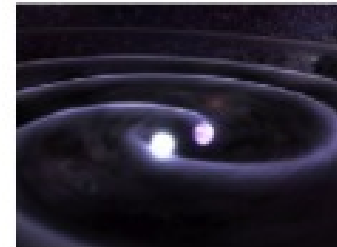
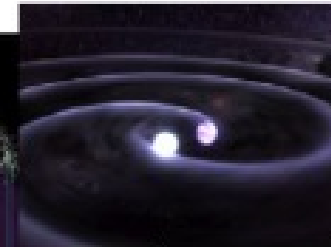
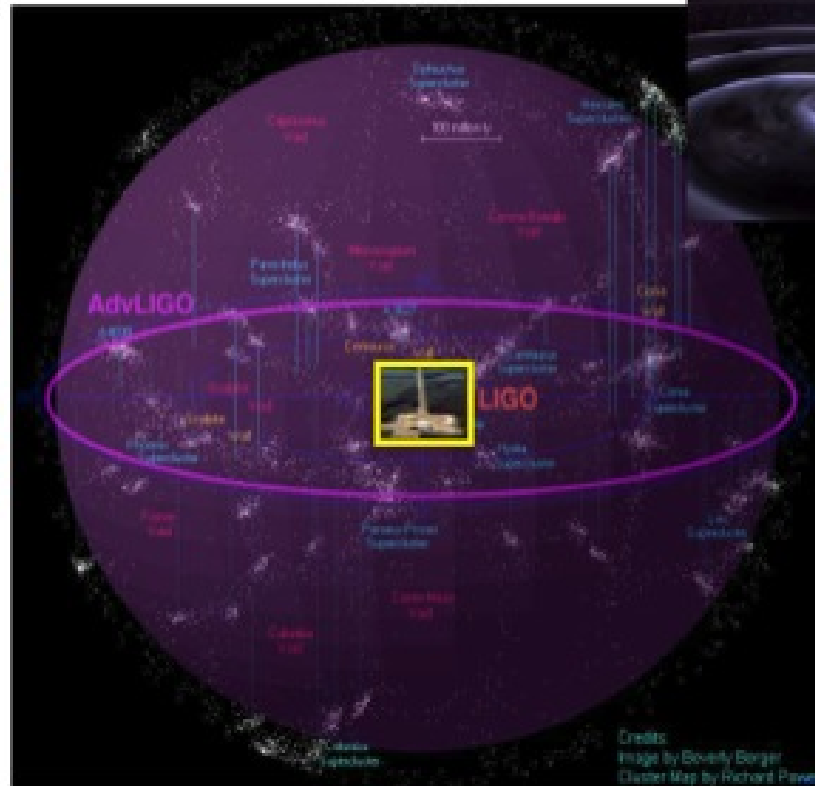
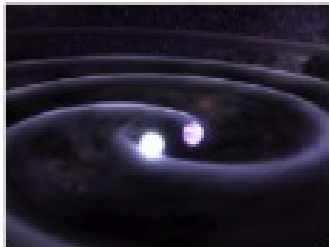
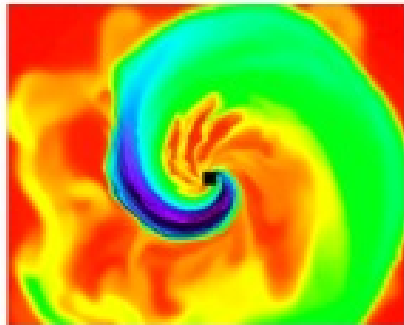
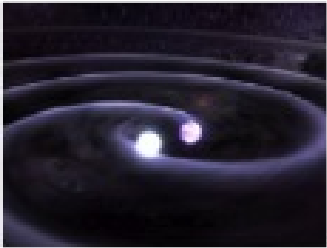
“Advanced” LIGO detectors:
~ 300 Mly in 2016-17 (or better!),
~ 600 Mly in ~2020

Realistic rate ~ 4-40/year !





Gravitational waves are coming!



Questions?

gonzalez@lsu.edu

Also, visit www.ligo.org for more info,
download the movie in www.einsteinsmessengers.org,
and sign up to help us in www.einsteinathome.org