

BLACK HOLES & GRAVITATIONAL WAVES: LIGO'S NEW VIEW OF THE COSMOS

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STORYLINE

Seeing the Cosmos

Modern Gravity

Listening to the Cosmos
with gravity

The COSMOS

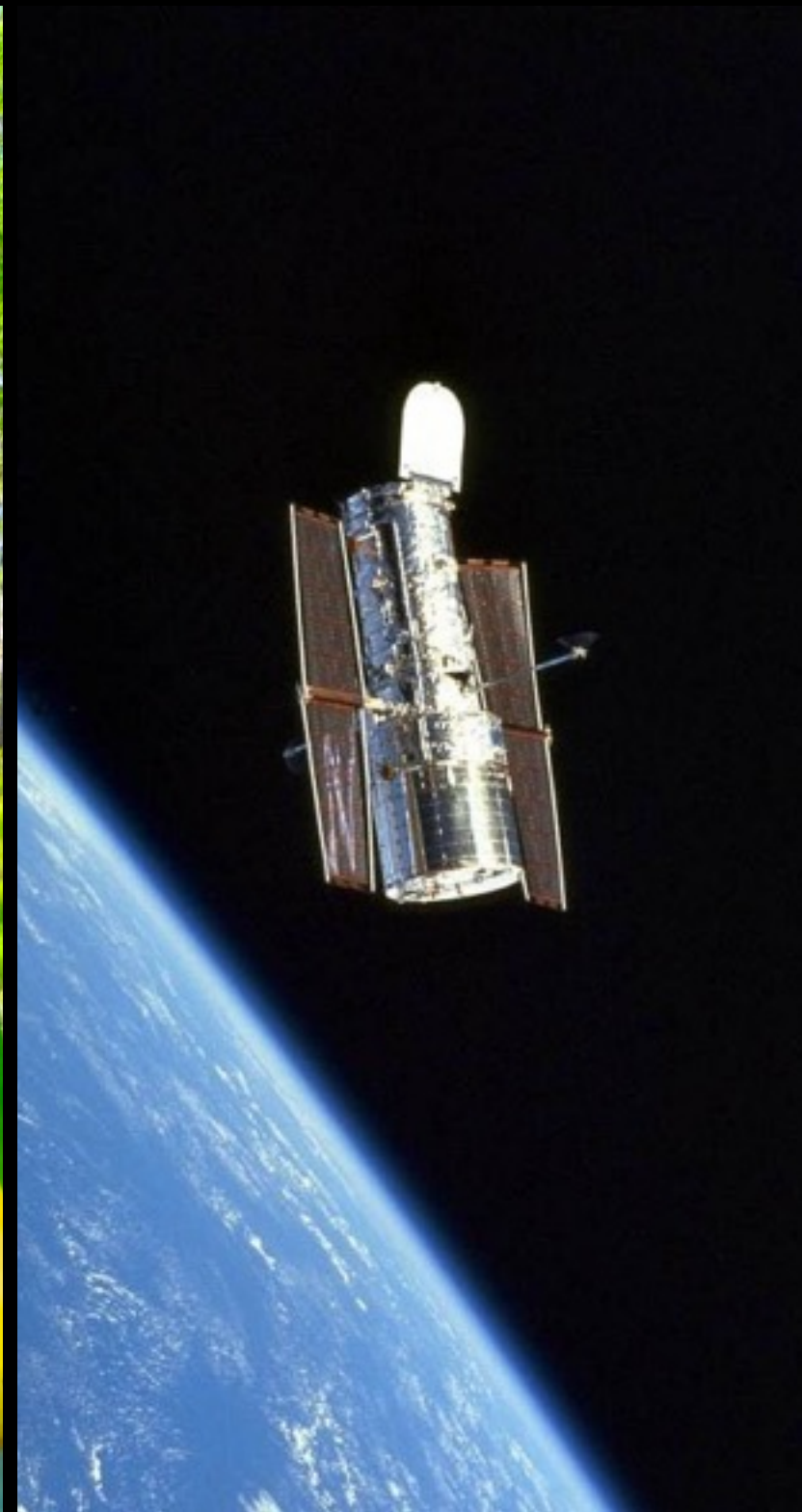


1609: Galileo used a **telescope**



What he saw transformed the Cosmos...
in a way, he **made** the Cosmos.


Telescopes





*Light tells the stories of atoms and the
things that happen to them...*

*The beautiful things we see in the sky are
often the Universe obscuring light...*



*But there are more things in the Cosmos
than what we can see with light...*

Dim stars

Black Holes

Dark Matter

*Everything moves and changes under
the influence of **gravity**.*

Albert Einstein: 1905 (the Miracle Year)

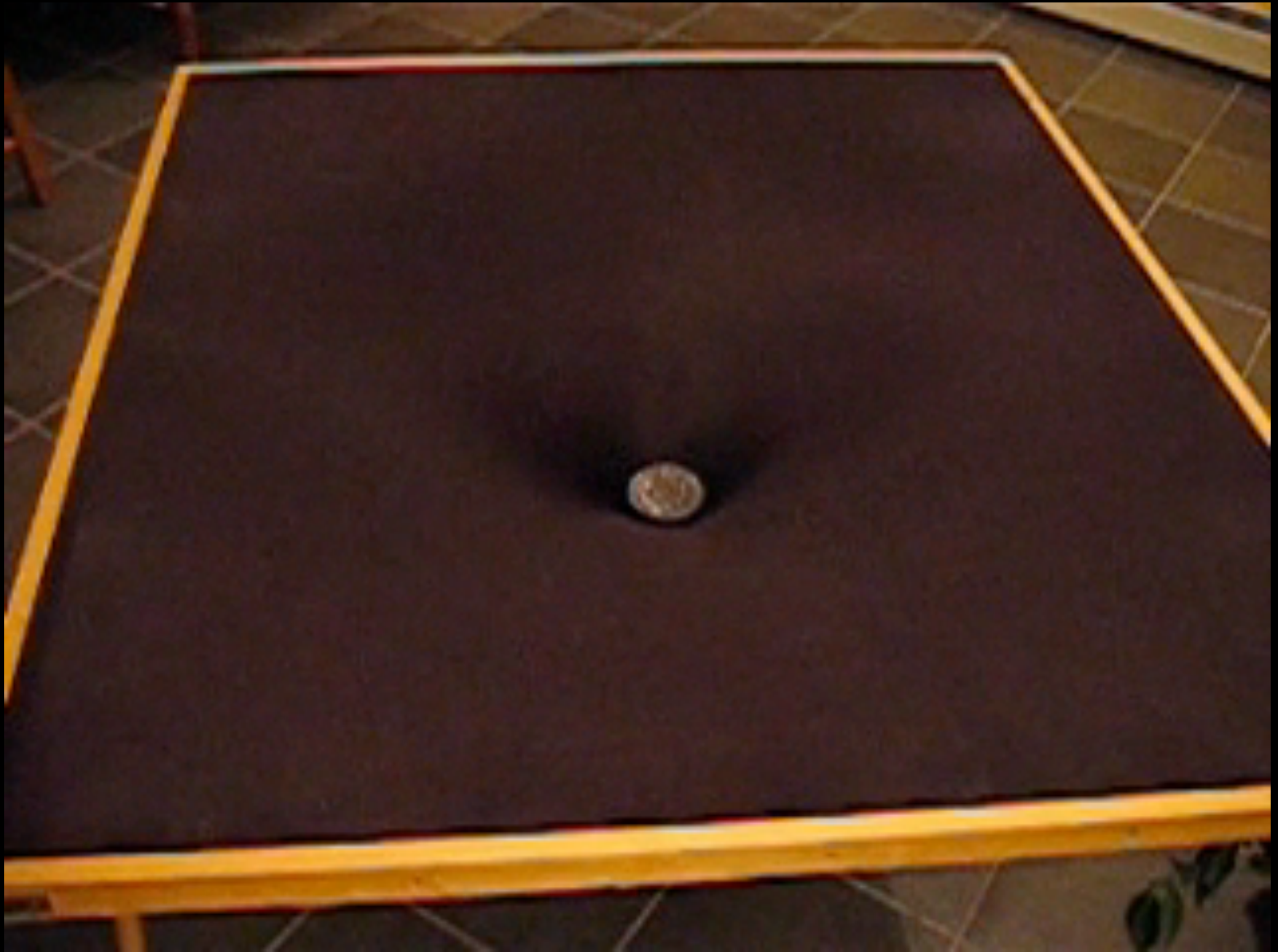
*Special Relativity:
Nothing can travel faster
than the speed of light.*

***Gravity cannot travel
faster than light!***

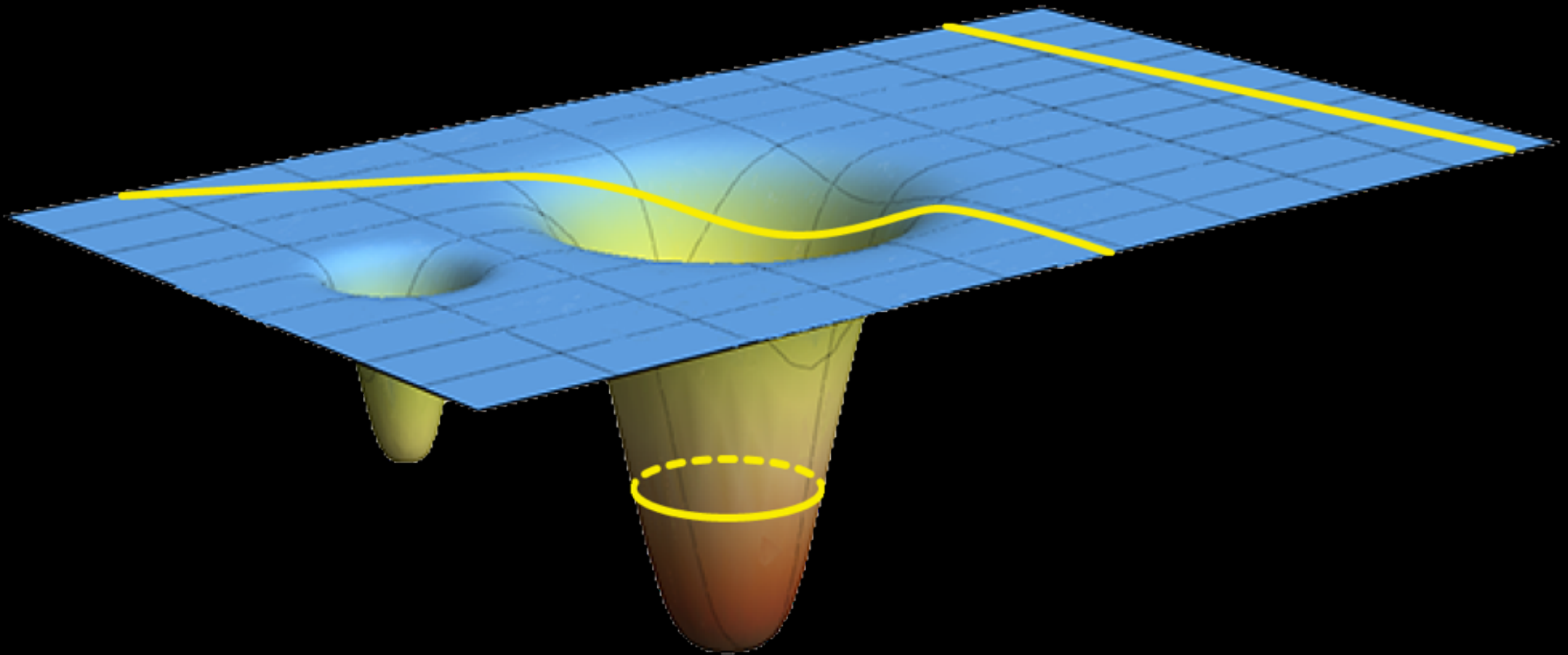




When there is no gravity, particles travel in straight lines.



When there is gravity, particles travel on curved lines.

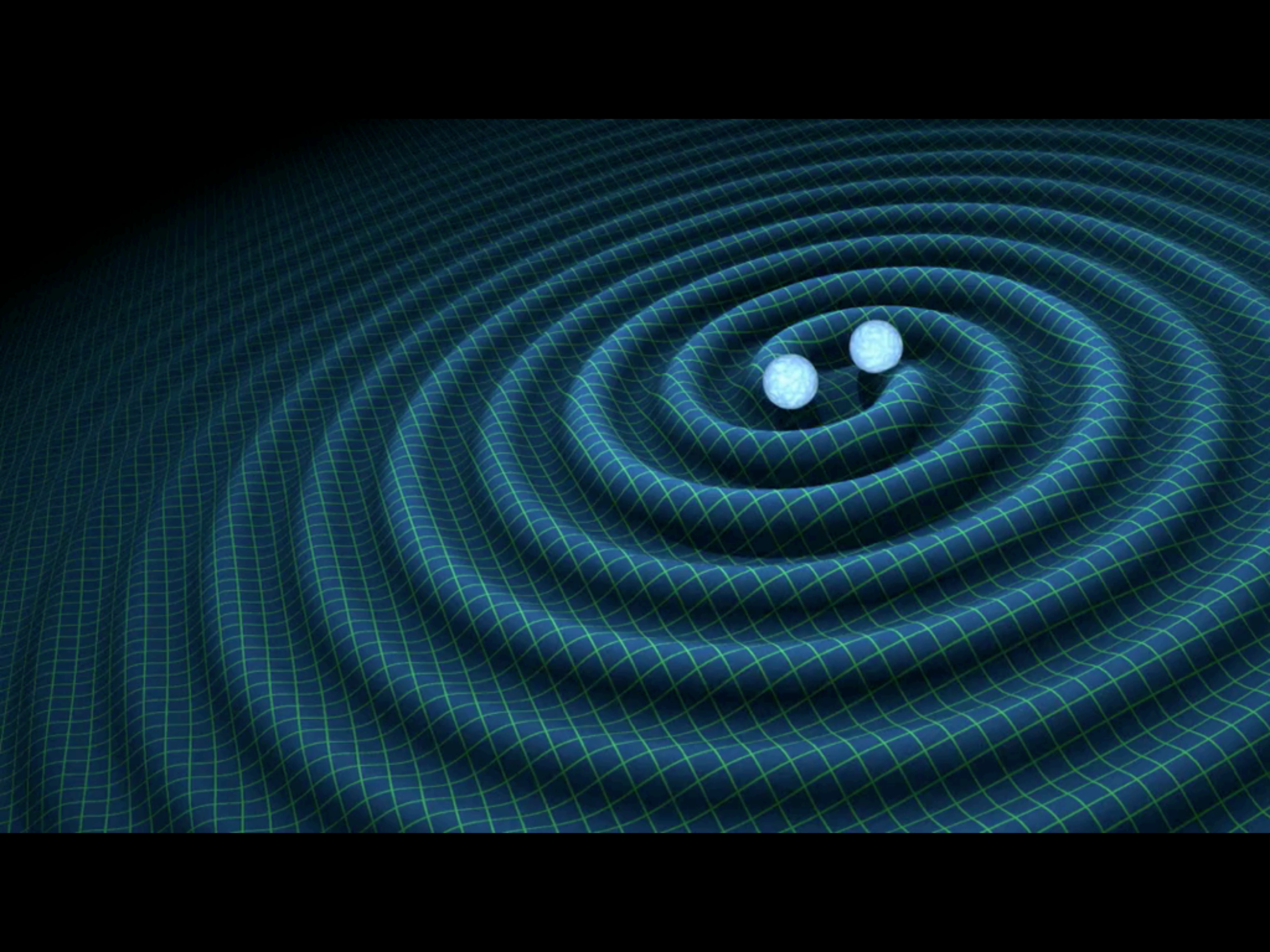


*Matter tells spacetime how to curve.
Spacetime tells matter how to move.*

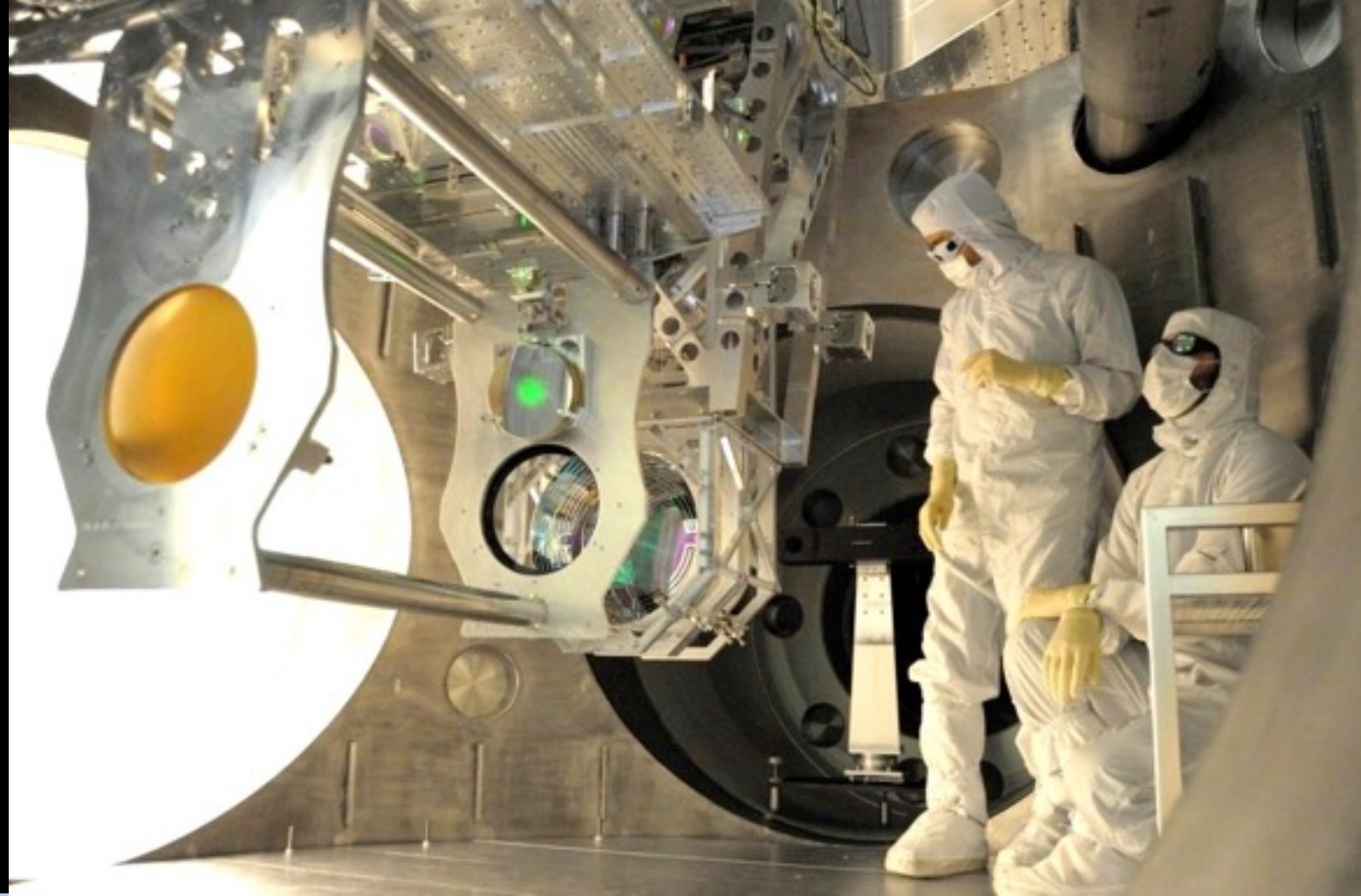


$G_{\mu\nu} = 8\pi T_{\mu\nu}$
MONTANA STATE UNIVERSITY
SOCIETY OF PHYSICS STUDENTS

**THEY
BOUGHT
IT**



LIGO

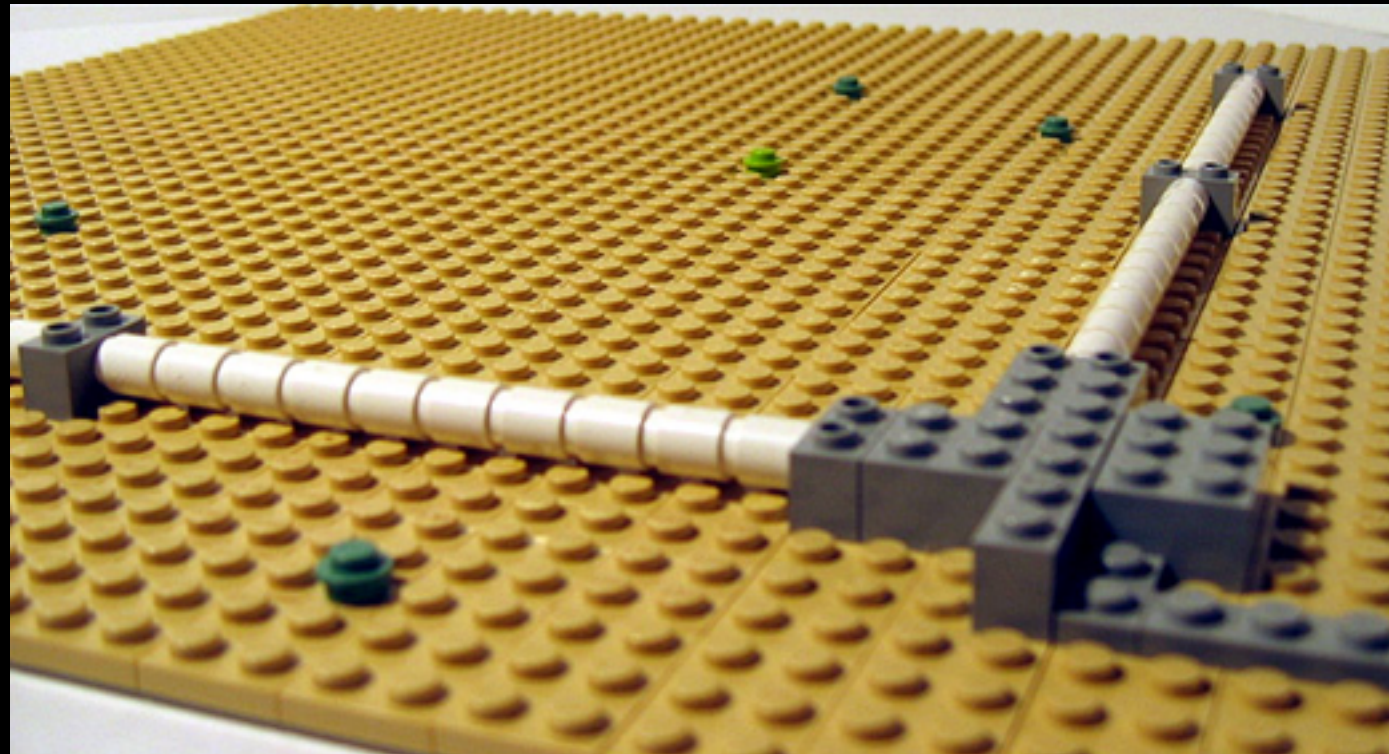
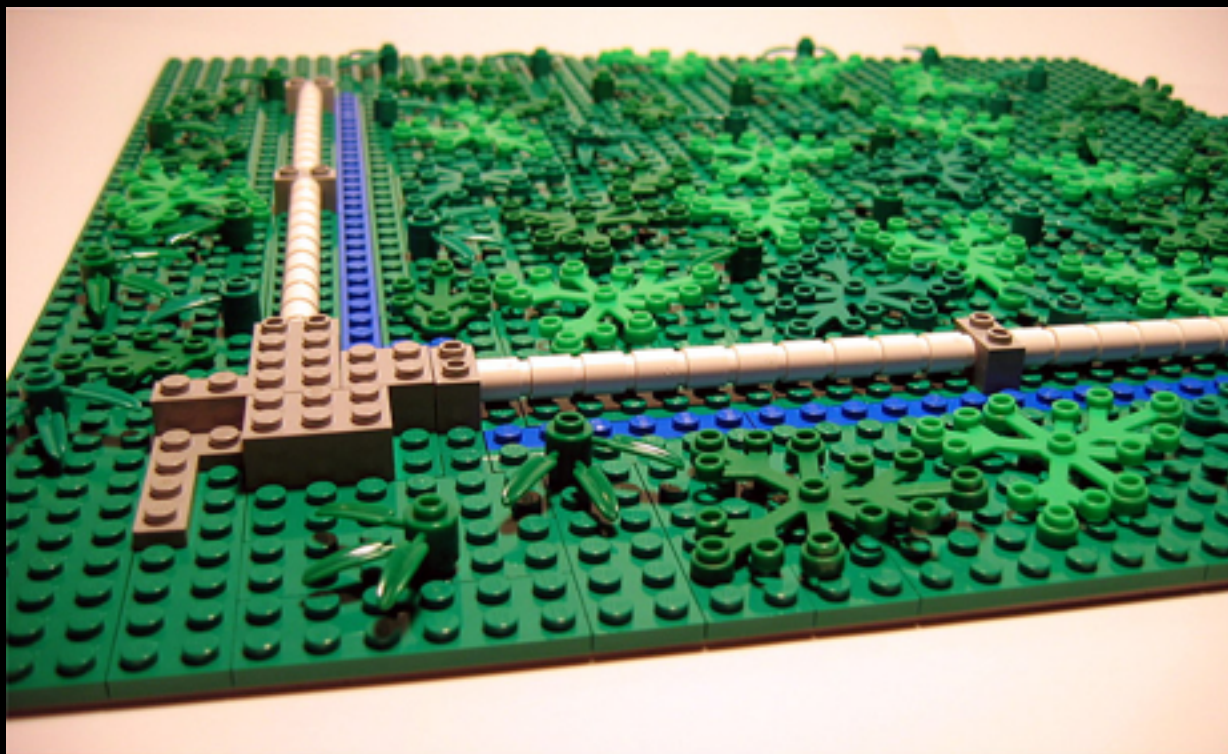
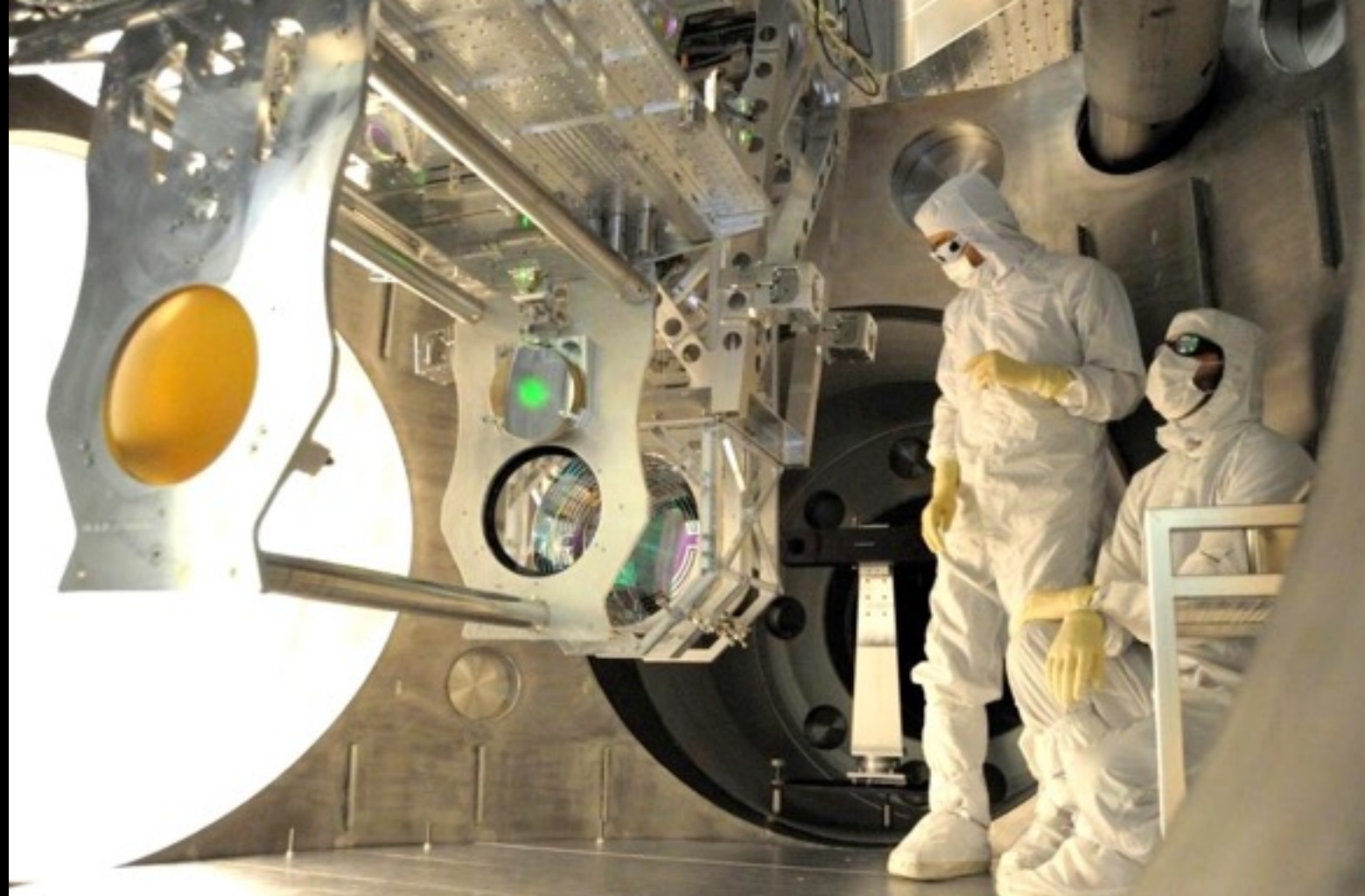


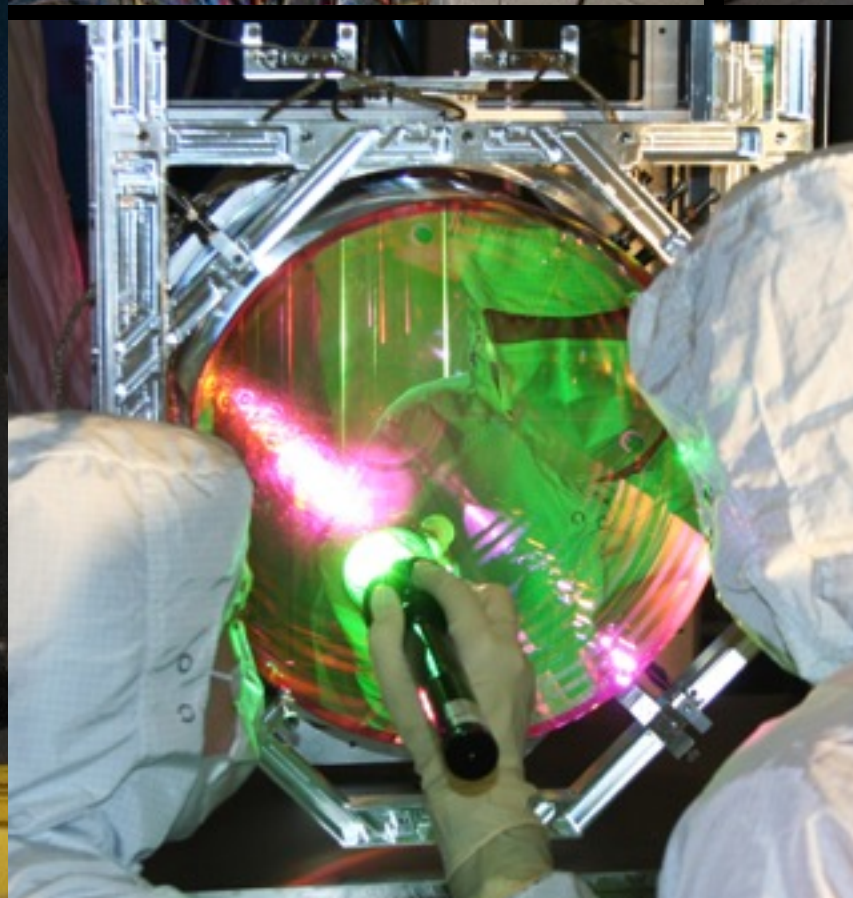
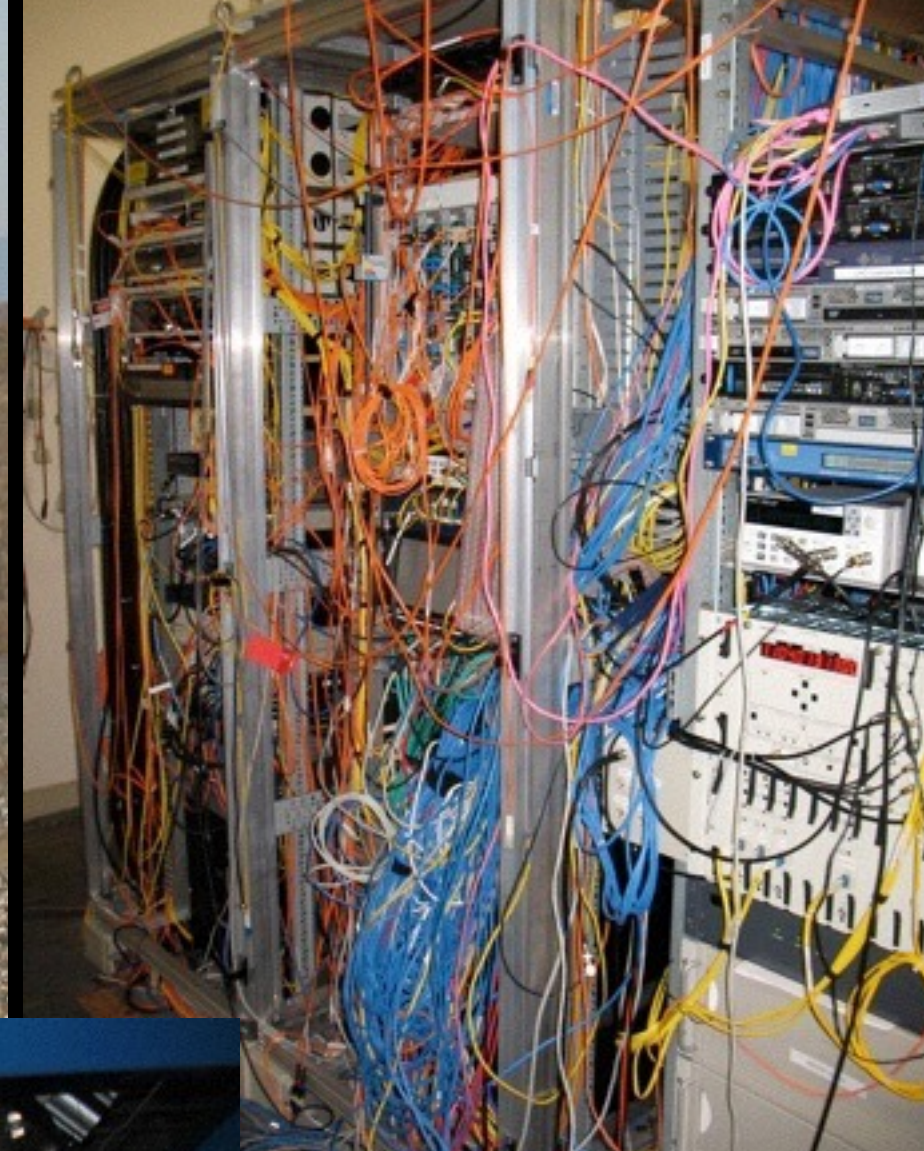
LIGO – Livingston, LA



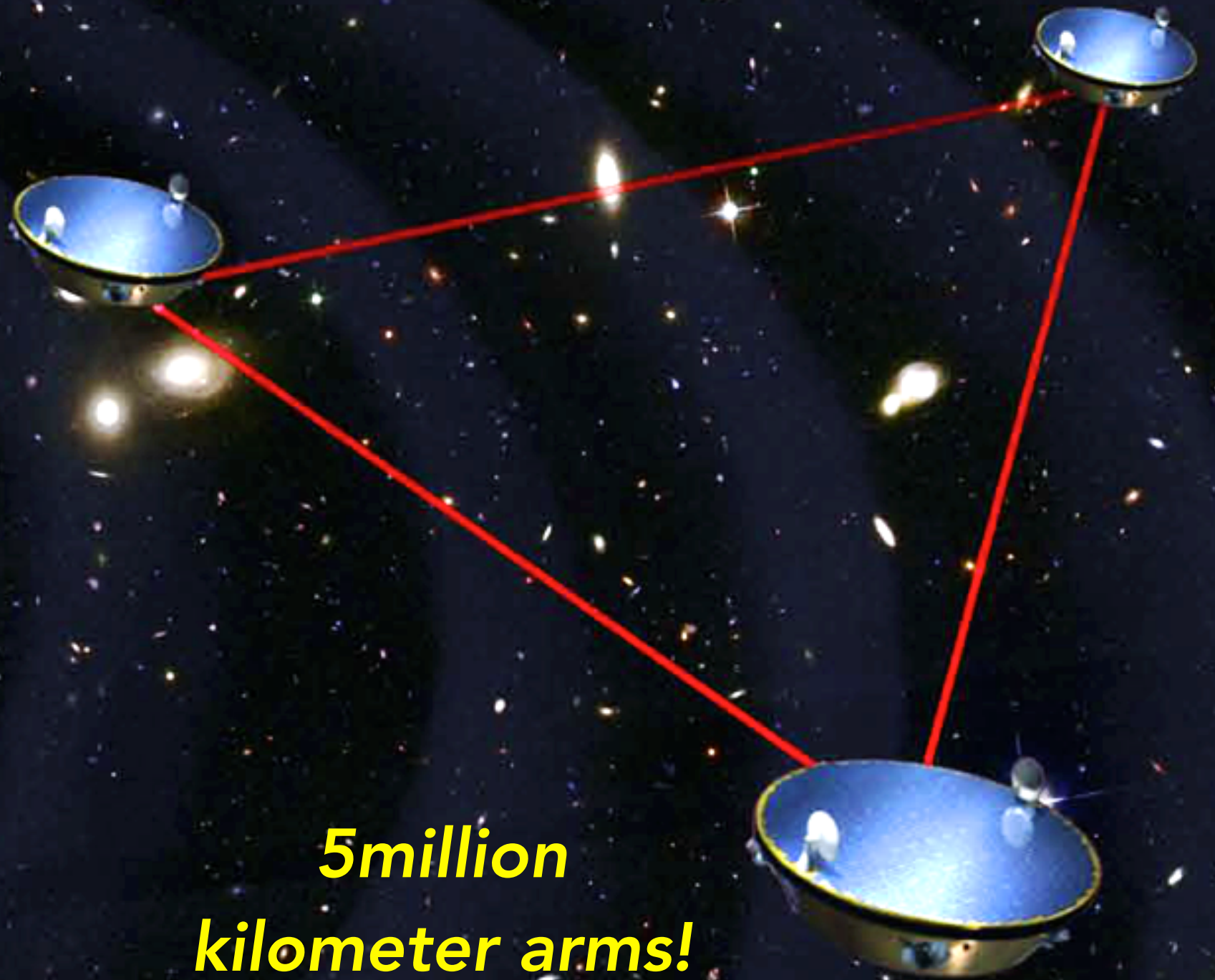
LIGO – Hanford, WA

LIGO



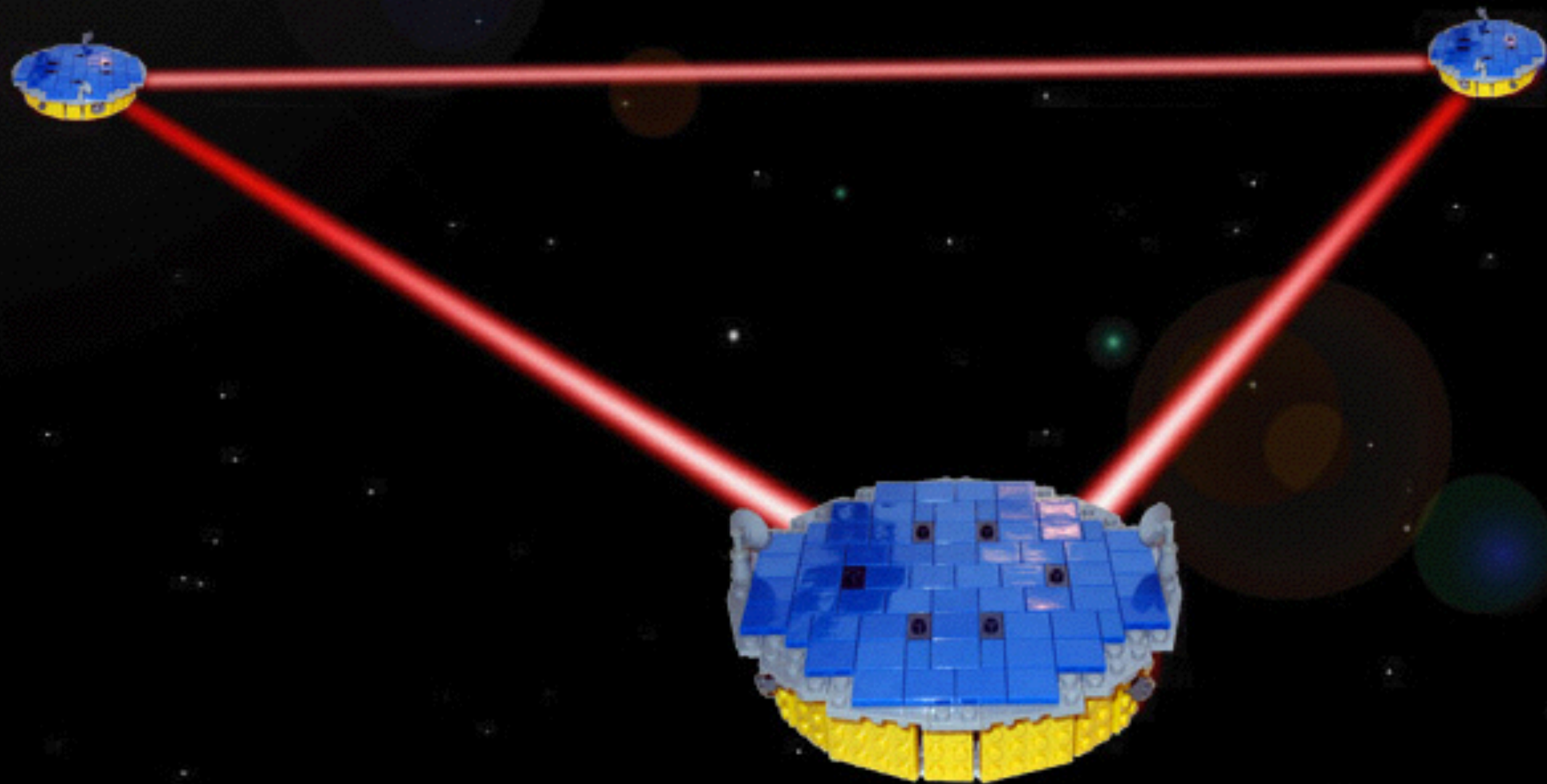


LISA



**5million
kilometer arms!**

LISA



LISA Pathfinder



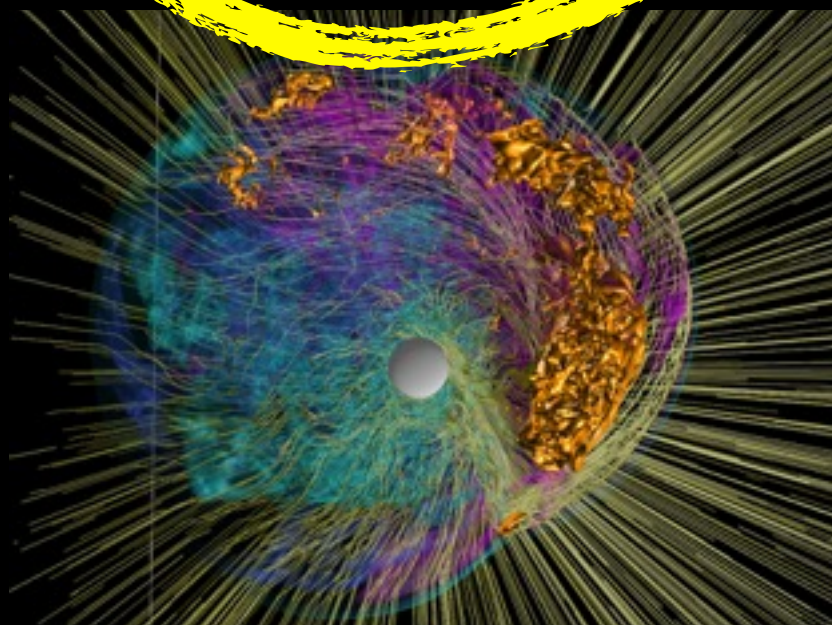
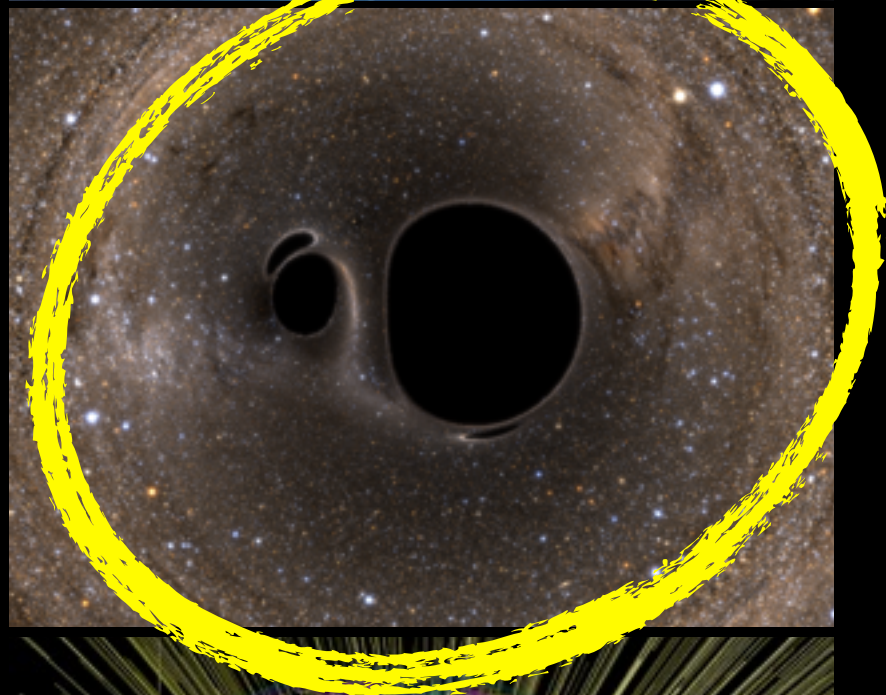


This is all nice...

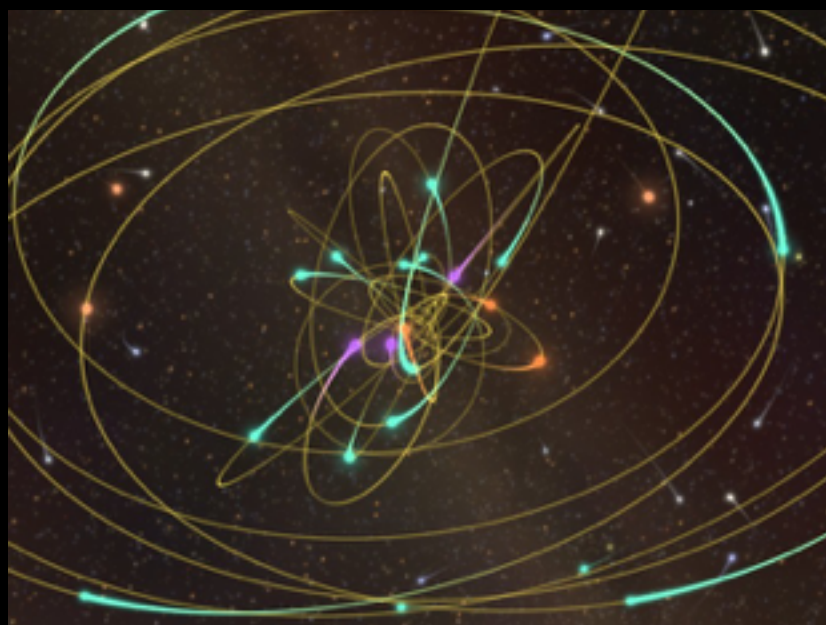
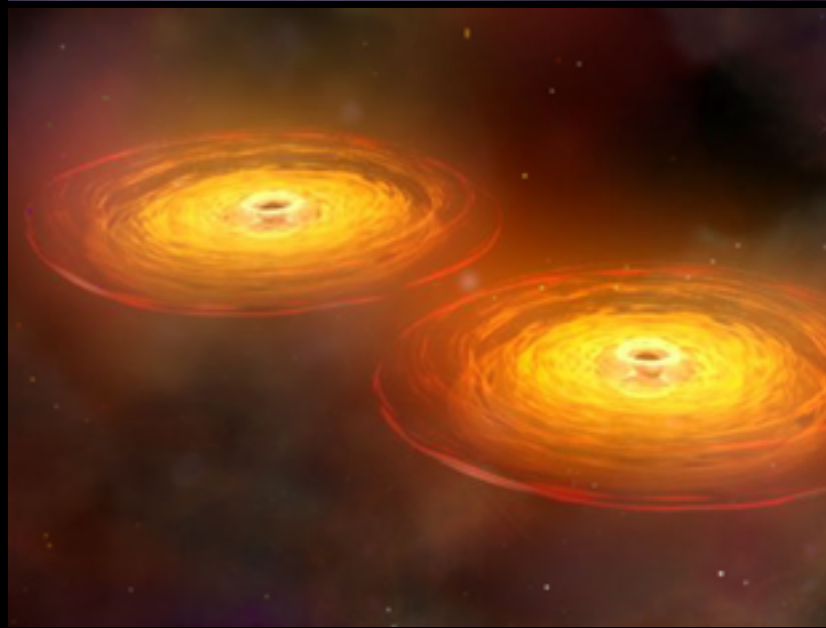
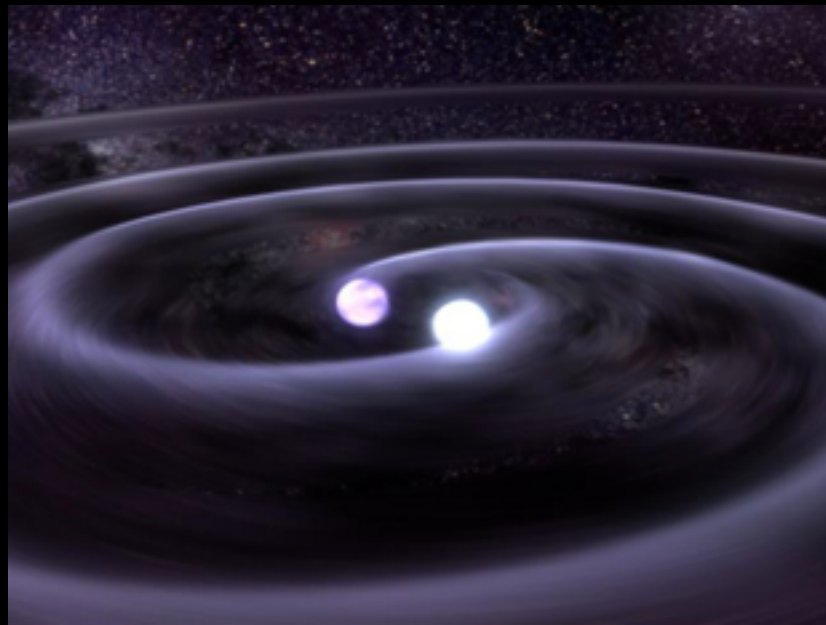
...but what can we "see"?

***Any dynamical motion of mass will
generate gravitational waves.***

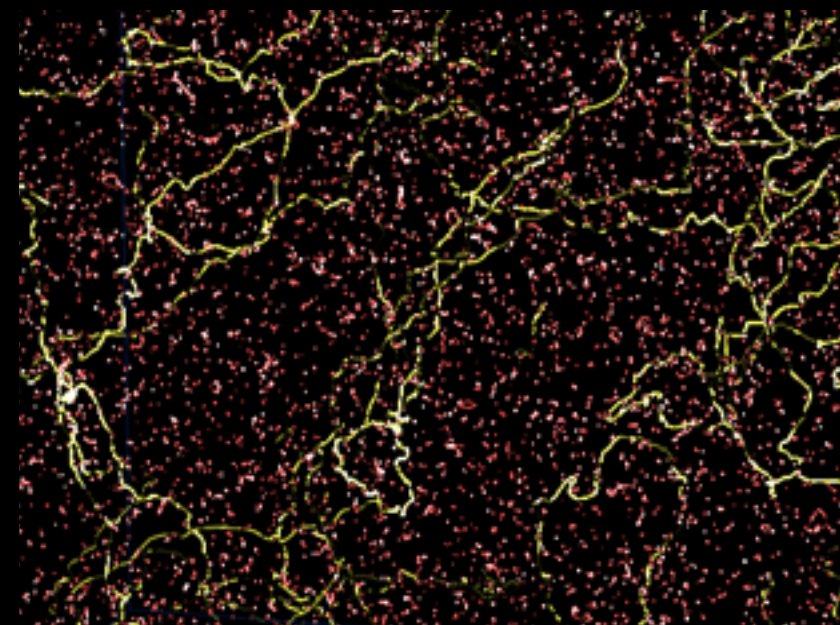
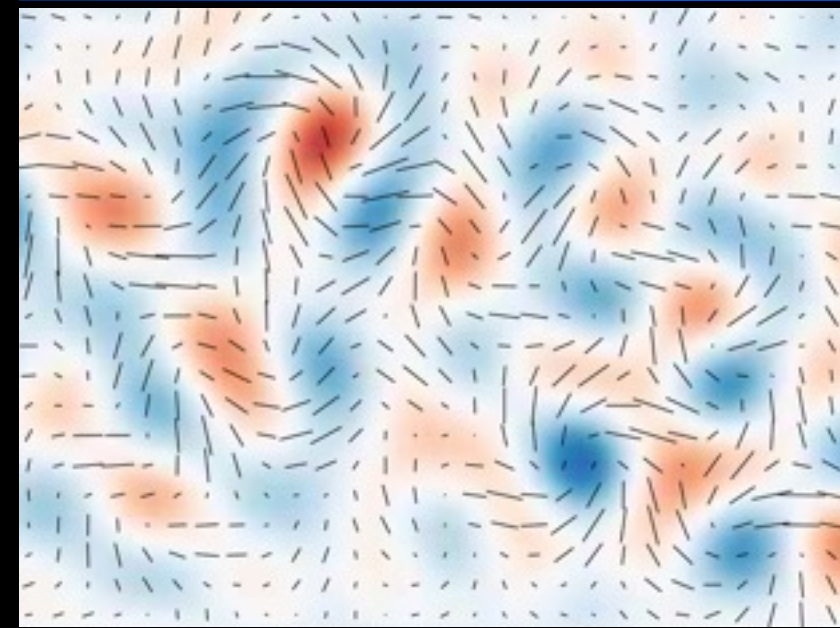
LIGO



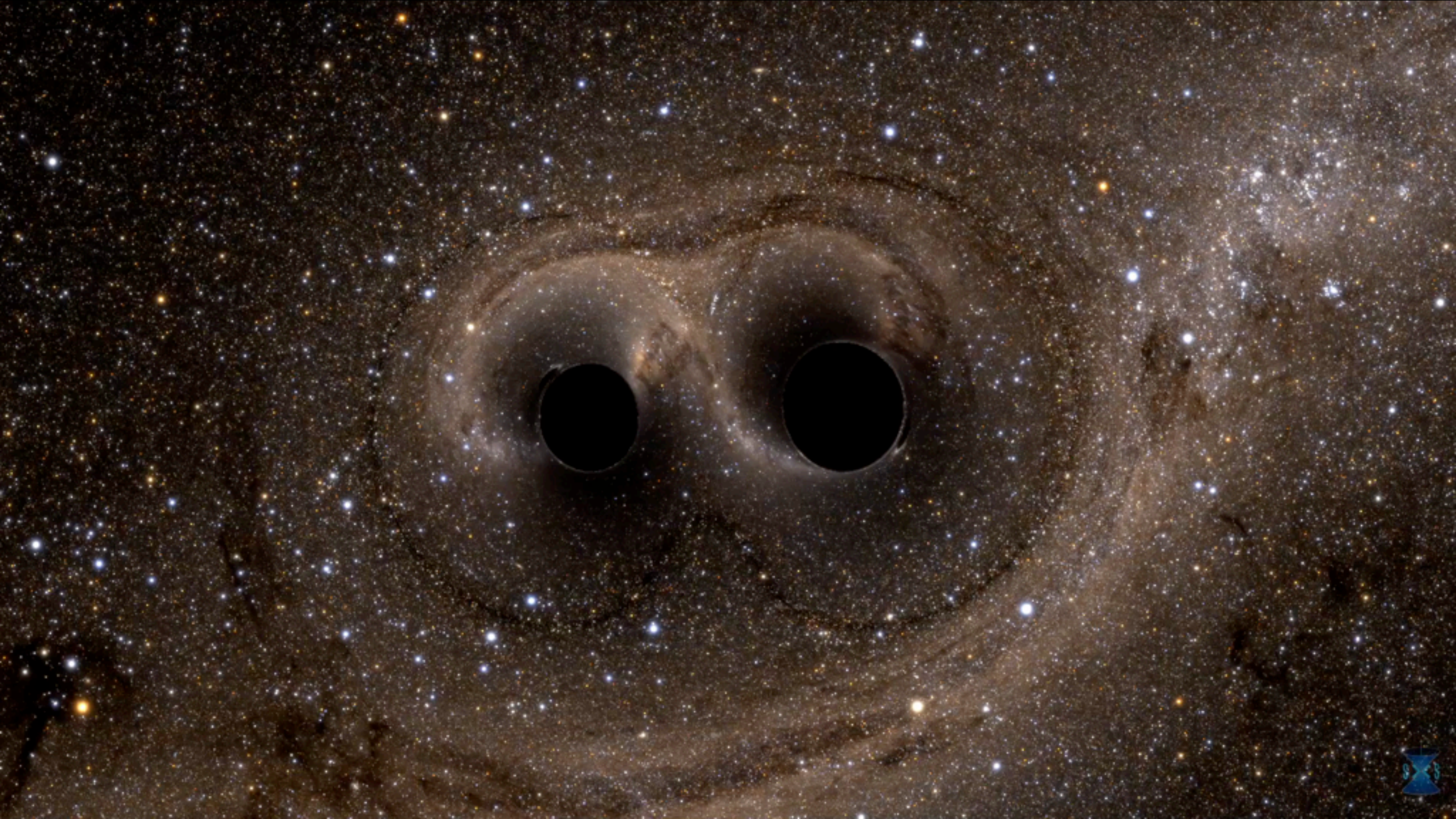
LISA



Others



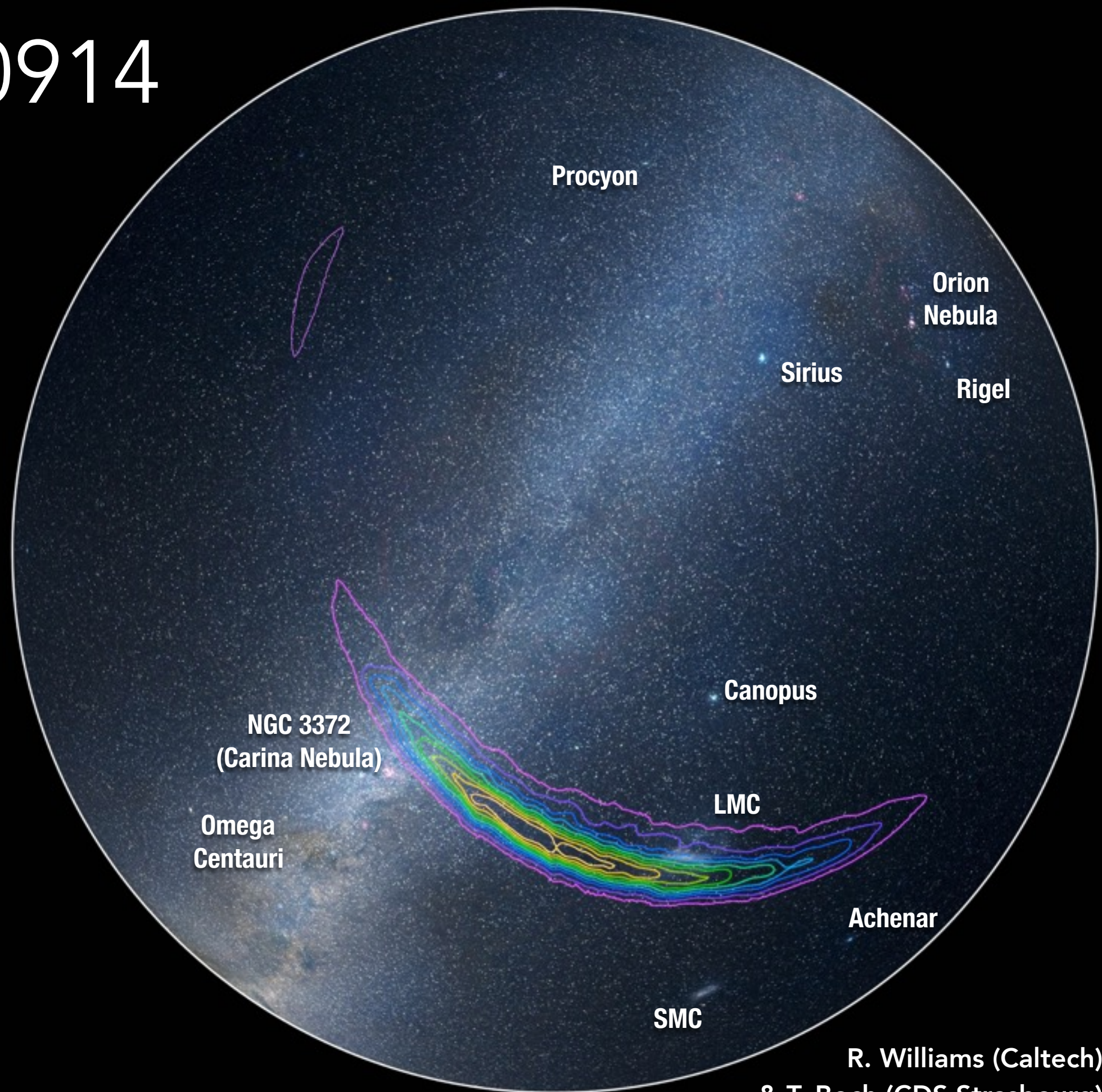
GW150914



29 solar mass black hole + a 36 solar mass black hole
1.3 billion lightyears away (400 Mpc)

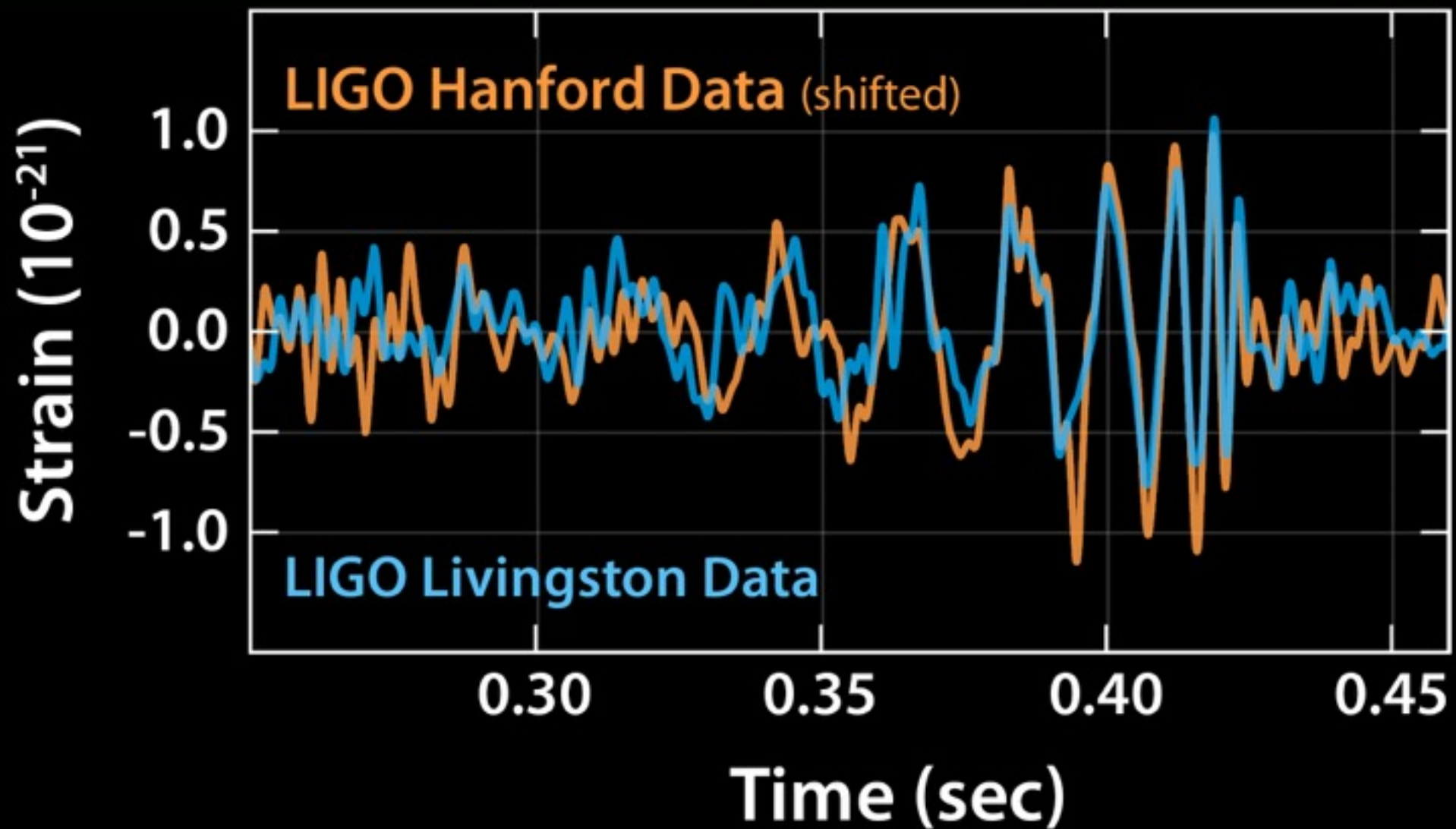
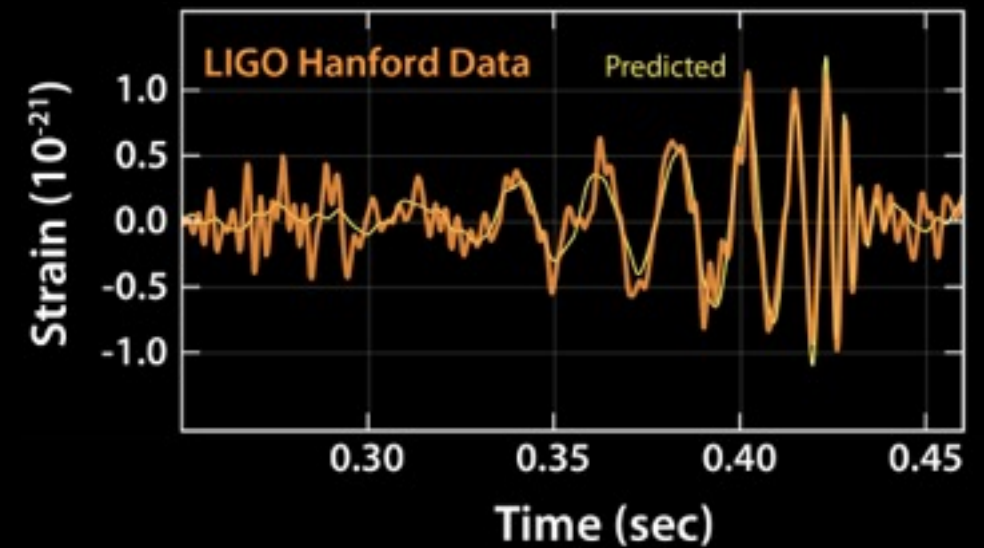
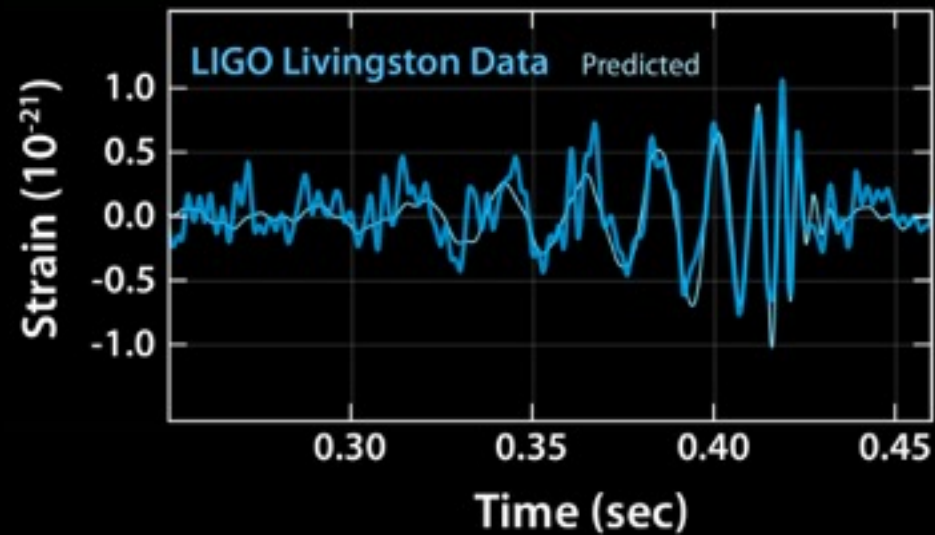


GW150914

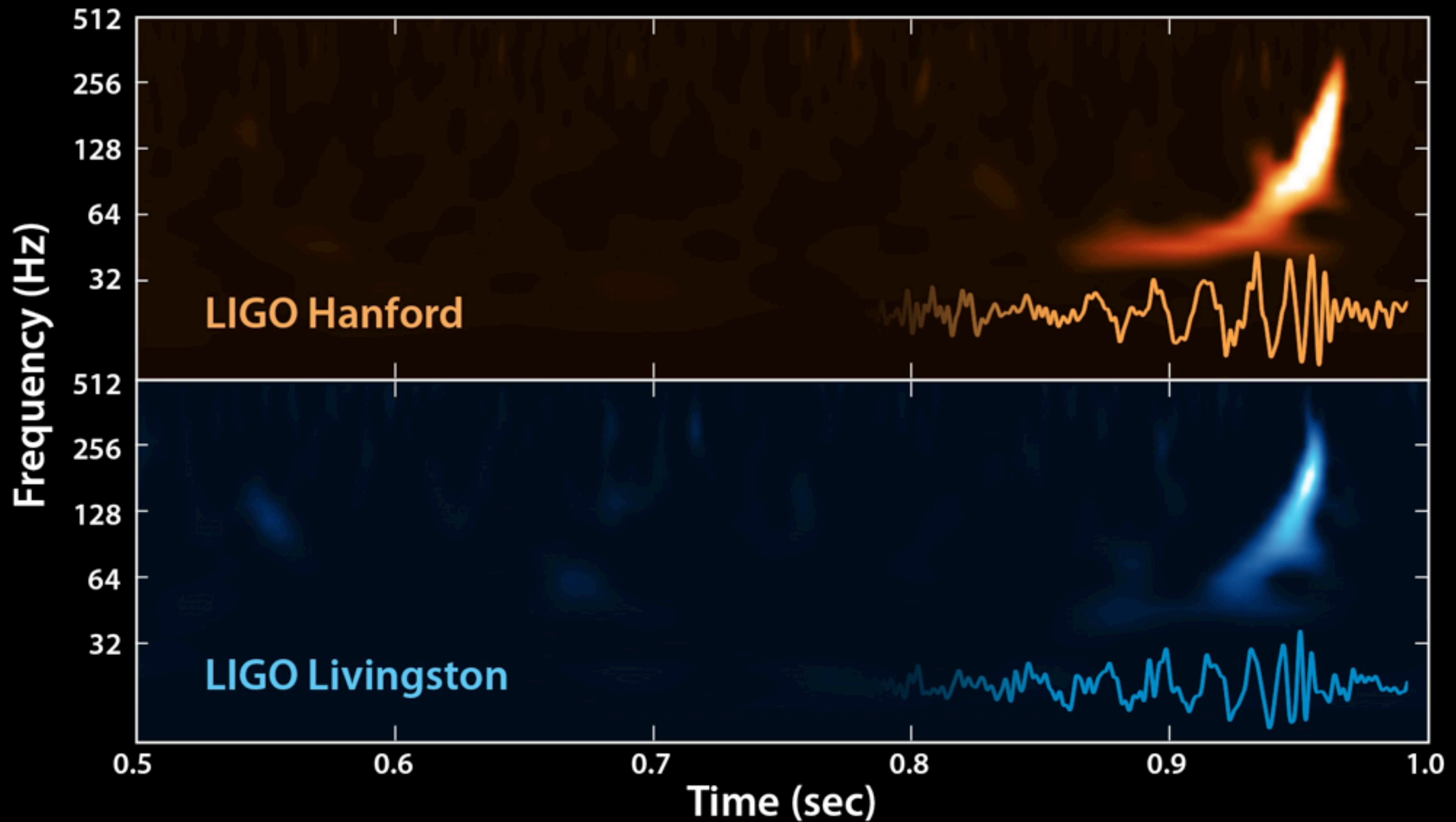


R. Williams (Caltech)
& T. Boch (CDS Strasbourg)

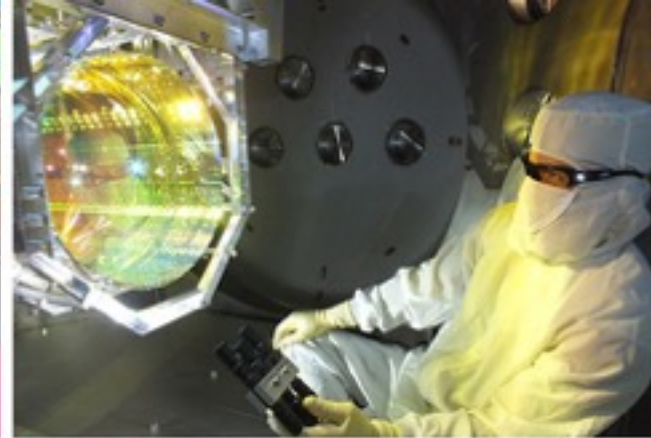
GW150914



GW150914



GW150914



LIGO is
all about
people

LAST THOUGHTS...

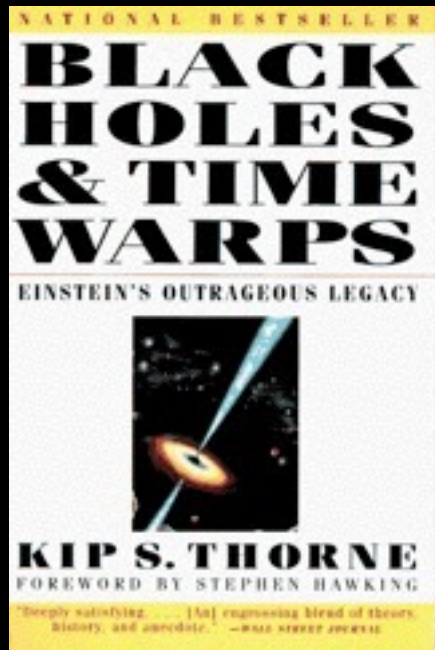
Technology is providing us with new ways to see the Cosmos

Gravity will reveal secrets about the most awesome and enigmatic things astronomers know about

We can see things with gravity that **cannot be seen with light!**

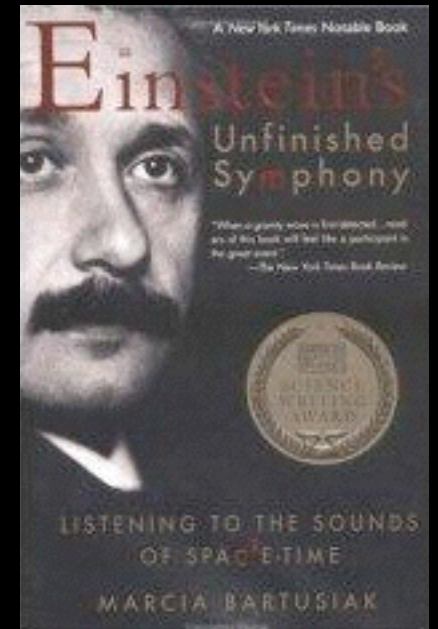
This is just **the beginning...**

A FEW OTHER THINGS TO READ



BLACK HOLES &
TIME WARPS
(Kip S. Thorne)

Einstein's Unfinished
Symphony
(Marcia Bartusiak)



My Blog & Videos

writescience.wordpress.com

tinyurl.com/grCentennial

tinyurl.com/grVideos

tinyurl.com/ligoVideos

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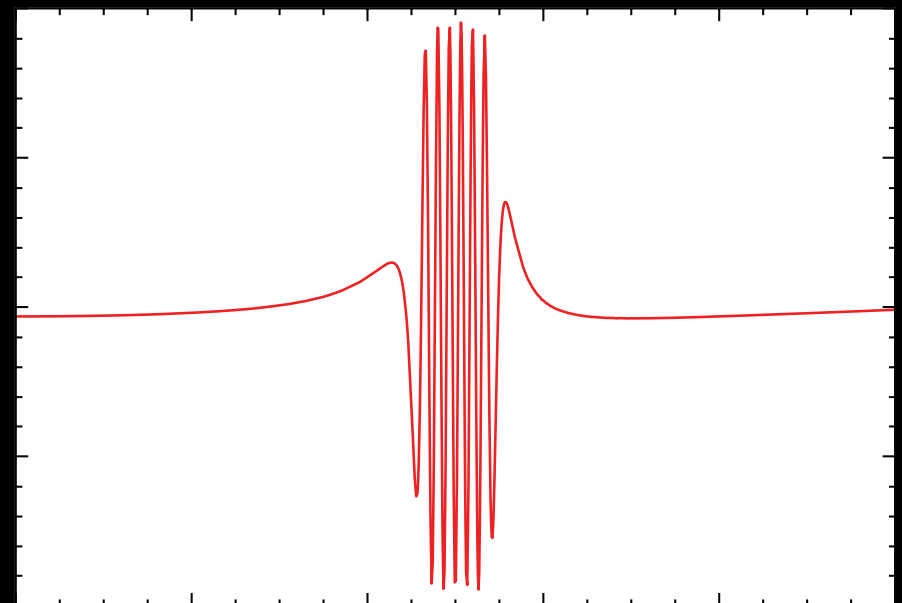
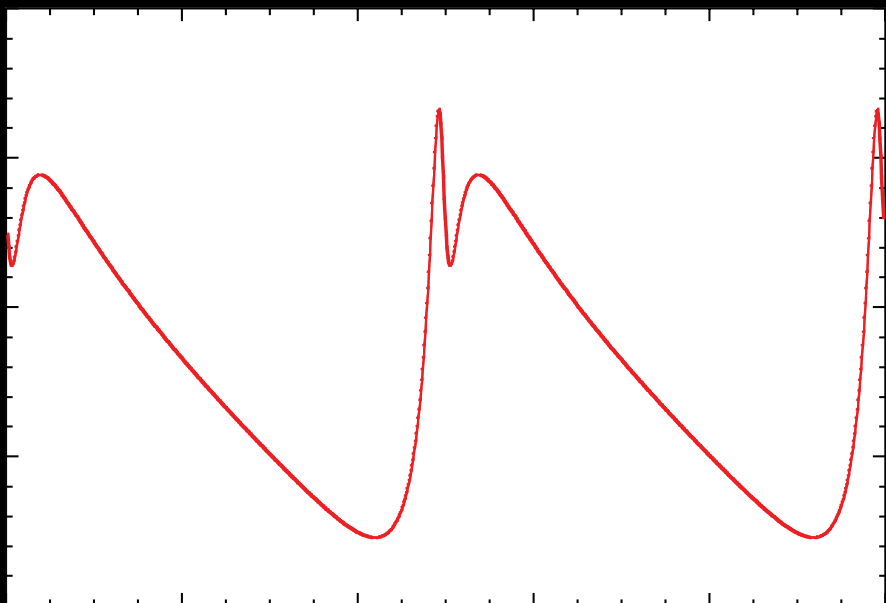
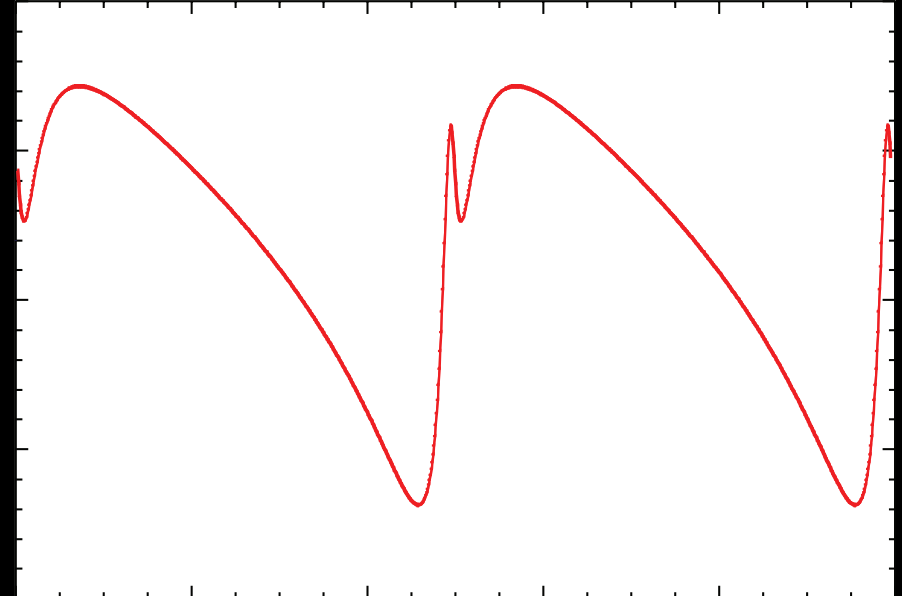
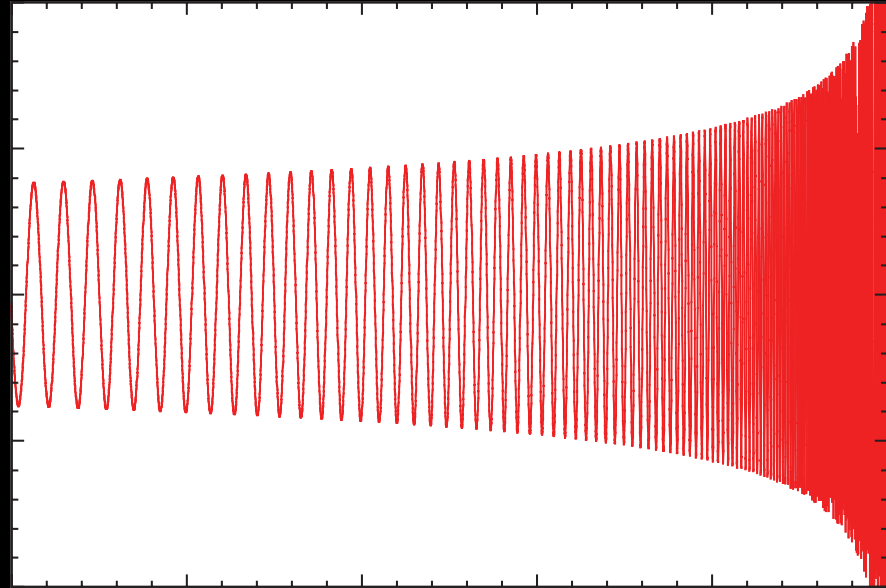


THANKS!

EXTRA SLIDES



Different Waves for Different Things



Different Waves for Different Things

10 Msun Black Hole + 10,000 Msun Black Hole
circular orbits

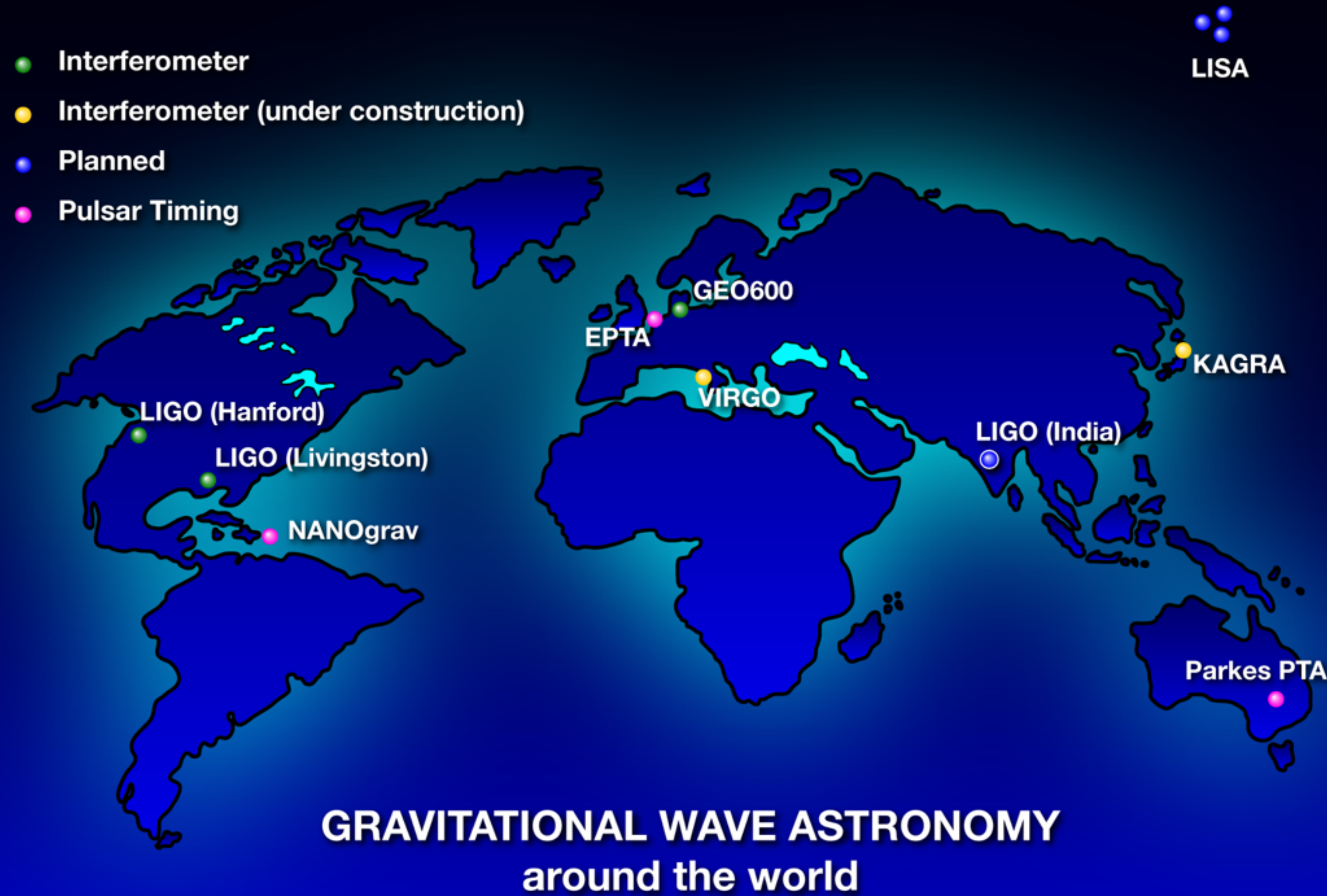
10 Msun Black Hole + 10,000 Msun Black Hole
eccentric orbits

USS CYGNUS (Disney's "The Black Hole")



U.S.S CYGNUS

www.roennin.deviantart.com



Gravitational Wave Spectrum

