Title: Chad Hanna, Pennsylvania State University

Speakers: Chad Hanna

Collection: Perimeter Public Lectures

Date: April 03, 2019 - 7:00 PM

URL: http://pirsa.org/19040089

Abstract: For thousands of years, astronomy was restricted to what we could see with our eyes. But visible light makes up only a tiny fraction of a spectrum emitted by celestial objects.

We now know that light is not the universeâ€™s sole means to reveal the mysteries of the heavens. Until recently, we simply lacked the windows through which to view these aspects of our universe.

Over the last few decades, astronomers have revolutionized our windows on the universe with telescopes of unprecedented sensitivity to light beyond what we can see with our eyes.

Observatories now allow us to see ghostly particles called neutrinos, and ripples in the fabric of space itself - called gravitational waves.

In his Perimeter Public Lecture on April 3, 2019, Chad Hanna will describe how these new windows have changed our view of the cosmos and explore what new wonders may be unveiled in the decades to come.

Hanna is an associate professor at Pennsylvania State University. His research focuses on studying the universe with gravitational waves using the Laser Interferometer Gravitational-Wave Observatory (LIGO).

Hanna and his research group work to enable multi-messenger astronomy through gravitational wave observations of merging neutron stars and black holes. Prior to joining Penn State, he was a senior postdoctoral researcher at Perimeter Institute.

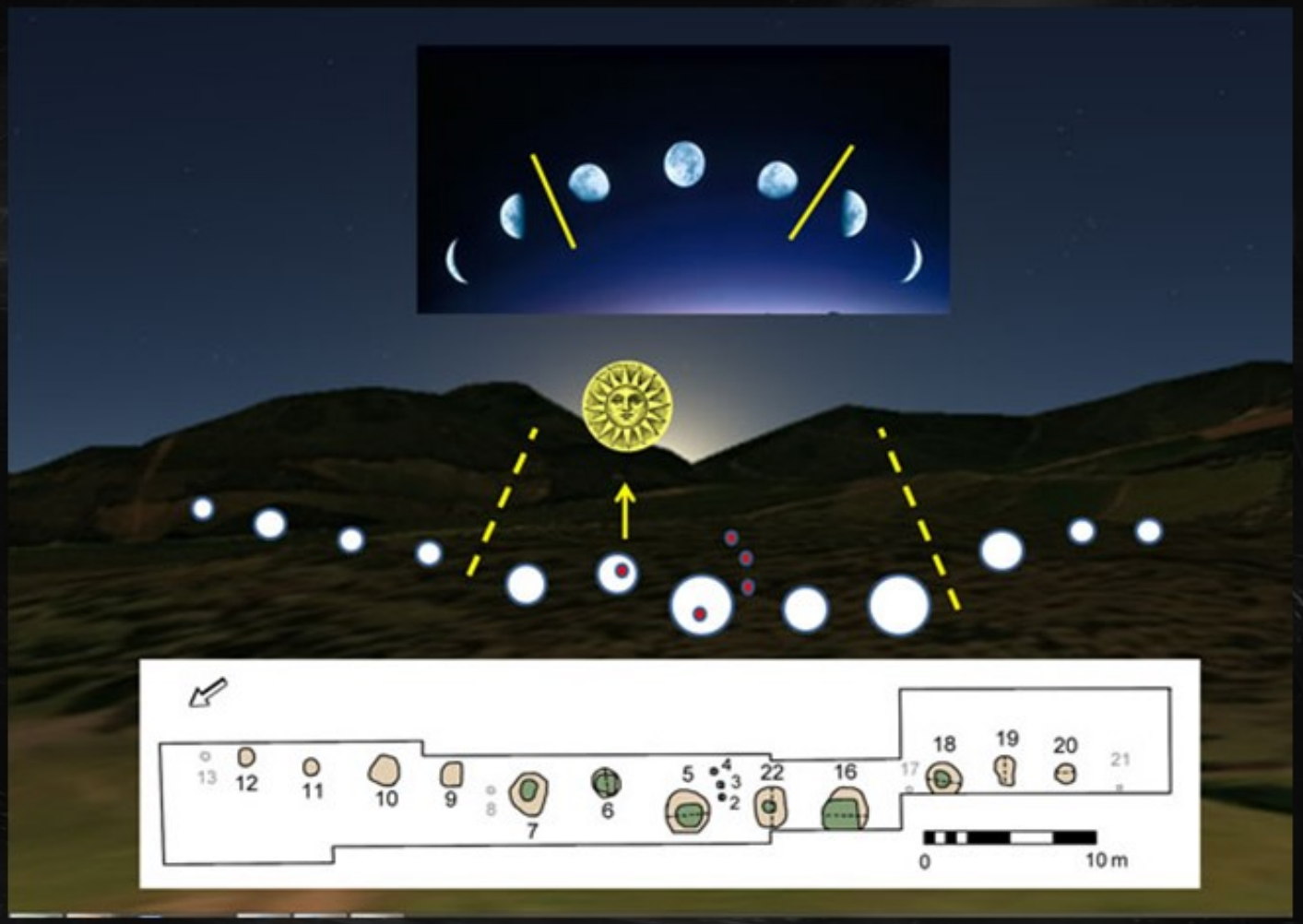
Windows on the universe

Perimeter Institute April 3, 2019

Chad Hanna

Warren Field

8000 BC



University of Birmingham


Nebra
Sky Disk
~2000
BC
By Daderhmann, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=15600795
3

Guest Stars

185

386

393

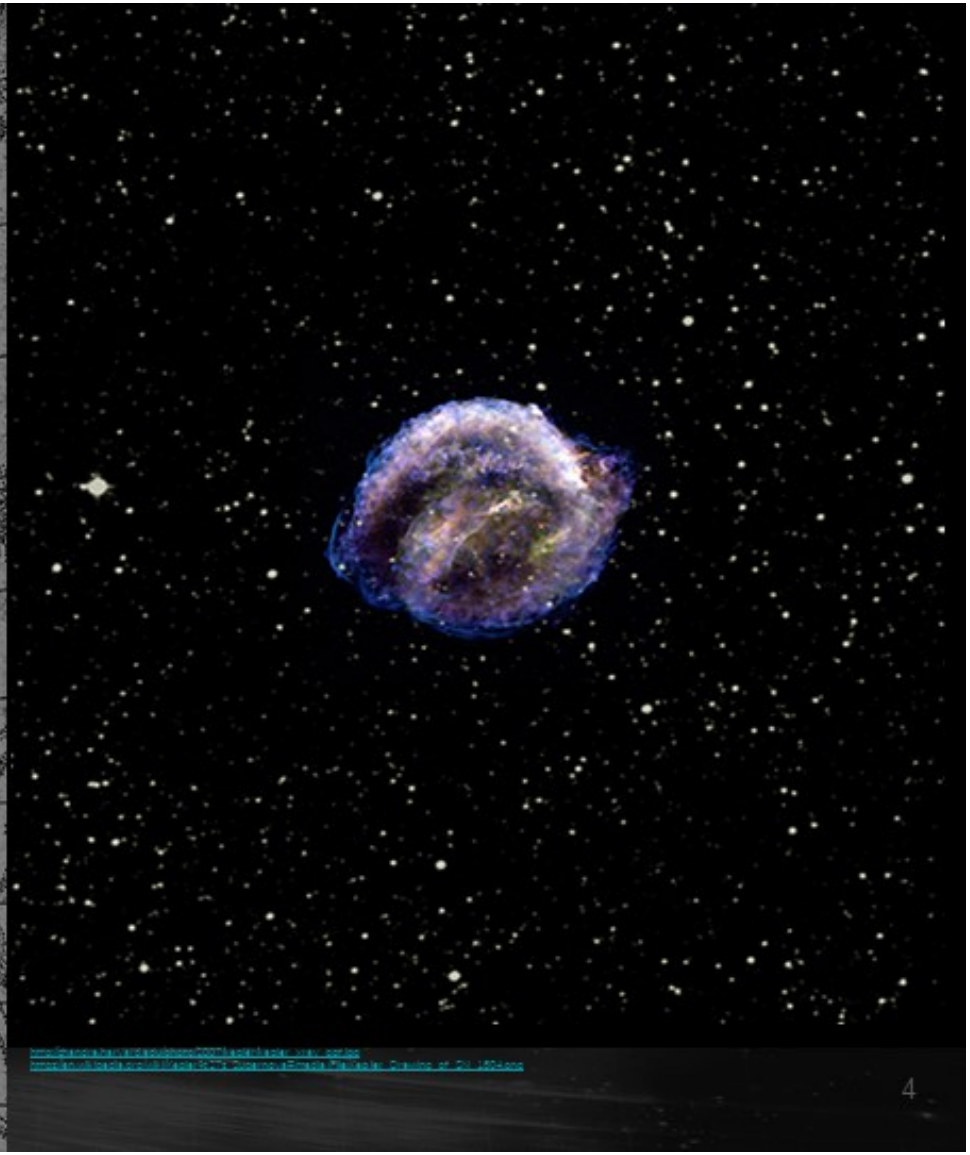
1006

1054

1181

1572

1604



First Telescopes

~1600

By Thomas Bresson - Jupiter(2). CC BY 2.0.

Discovery of light beyond the visible

1800

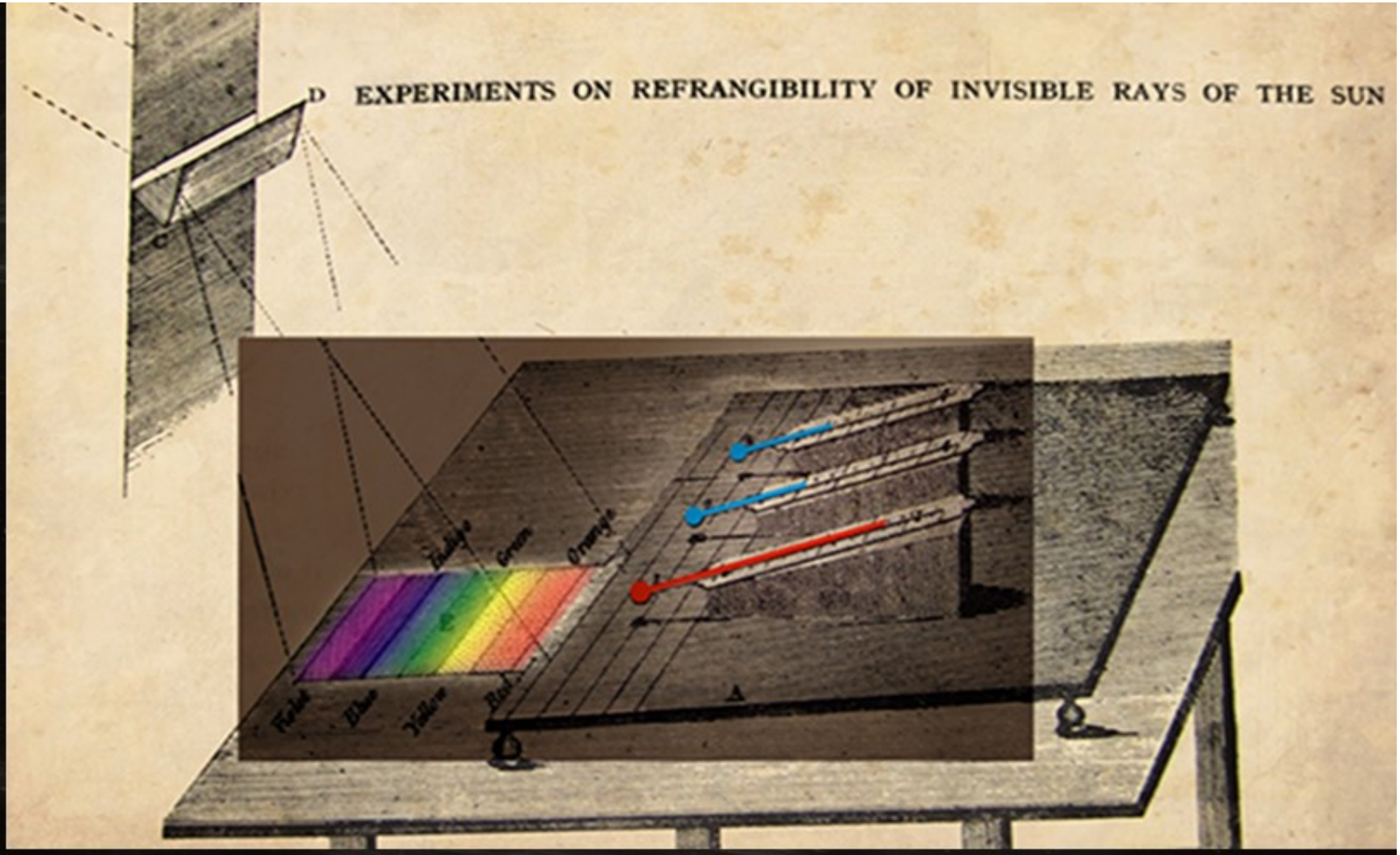


Illustration by Vilmos Theresz based on the original figure in Herschel, W., 1800. "Experiments on the refrangibility of the invisible rays of the Sun". Phil. Trans. Roy. Soc. London 90: 284–292.

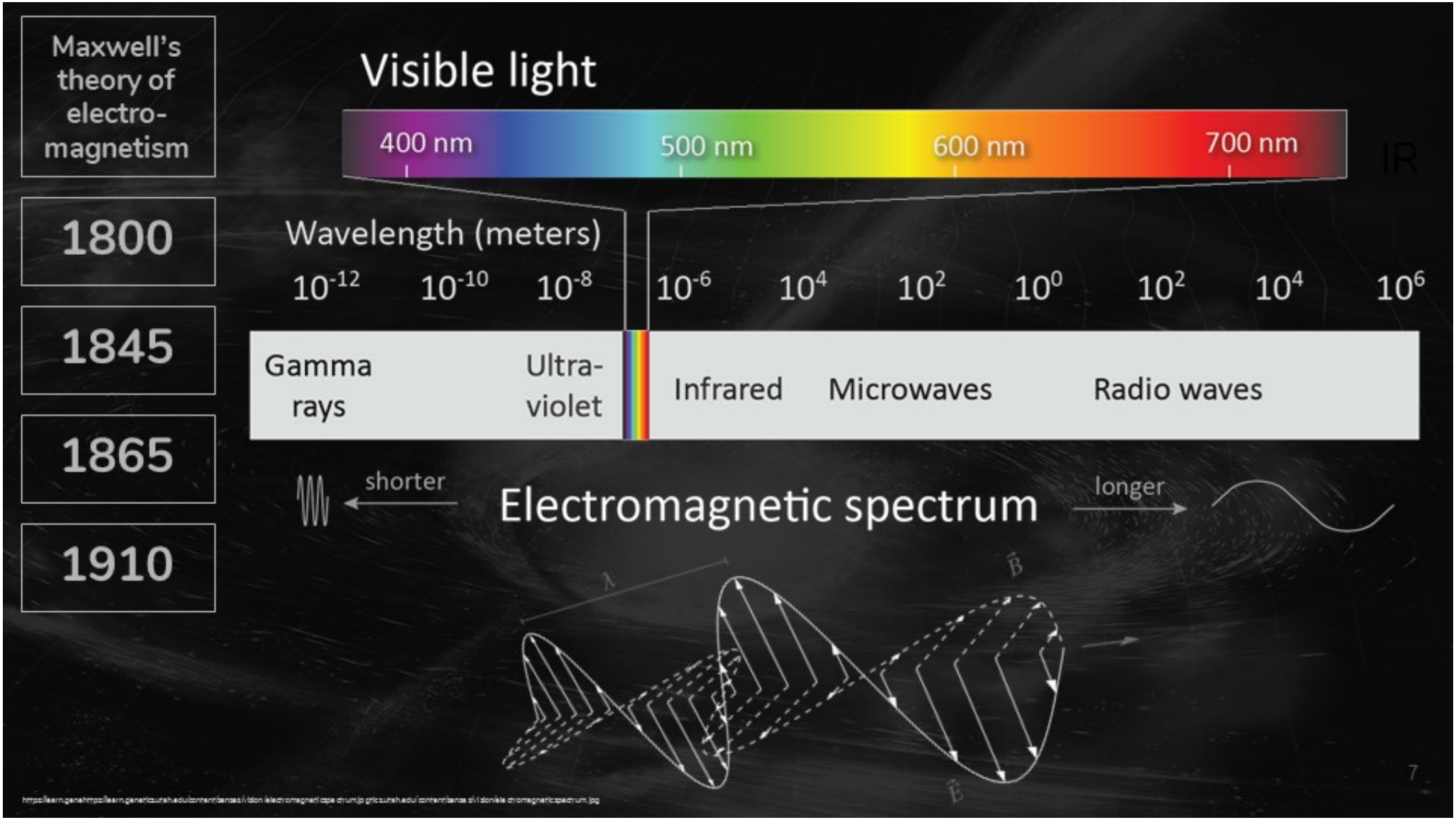
Maxwell's theory of electro-magnetism

1800

1845

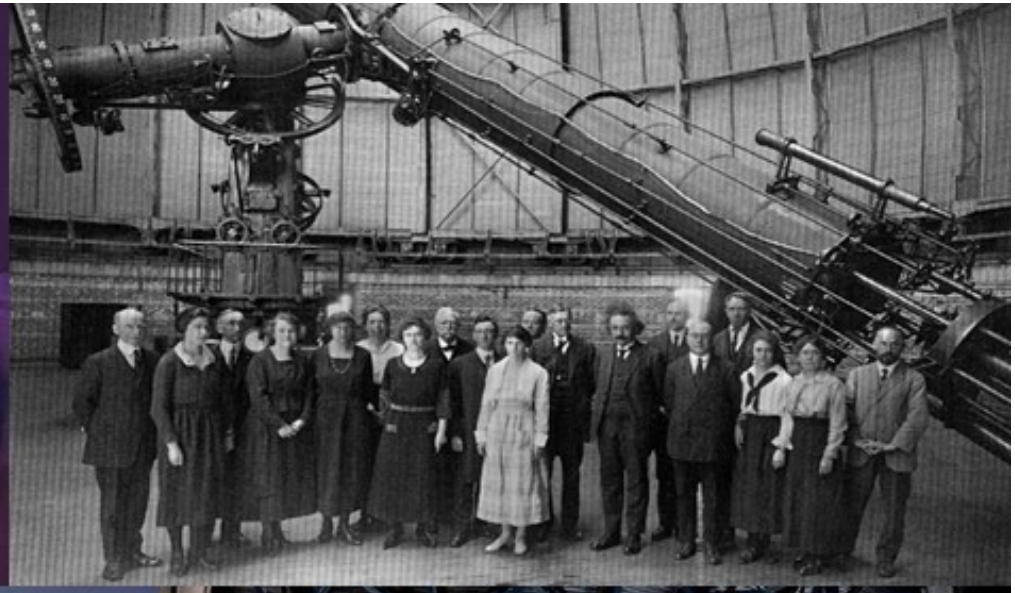
1865

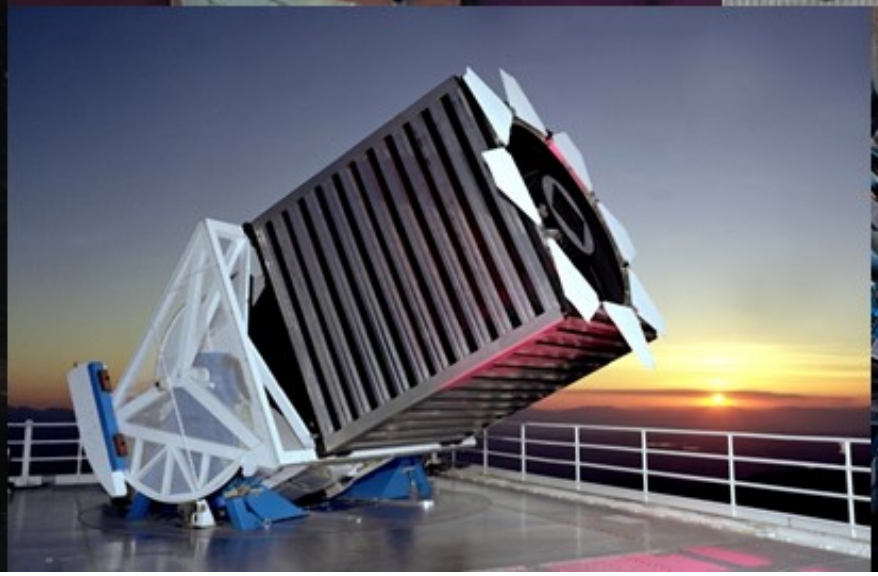
1910



Evolution of Telescopes

18-20th Centuries





User:Zolipsist (Andrew Dunn) [CC BY-SA 3.0 (https://creativecommons.org/licenses/by-sa/3.0)]

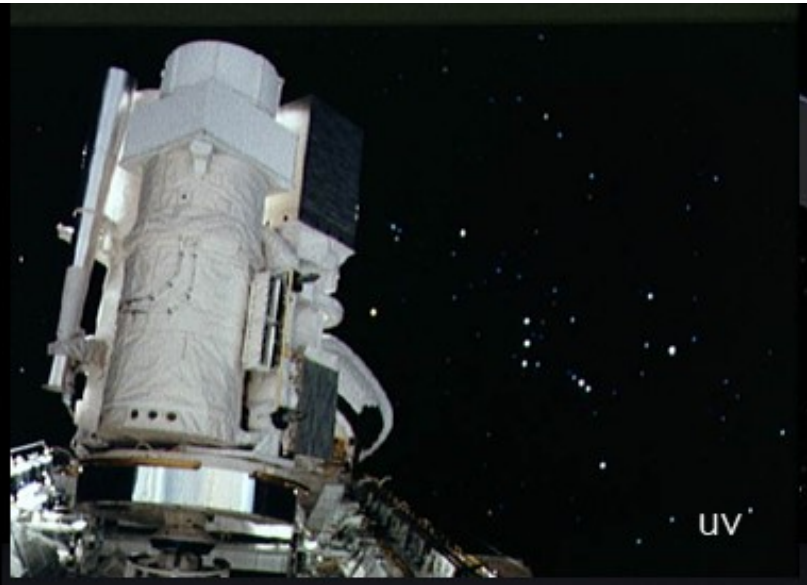
Photo Credit: Yerkes Observatory [Public domain]

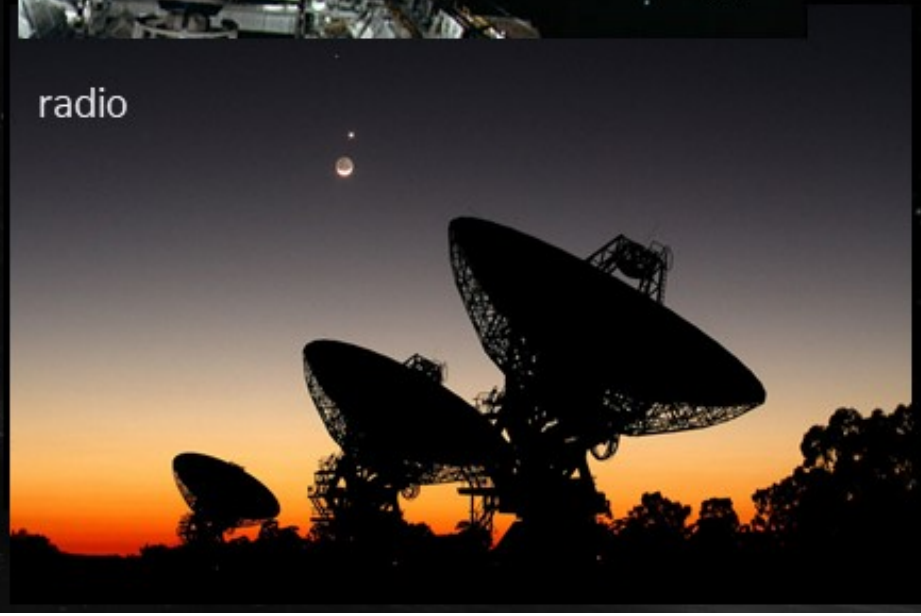
Zbeen.org

ESO/José Francisco Salgado (josefrancisco.org) [CC BY 4.0 (https://creativecommons.org/licenses/by/4.0)]

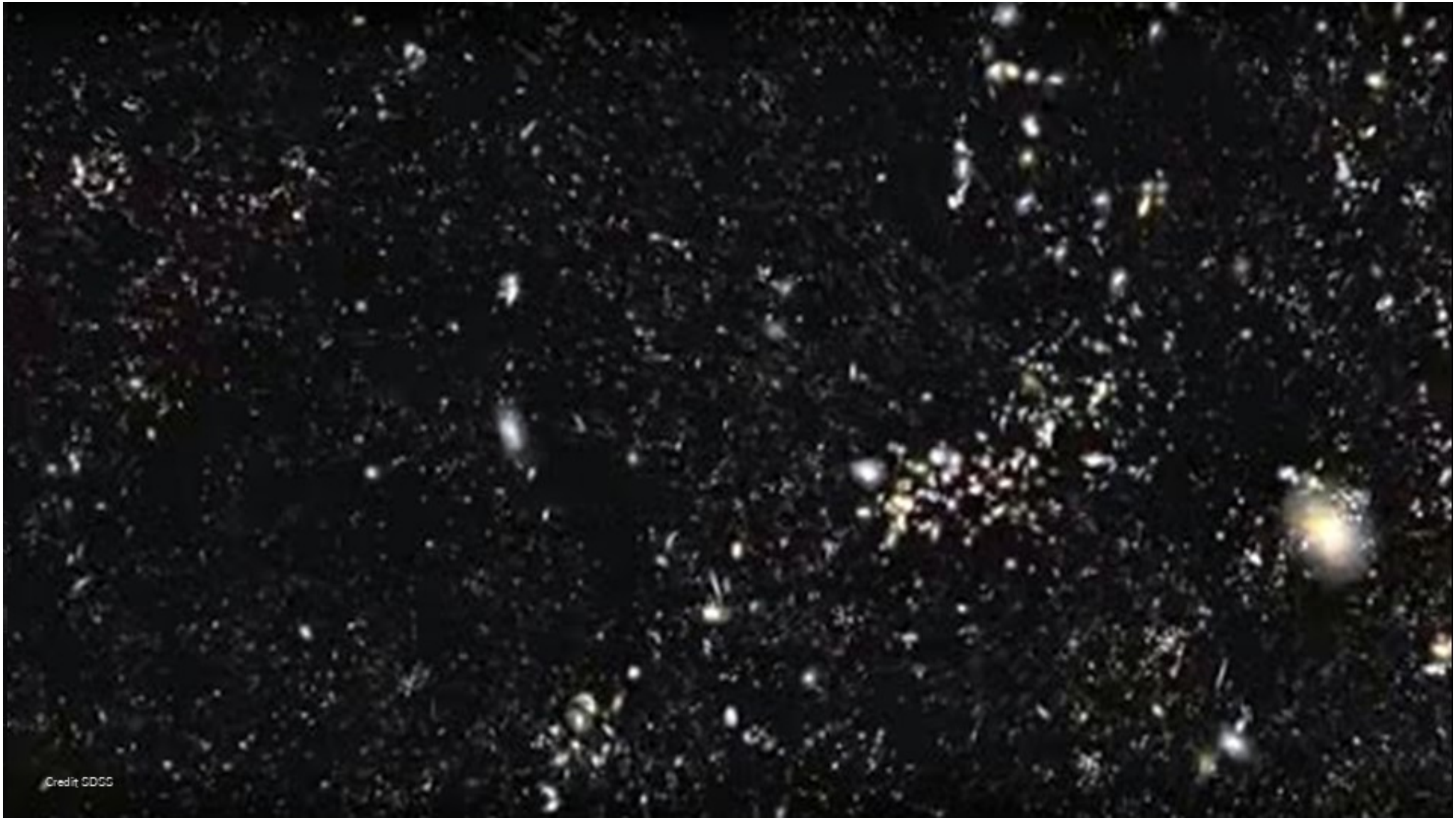
Telescopes At other electro-magenetic wave-lengths

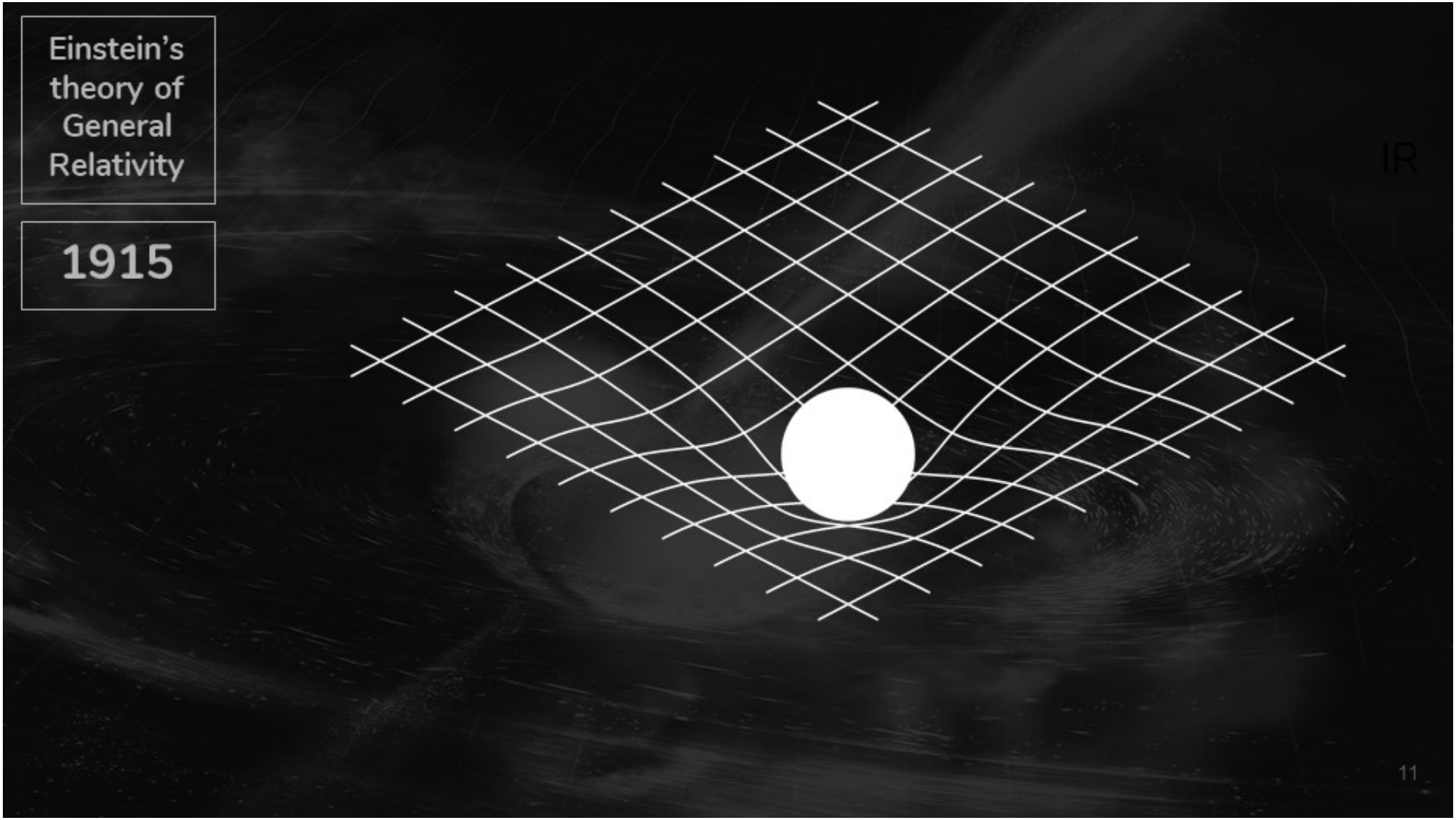
20th-21st Century

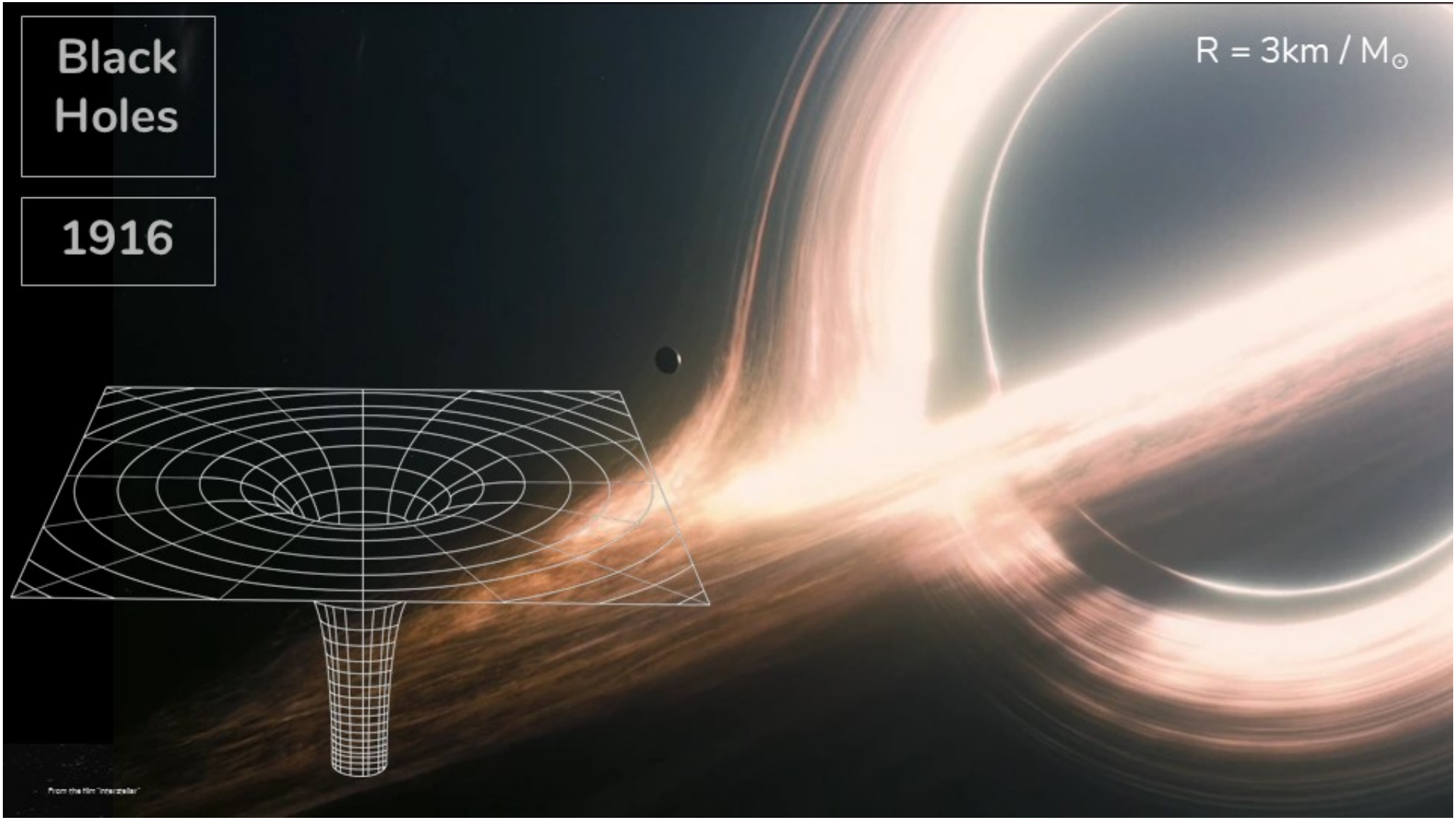


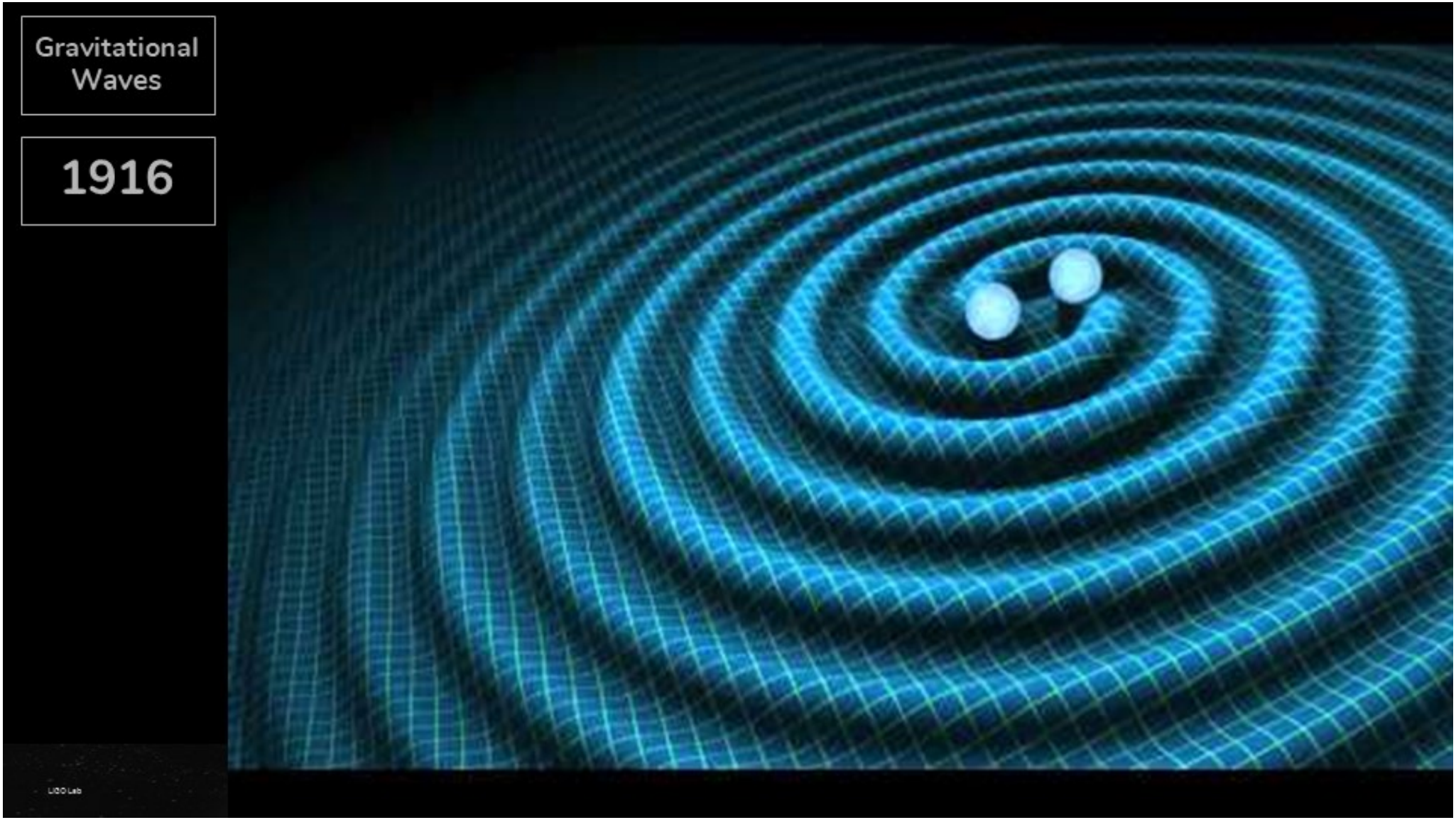


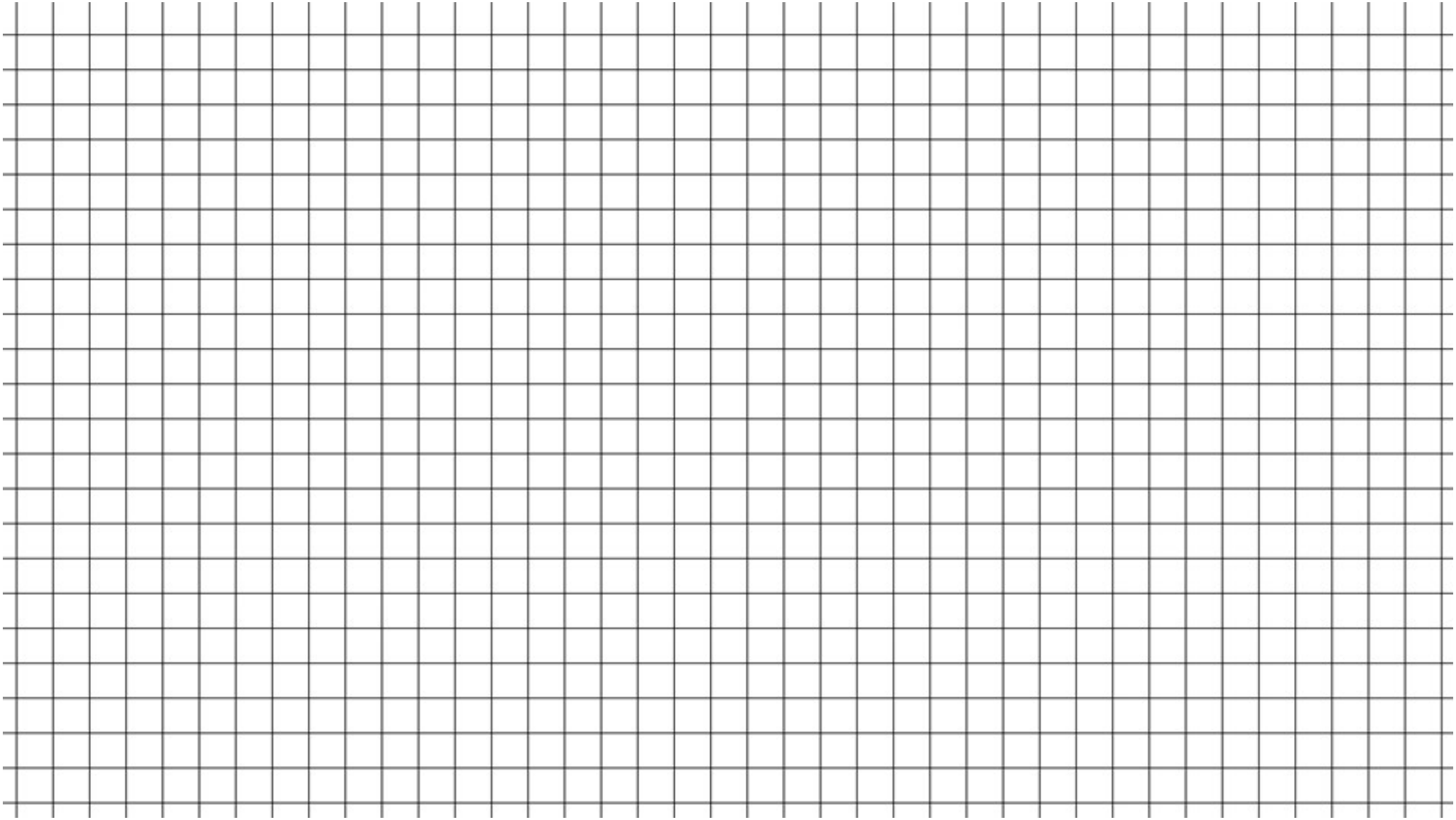
NASA
UT - Austin (Hoby Eberly)

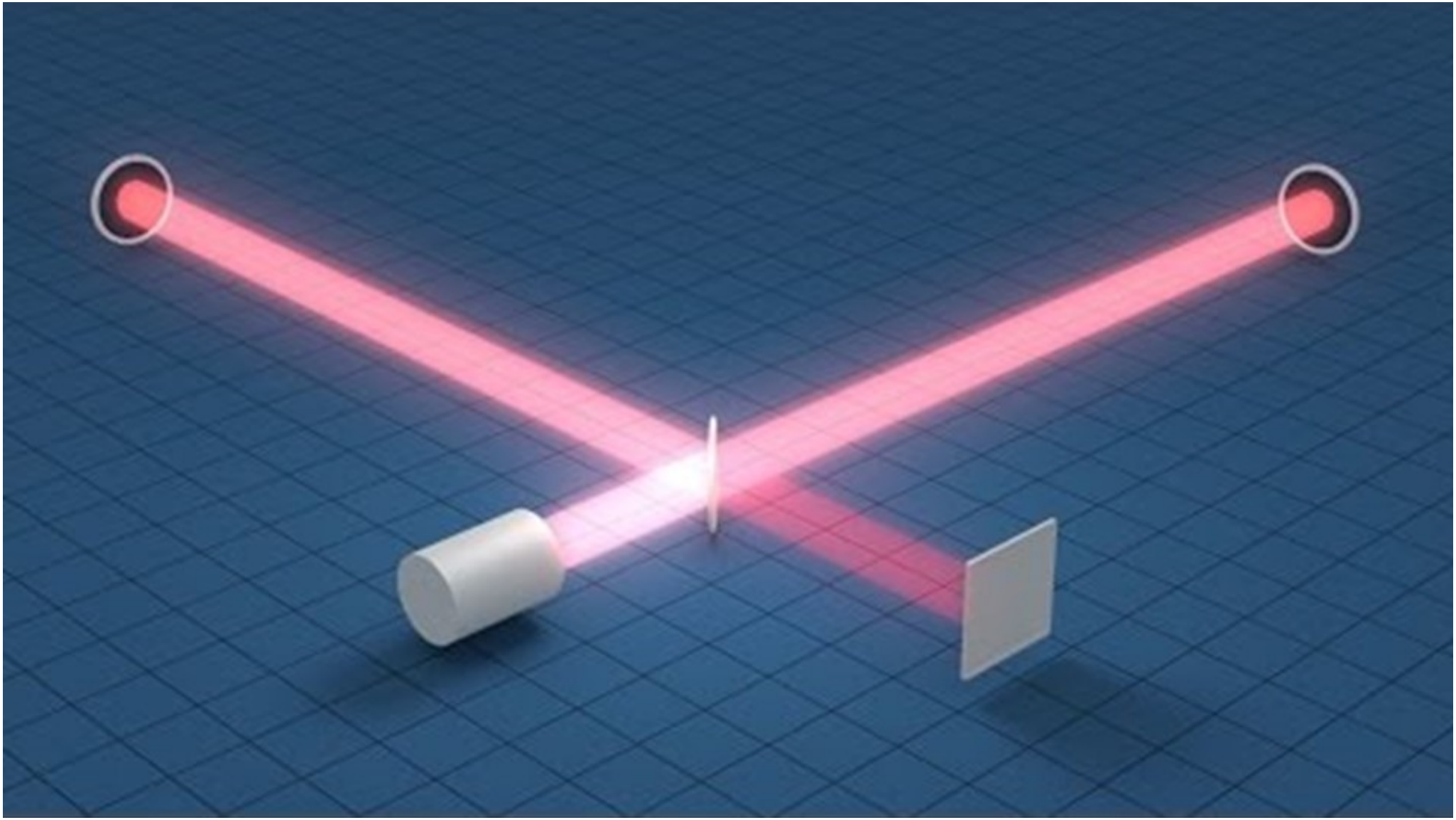

Credit SDSS


Einstein's theory of General Relativity
1915
IR
11

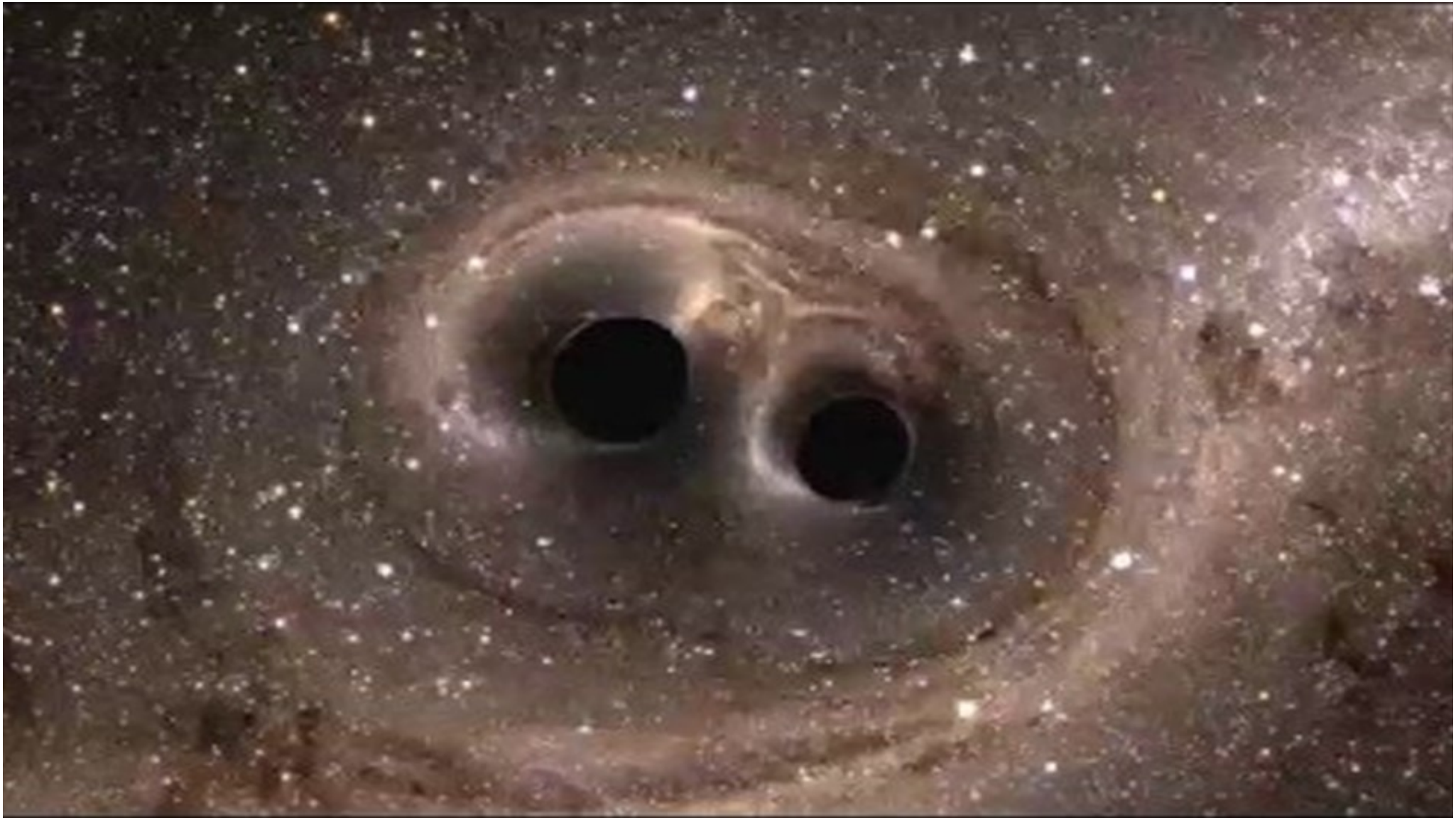

Black Holes
1916
R = 3km / M⊙
From the film "Interstellar"


Gravitational Waves
1916
LIGO Lab



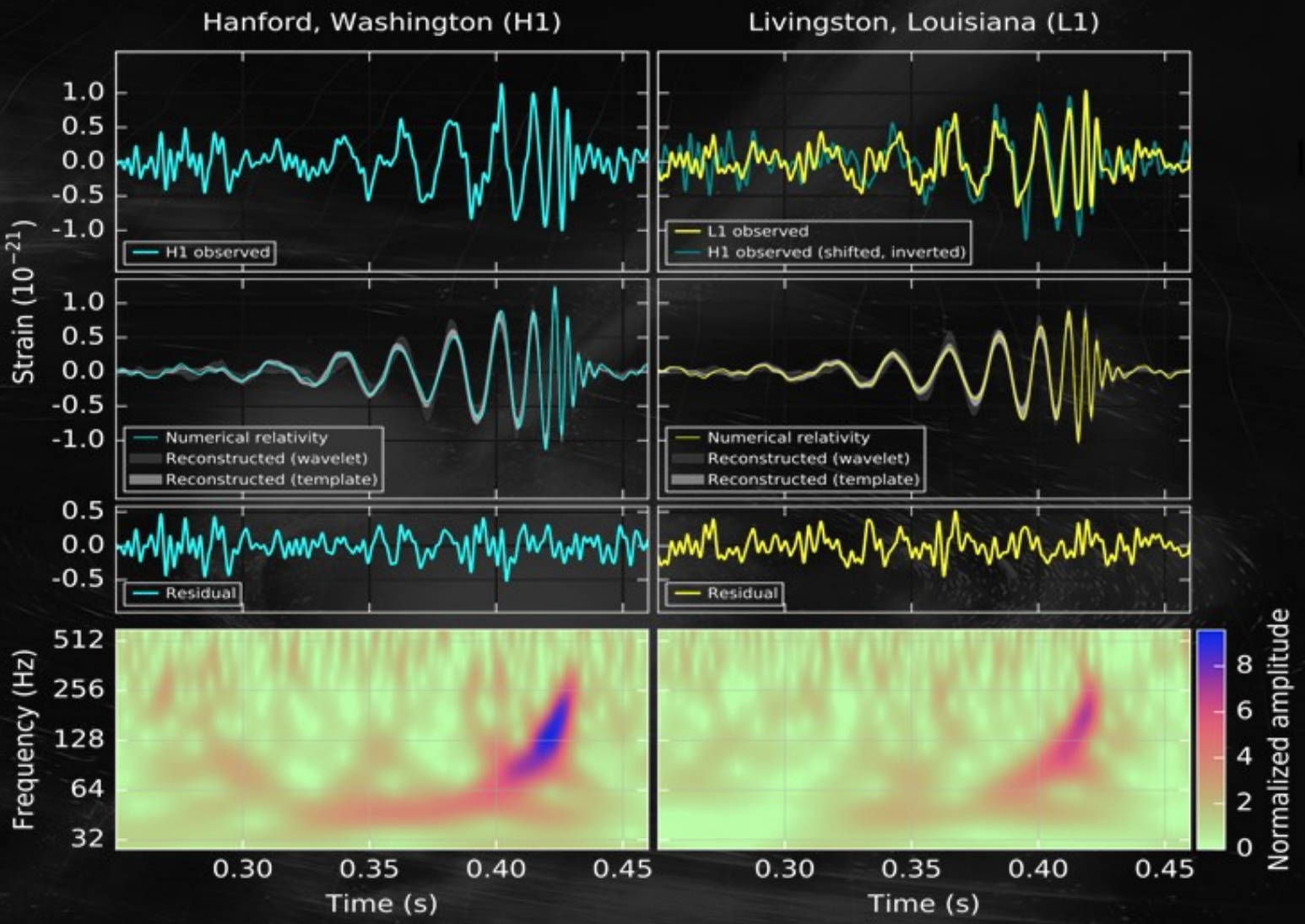


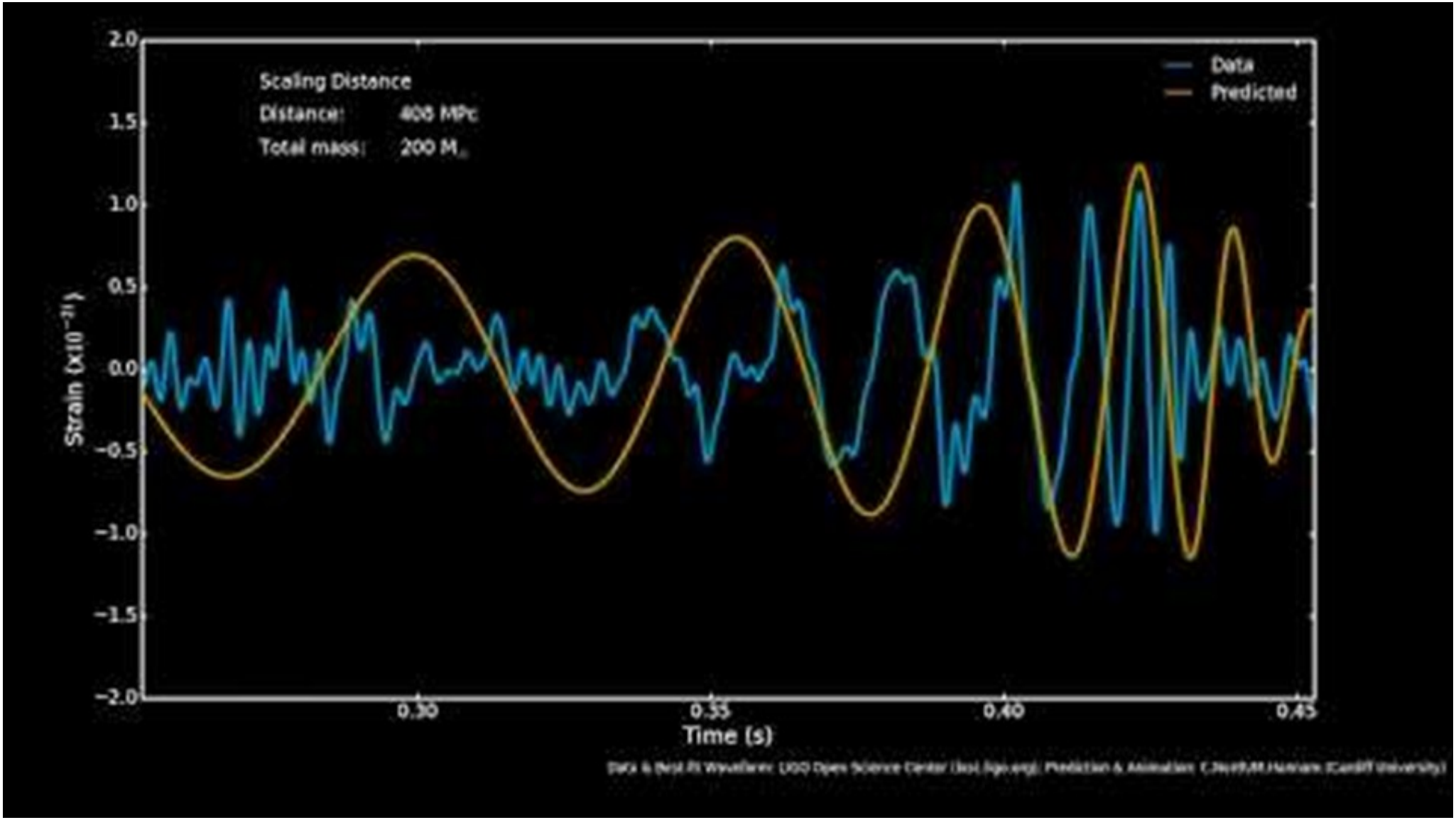

Initial LIGO Observations
“Dark Ages”
Advanced LIGO
A+
~2000
2010
2015
Present
2023
Livingston
Hanford

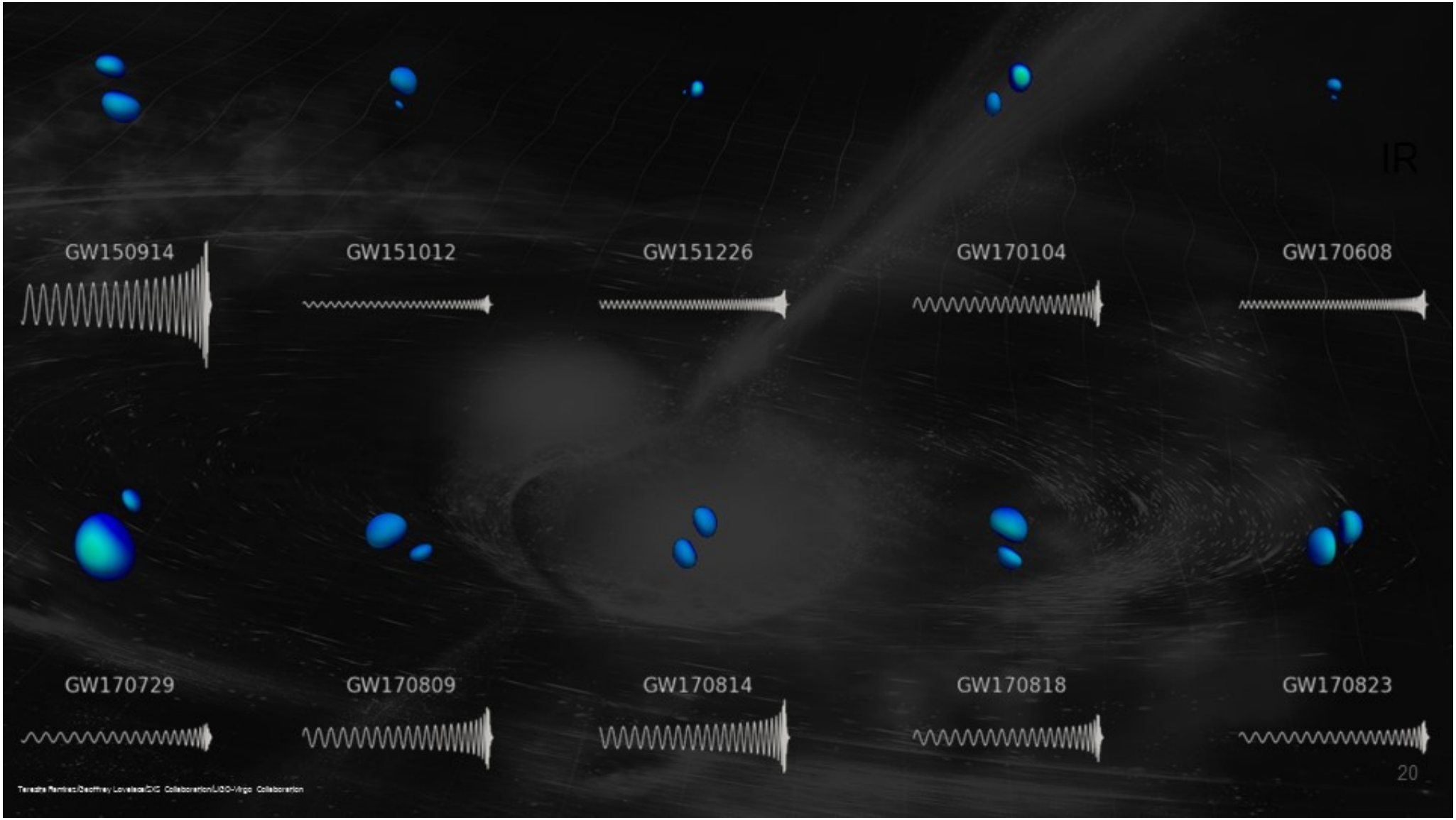


First Gravitational wave signal

2015

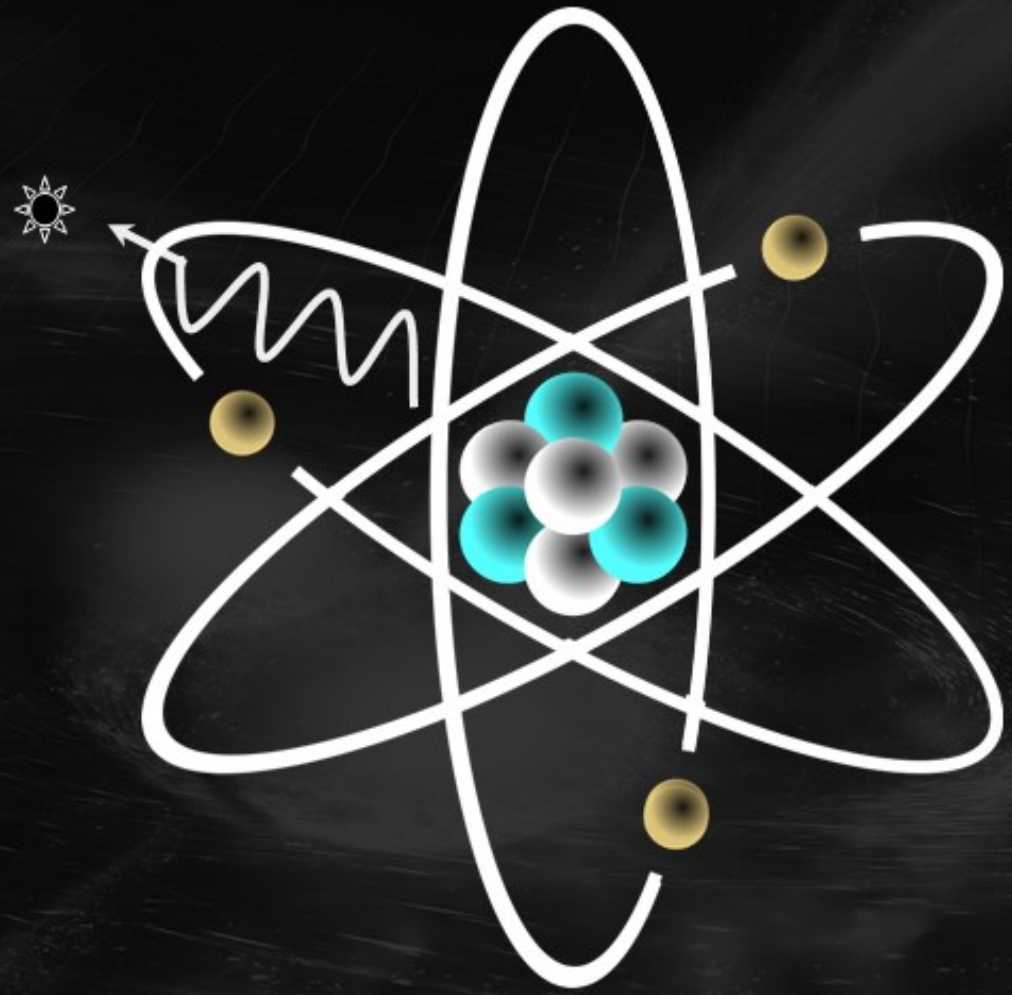



Scaling Distance
Distance: 400 MPc
Total mass: 200 M⊙
Data
Predicted
Strain (x10⁻²¹)
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
0.30
0.35
0.40
0.45
Time (s)


IR
GW150914
GW151012
GW151226
GW170104
GW170608
GW170729
GW170809
GW170814
GW170818
GW170823
20
Teresita Ramirez/Geoffrey Lovelace/ZIG Collaboration/LIGO-Virgo Collaboration

The Neutrino

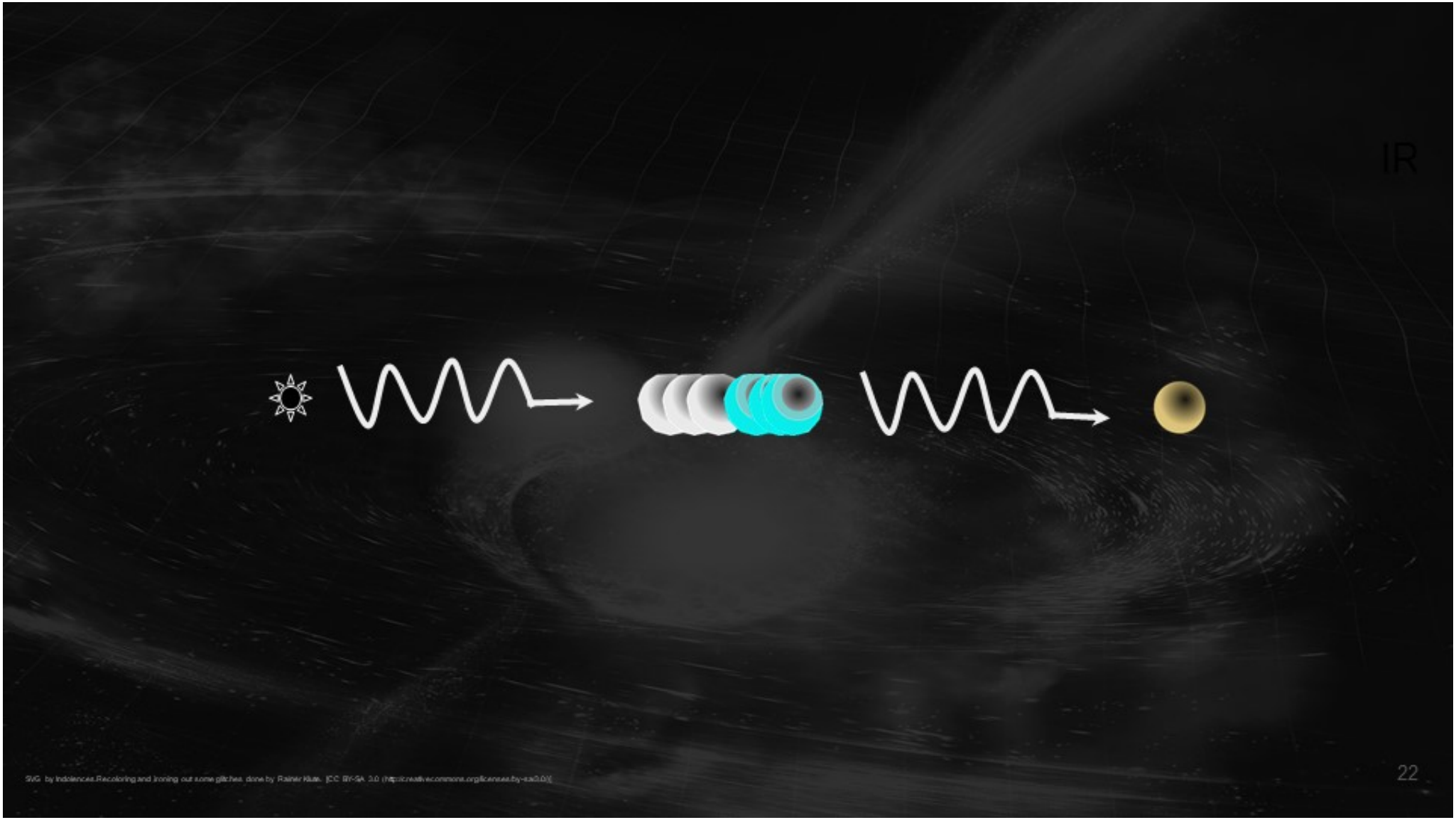
1930-1934



IR

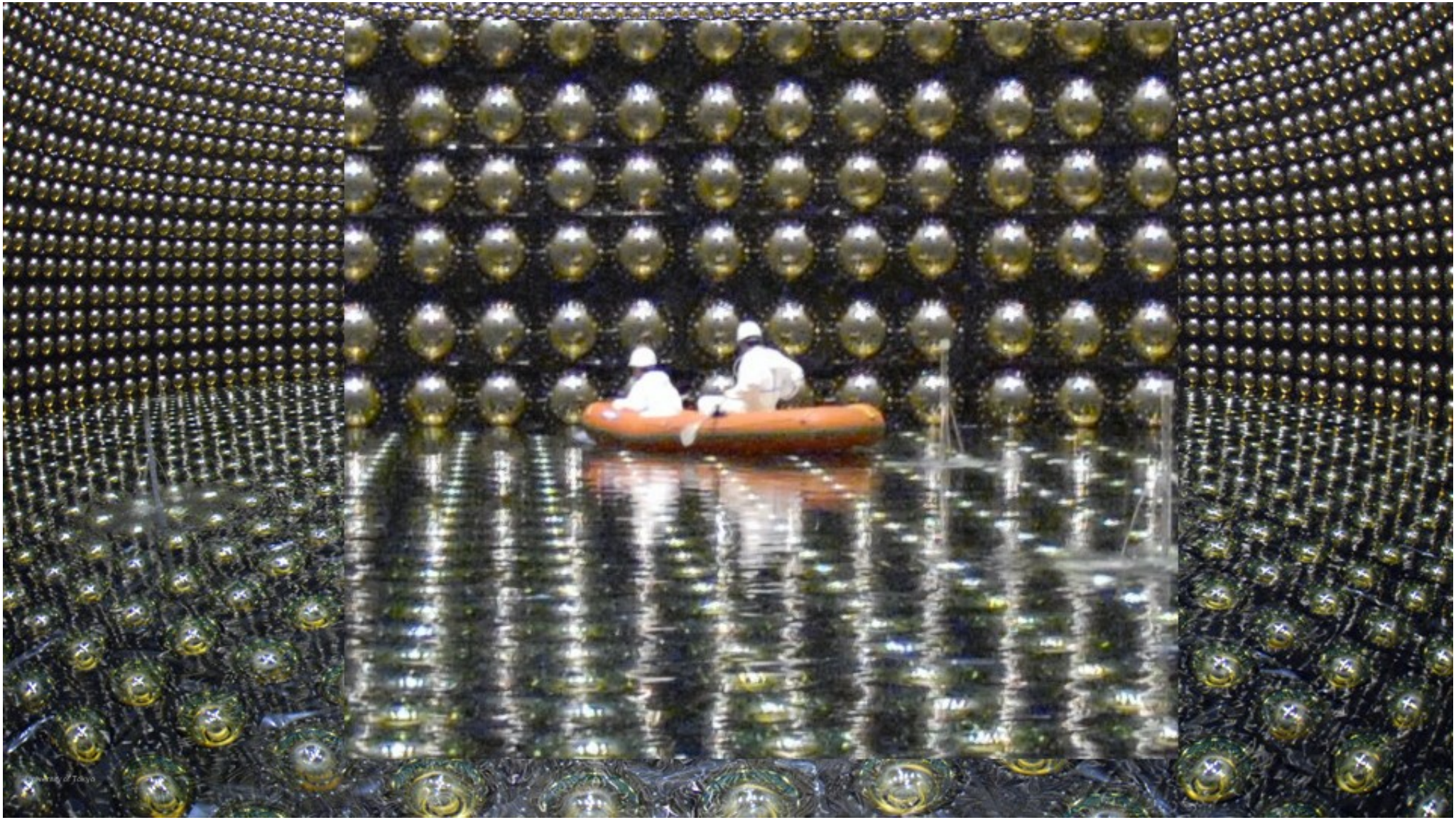
SVG by Indolences.Recoloring and ironing out some glitches done by Rainer Klute. [CC BY-SA 3.0 (http://creativecommons.org/licenses/by-sa/3.0/)]

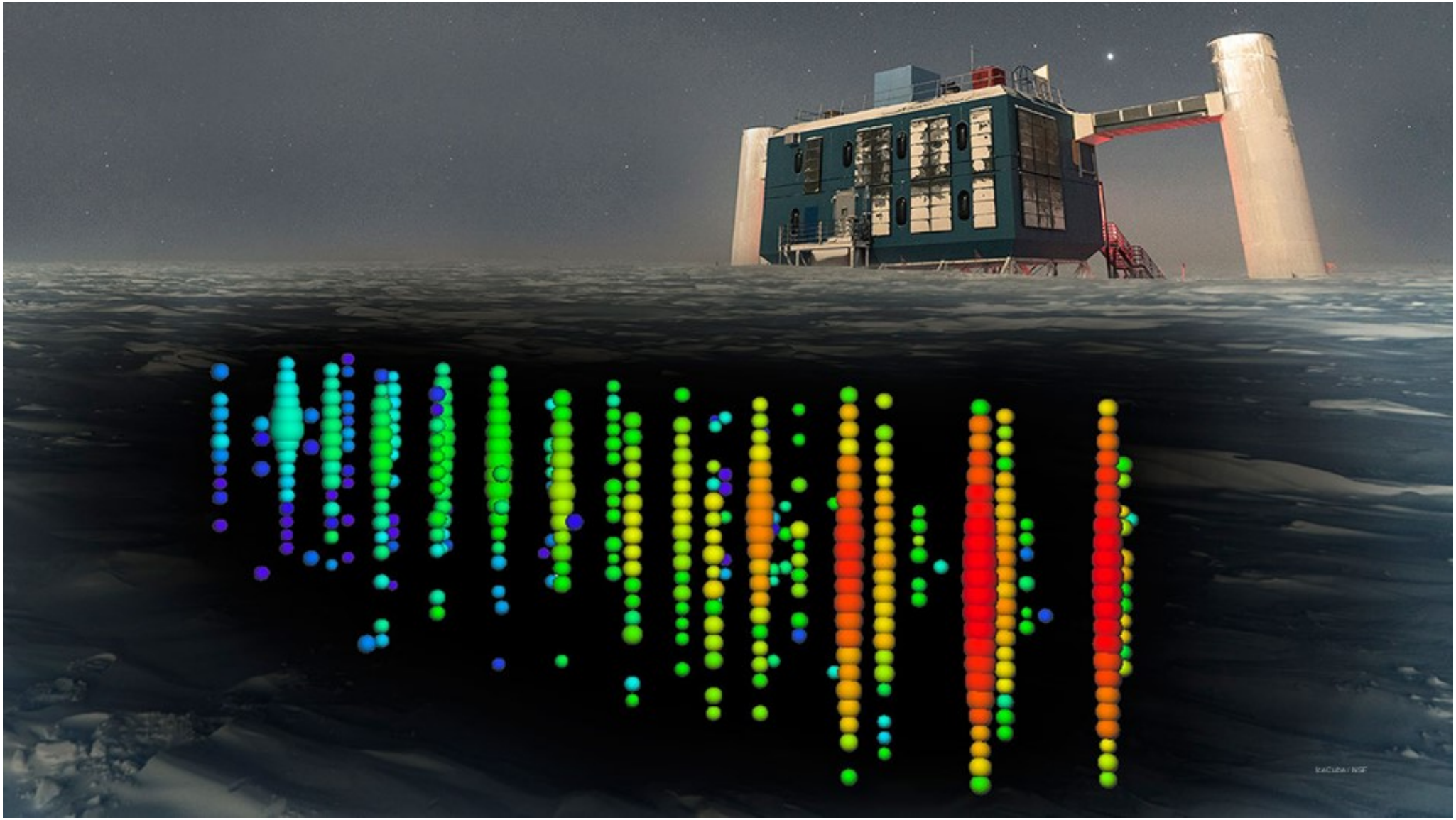
21


IR
22

Homestake Experiment 1969

First to detect **extraterrestrial** neutrinos.

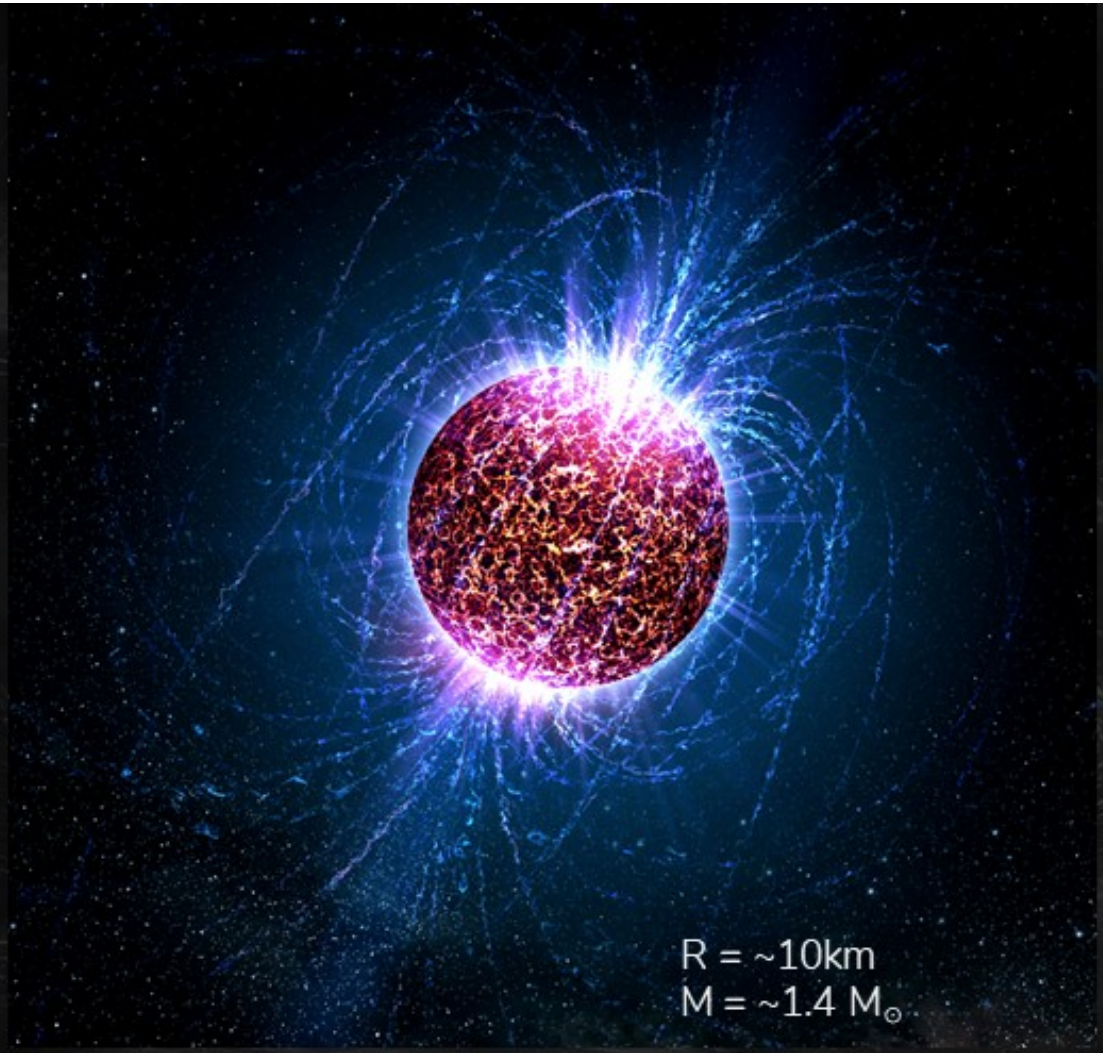



IceCube / NSF

Neutron Star

1933

1965-1967



IR

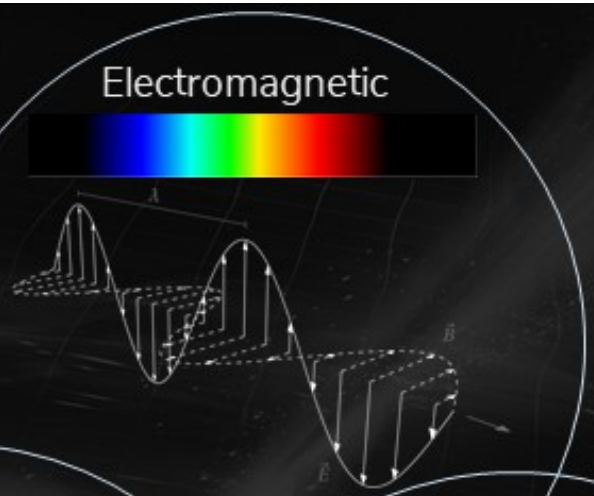
Artist's conception of a neutron star. (Casey Reed. Penn State University Artist's conception of a neutron star. (Casey Reed. Penn State University)

Multimessenger Astronomy

1987

2017

2017



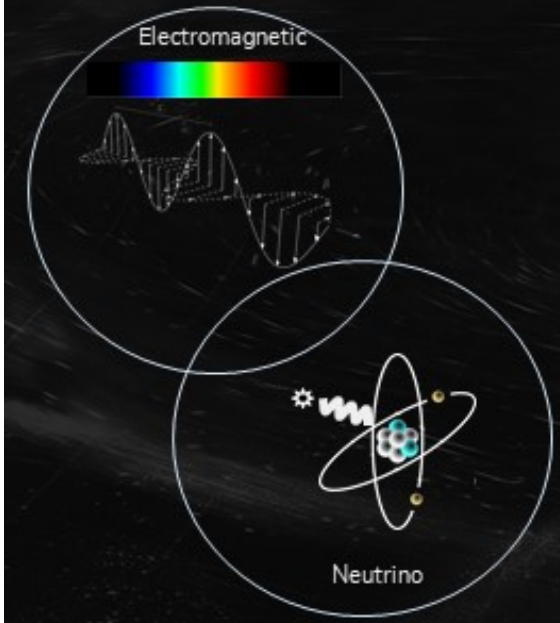
IR

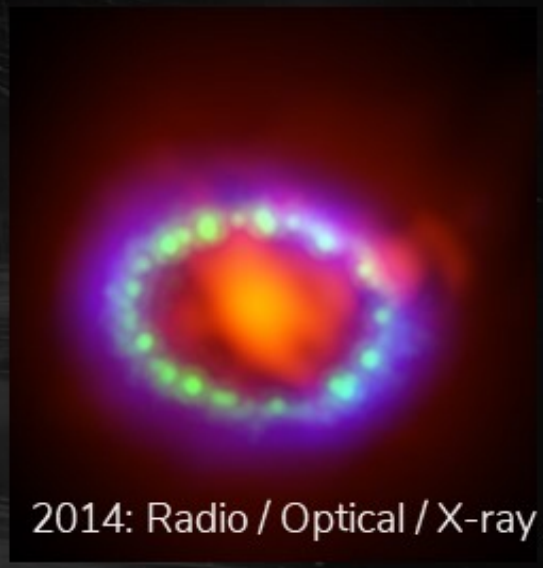
Gravitational Wave

Neutrino

27

Multimessenger Astronomy Supernova 1987A

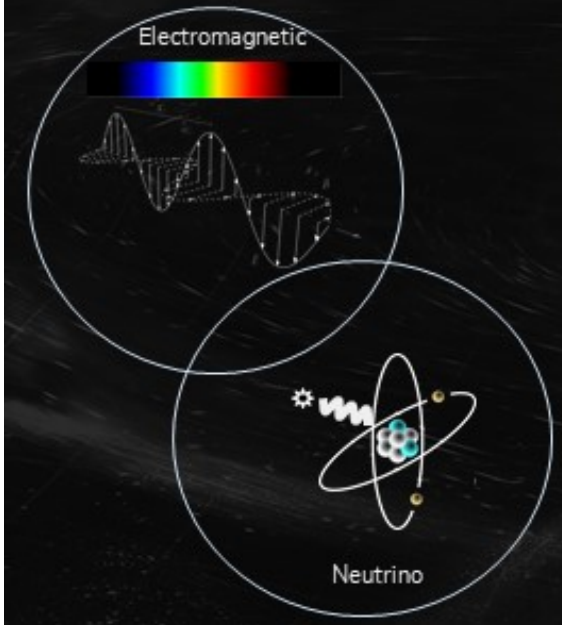


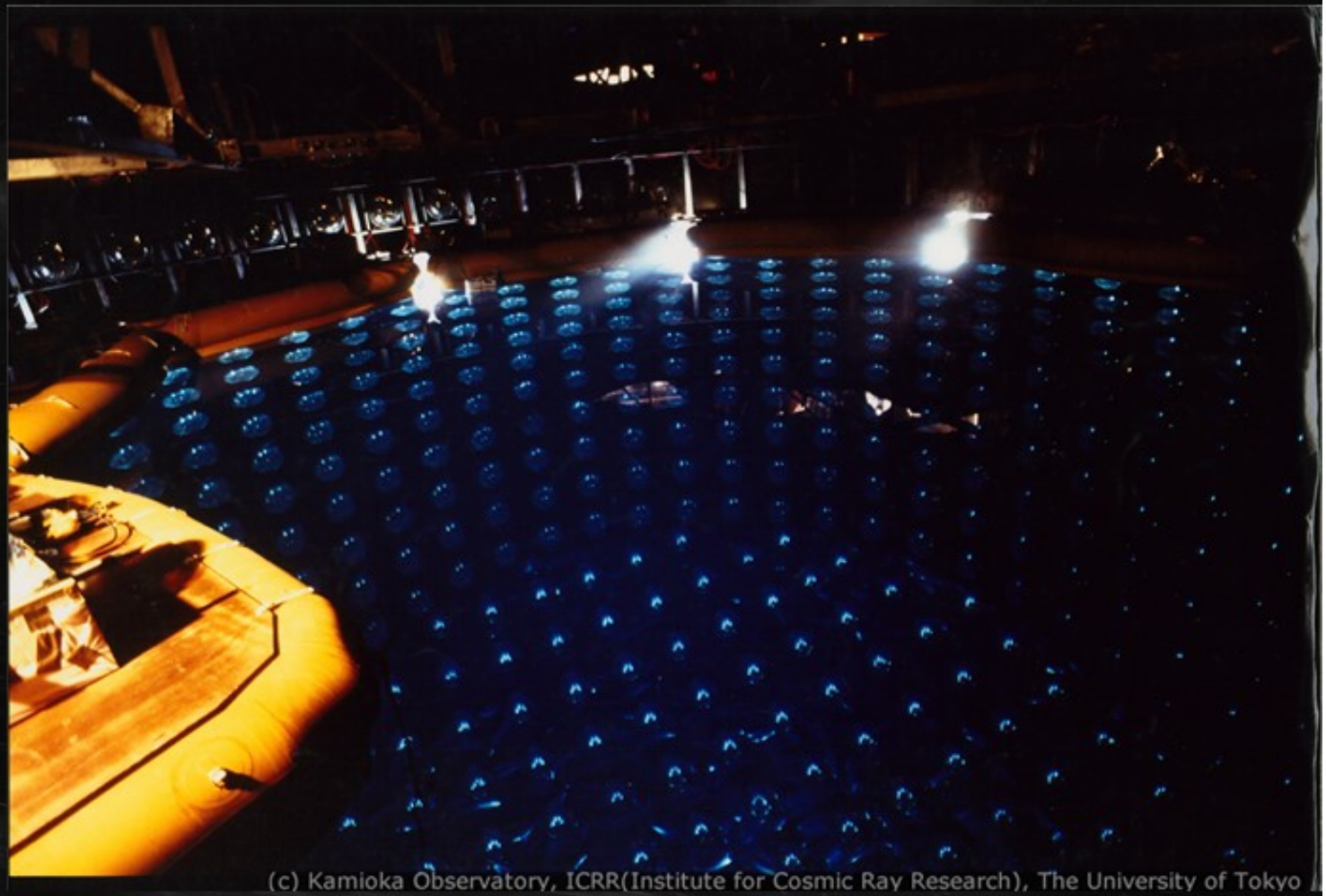


28

ALMA (ESO/NAOJ/NRAO)/A. Angelich. Visible light image: the NASA/ESA Hubble Space Telescope. X-Ray Image: The NASA Chandra X-Ray Observatory

Multimessenger Astronomy Supernova 1987A





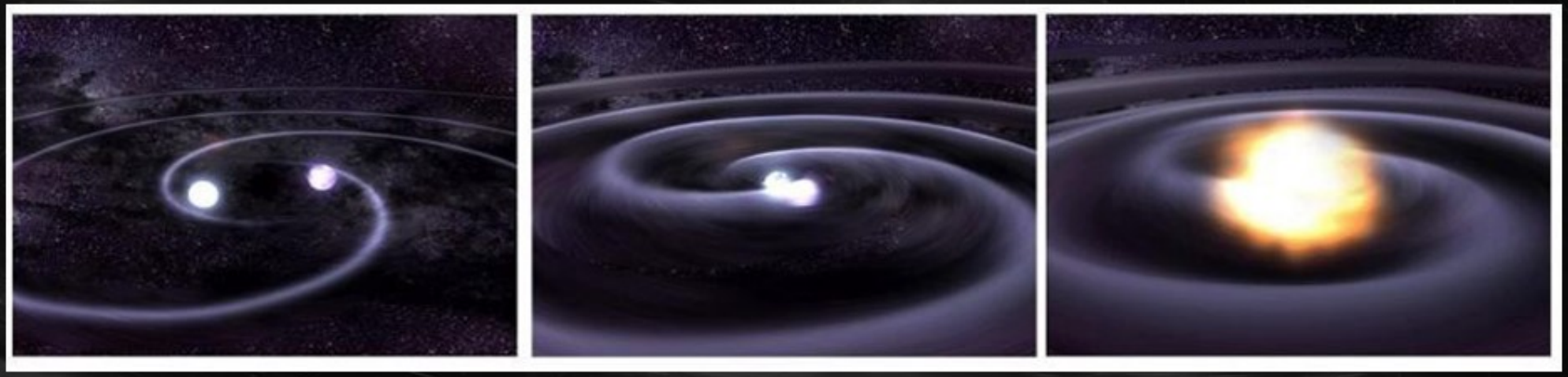
29


FIRST CONFIRMED SOURCE
OF HIGH-ENERGY NEUTRINOS
AND EXTRA-GALACTIC
COSMIC RAYS
NSF
National Science Foundation

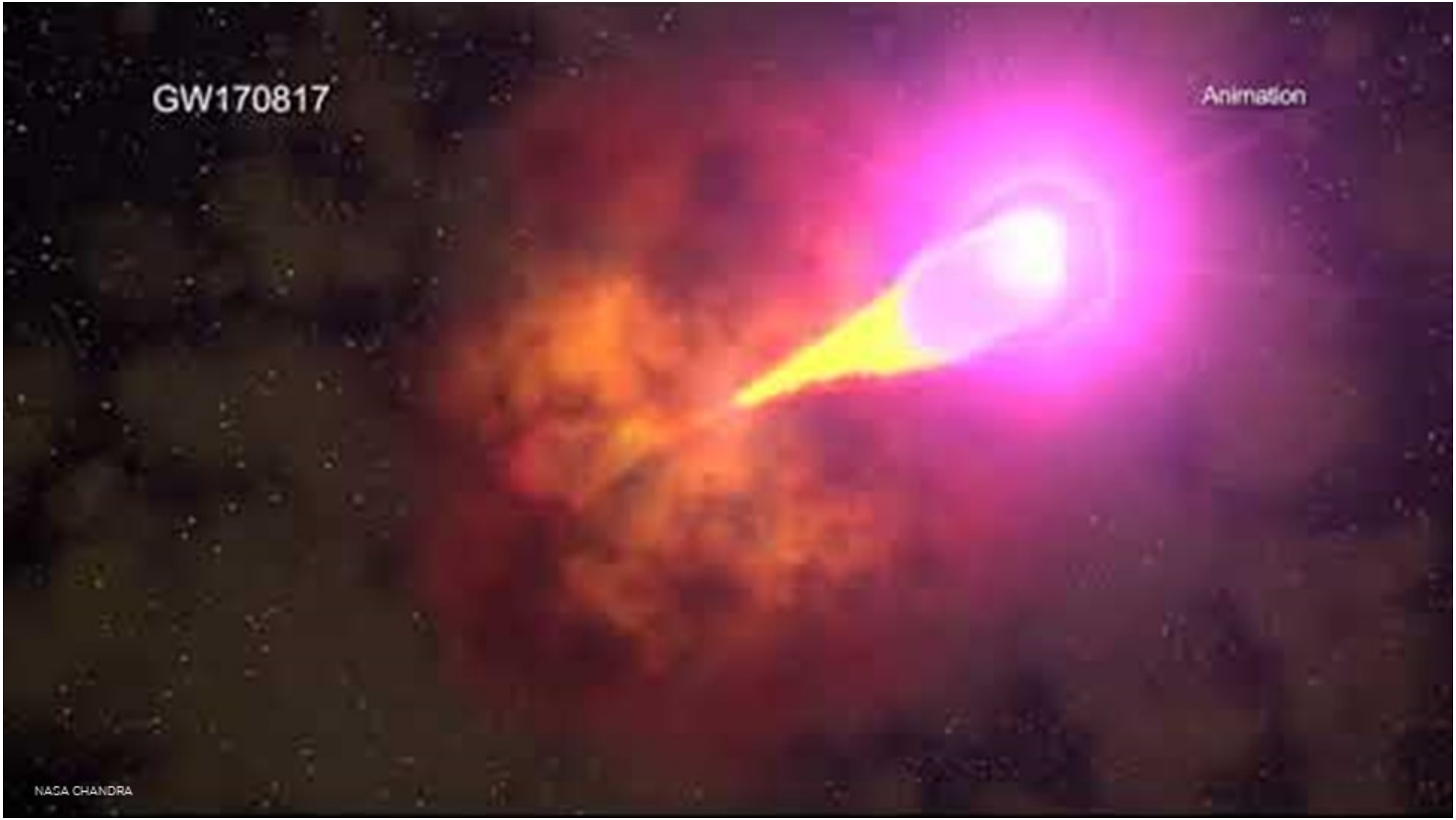

FIRST CONFIRMED SOURCE
OF HIGH-ENERGY NEUTRINOS
AND EXTRA-GALACTIC
COSMIC RAYS
NSF
National Science Foundation

Multimessenger Astronomy GW170817

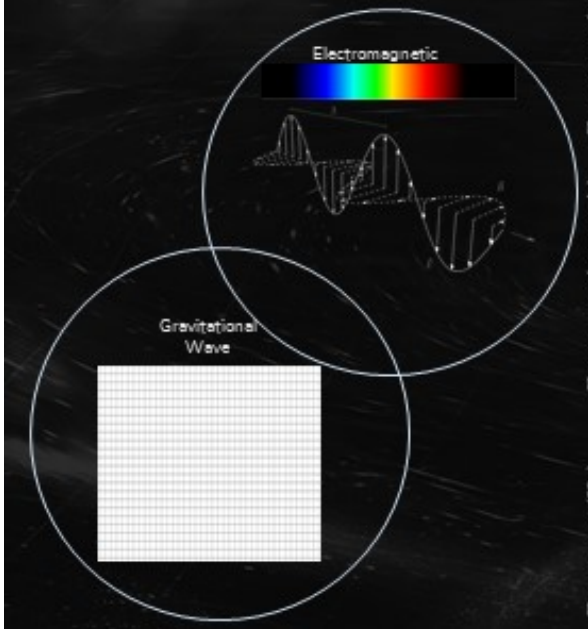
IR

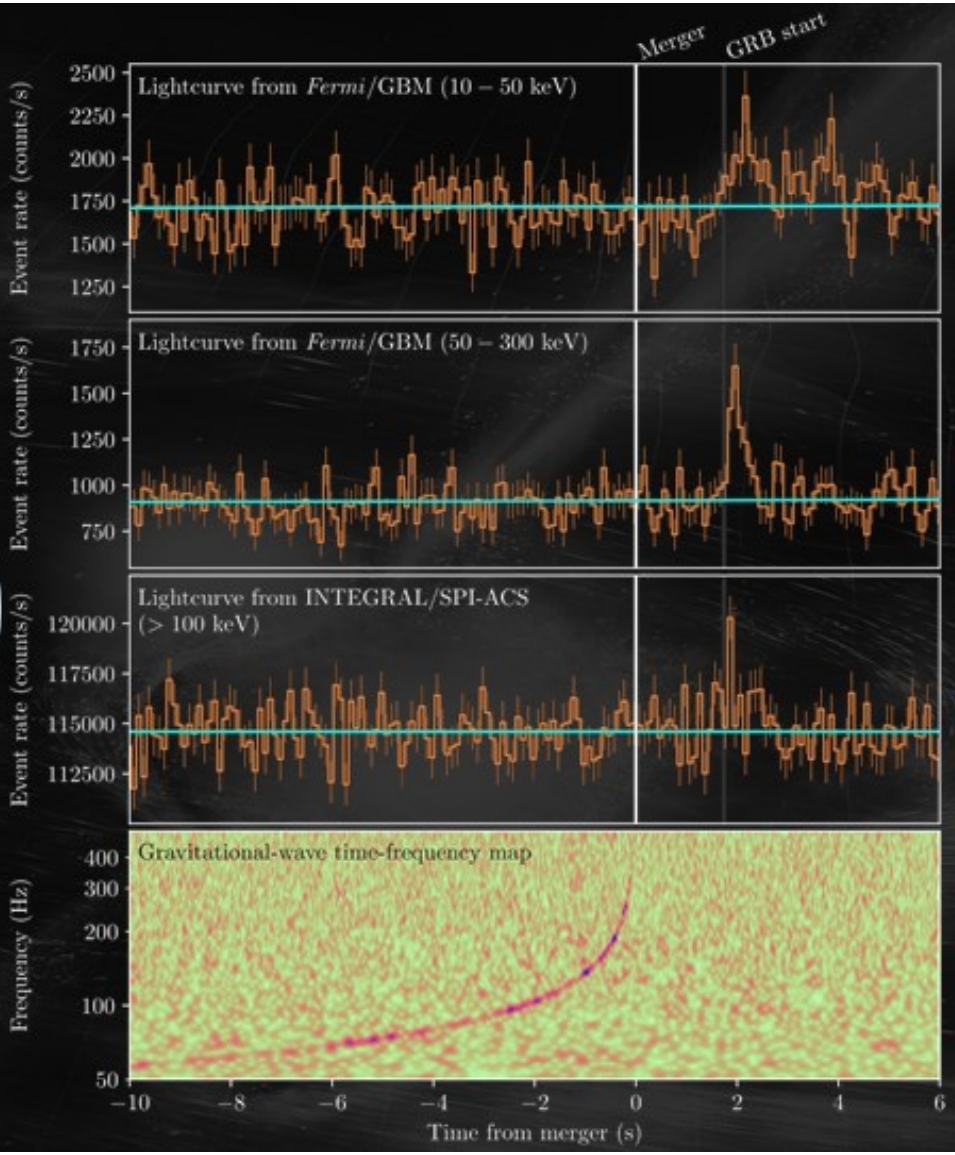


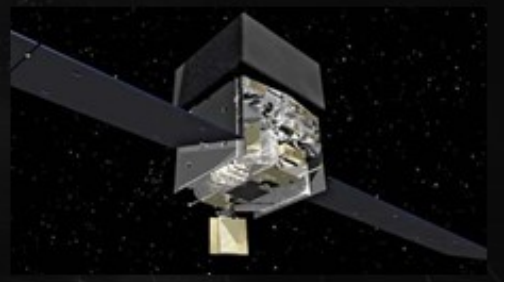
NASA

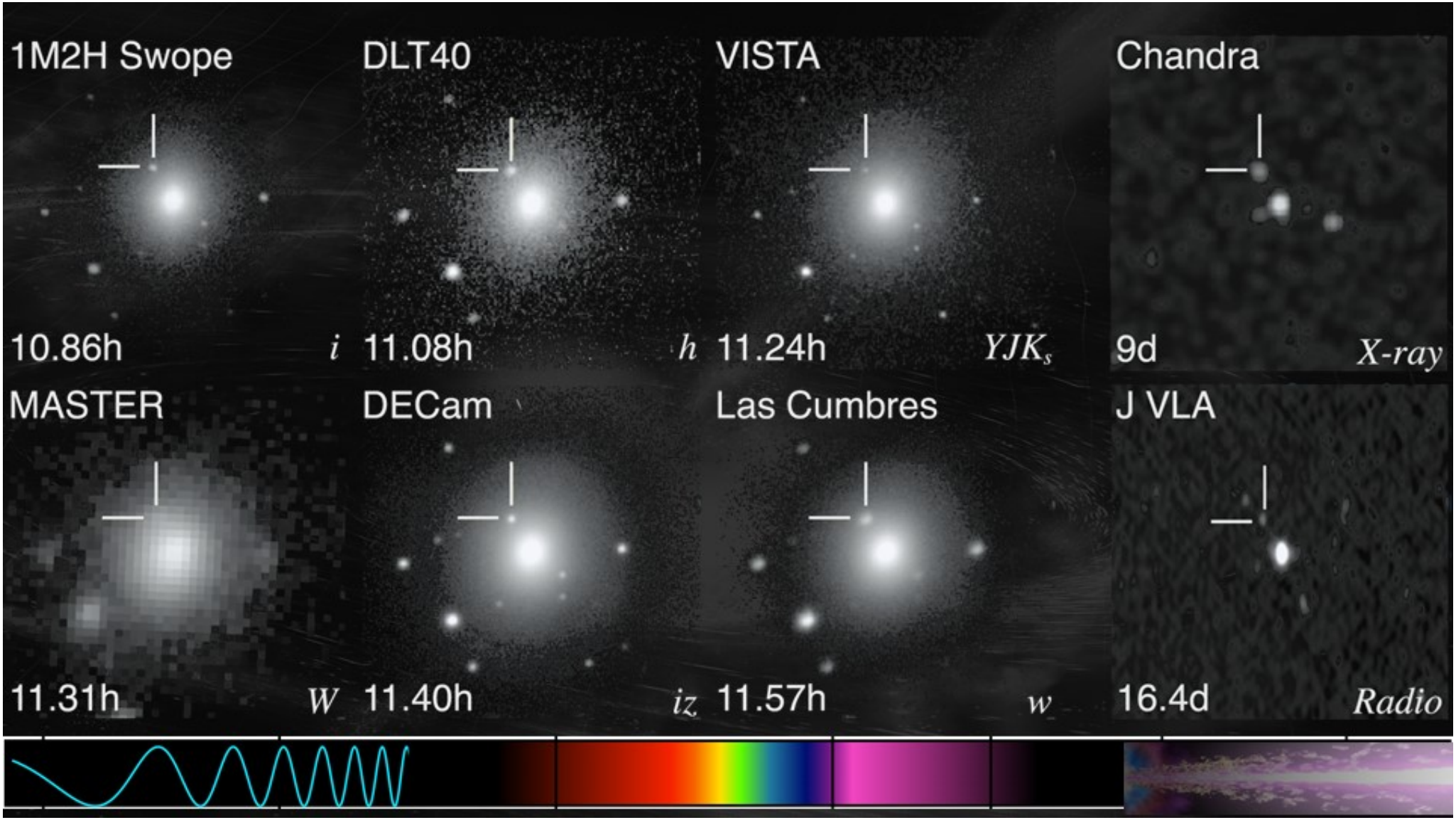

GW170817
Animation
NASA CHANDRA

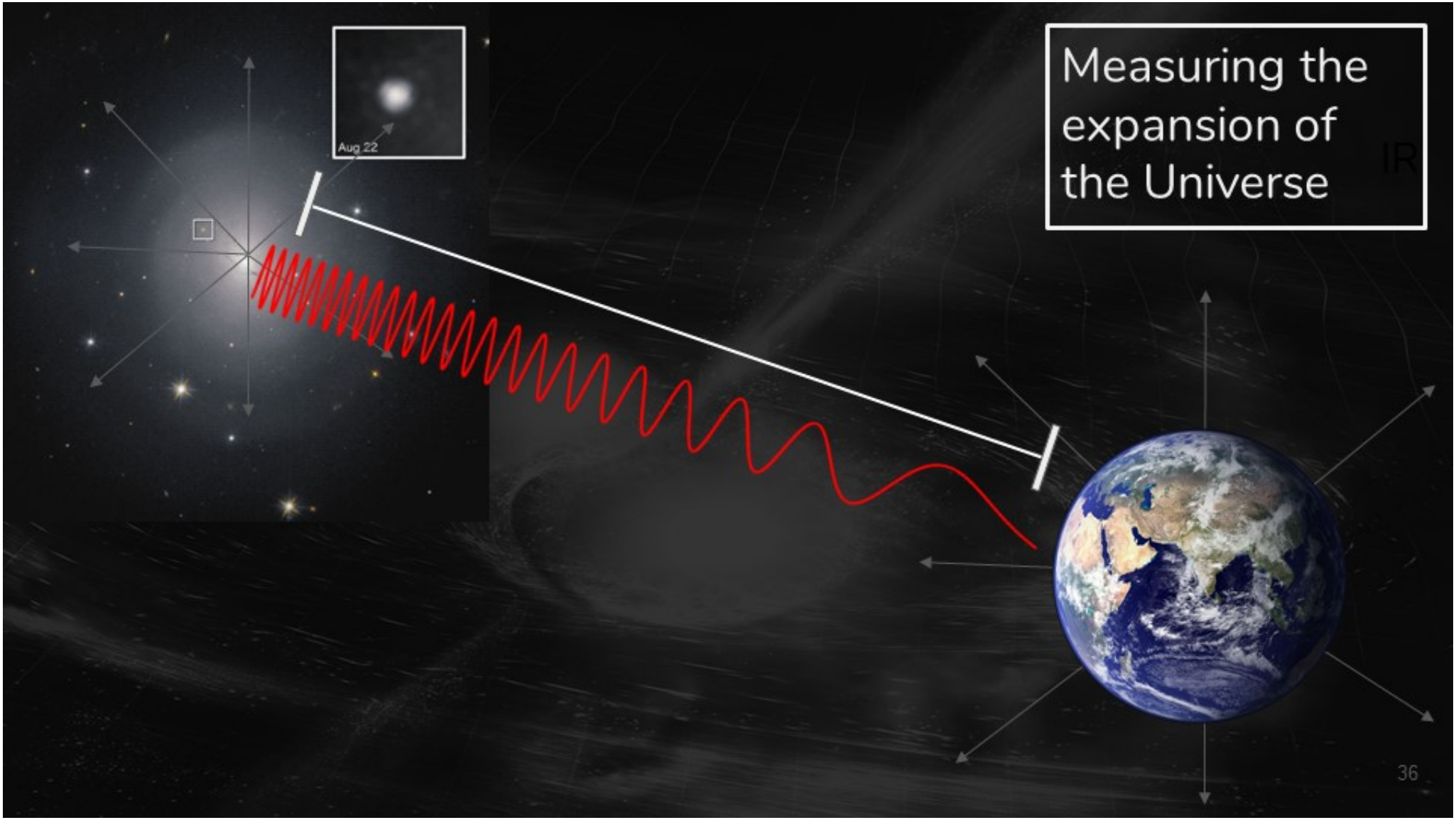
Multimessenger Astronomy GW170817

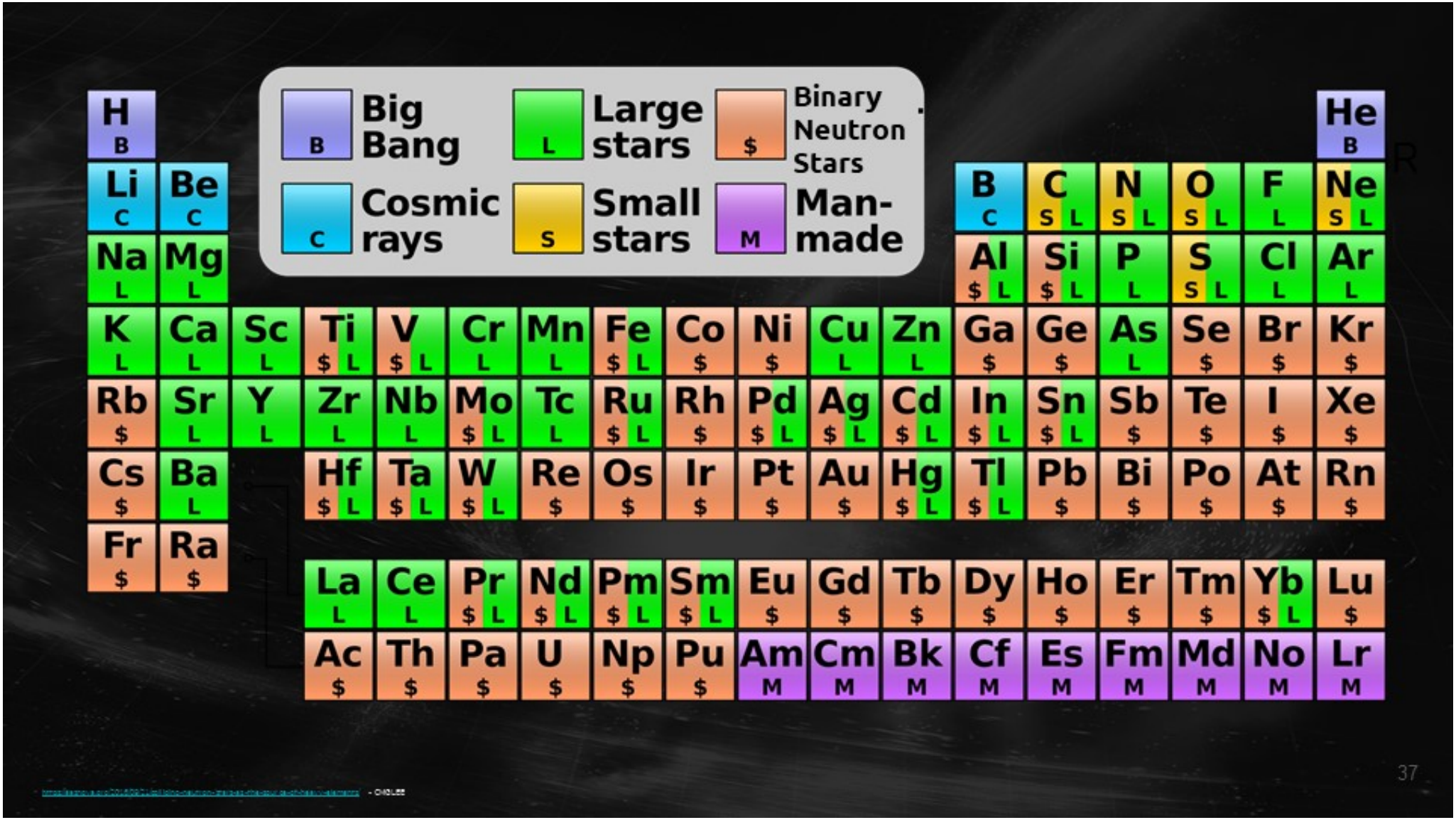






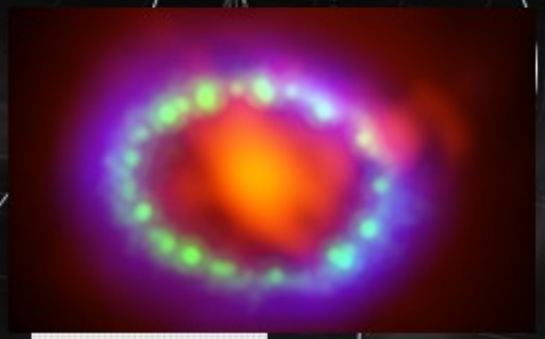

1M2H Swope
10.86h
i
DLT40
11.08h
h
VISTA
11.24h
YJK_s
Chandra
9d
X-ray
MASTER
11.31h
W
DECam
11.40h
iz
Las Cumbres
11.57h
w
J VLA
16.4d
Radio


Measuring the expansion of the Universe
IR
Aug 22
36

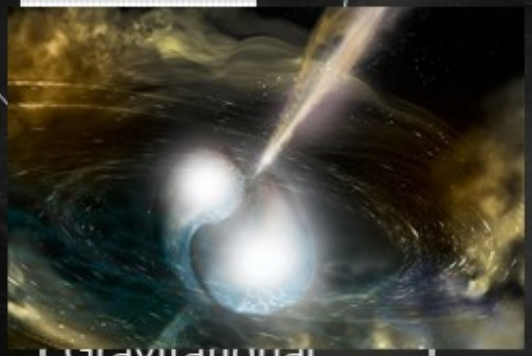

B Big Bang
L Large stars
$ Binary Neutron Stars
C Cosmic rays
S Small stars
M Man-made
H B
He B
Li C
Be C
B C
C S L
N S L
O S L
F L
Ne S L
Na L
Mg L
Al $ L
Si $ L
P L
S S L
Cl L
Ar L
K L
Ca L
Sc L
Ti $ L
V $ L
Cr L
Mn L
Fe $ L
Co $
Ni $
Cu L
Zn L
Ga $
Ge $
As L
Se $
Br $
Kr $
Rb $
Sr L
Y L
Zr L
Nb L
Mo $ L
Tc L
Ru $ L
Rh $
Pd $ L
Ag $ L
Cd $ L
In $ L
Sn $ L
Sb $
Te $
I $
Xe $
Cs $
Ba L
Hf $ L
Ta $ L
W $ L
Re $
Os $
Ir $
Pt $
Au $
Hg $ L
Tl $ L
Pb $
Bi $
Po $
At $
Rn $
Fr $
Ra $
La L
Ce L
Pr $ L
Nd $ L
Pm $ L
Sm $ L
Eu $
Gd $
Tb $
Dy $
Ho $
Er $
Tm $
Yb $ L
Lu $
Ac $
Th $
Pa $
U $
Np $
Pu $
Am M
Cm M
Bk M
Cf M
Es M
Fm M
Md M
No M
Lr M
37

What's next? All three of course!

Supernova
1: EM + Neutrino

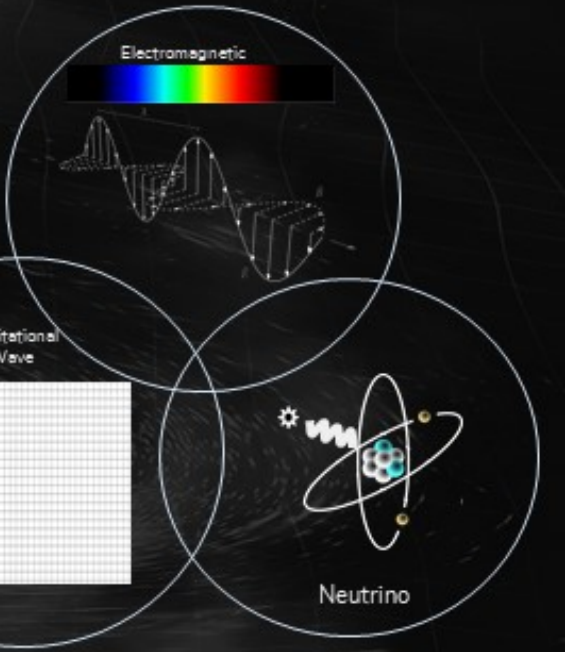


Binary Neutron Star Merger

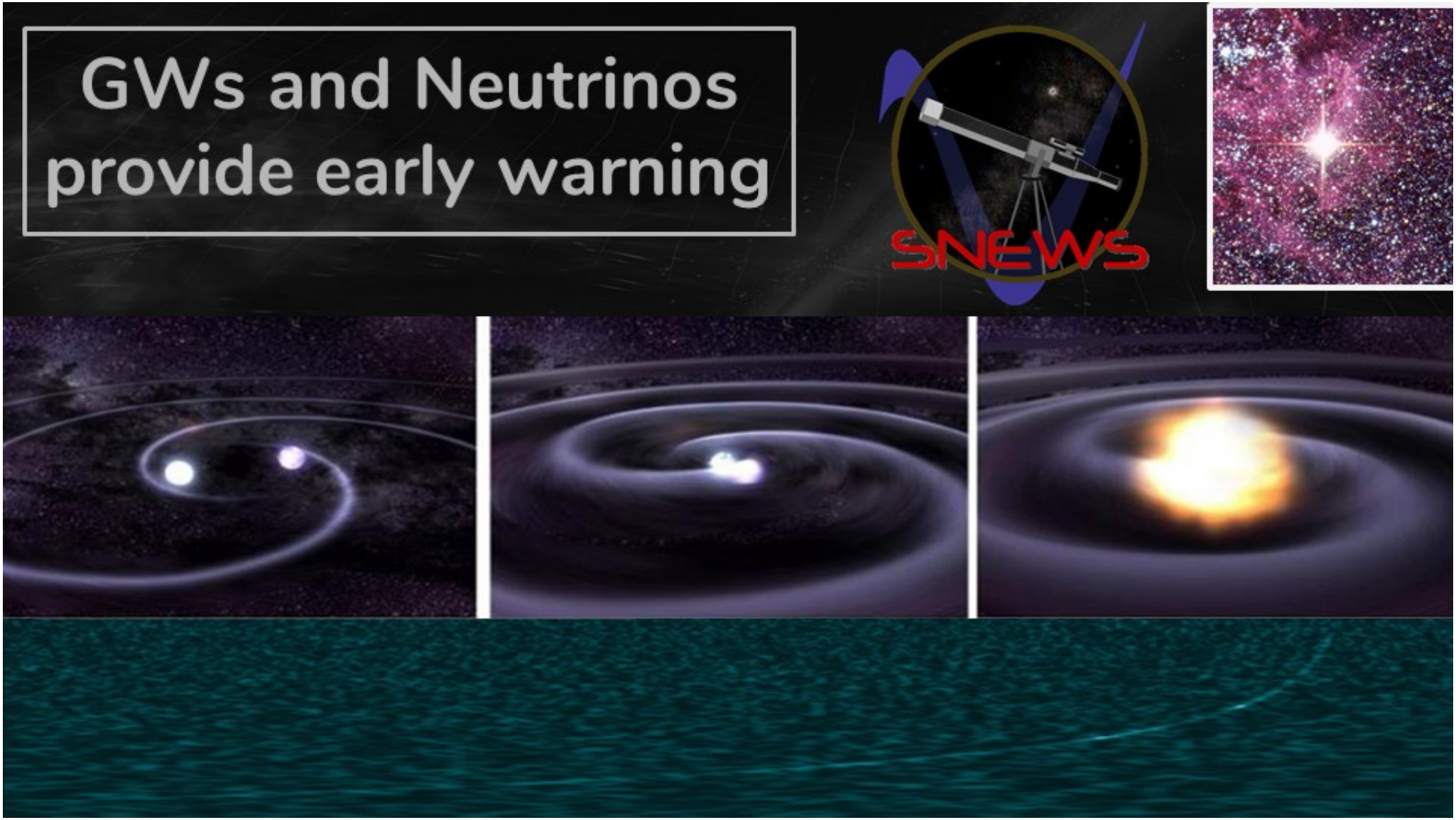


The unkown

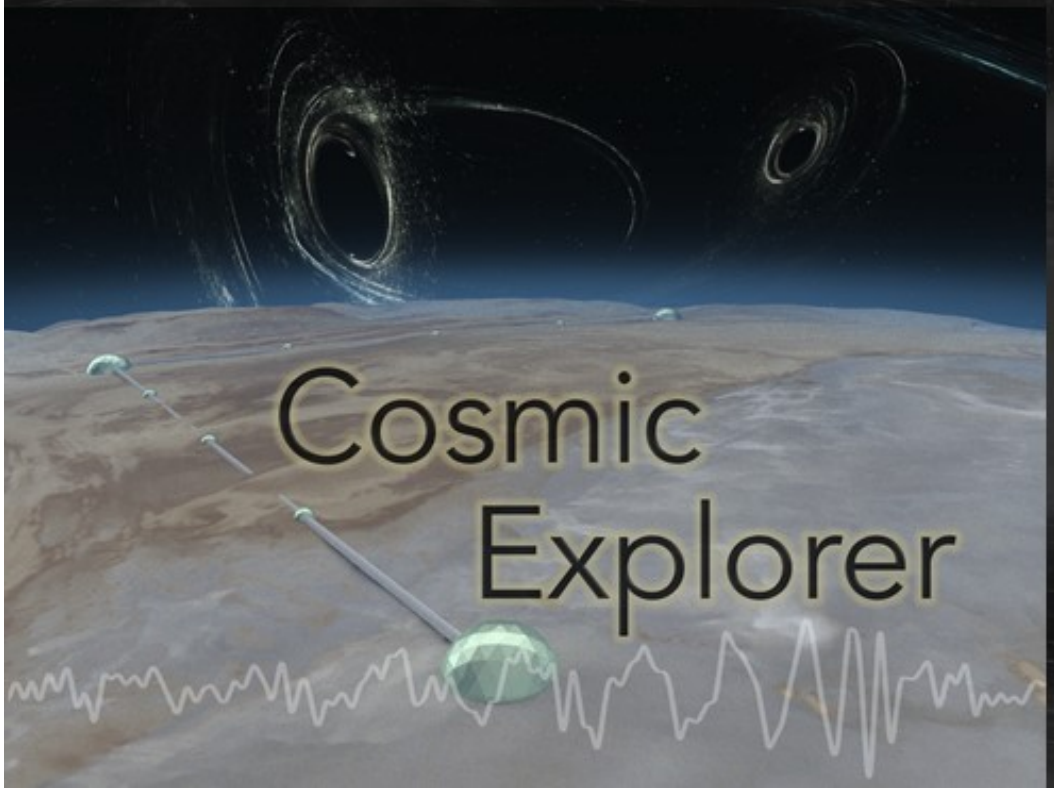
???

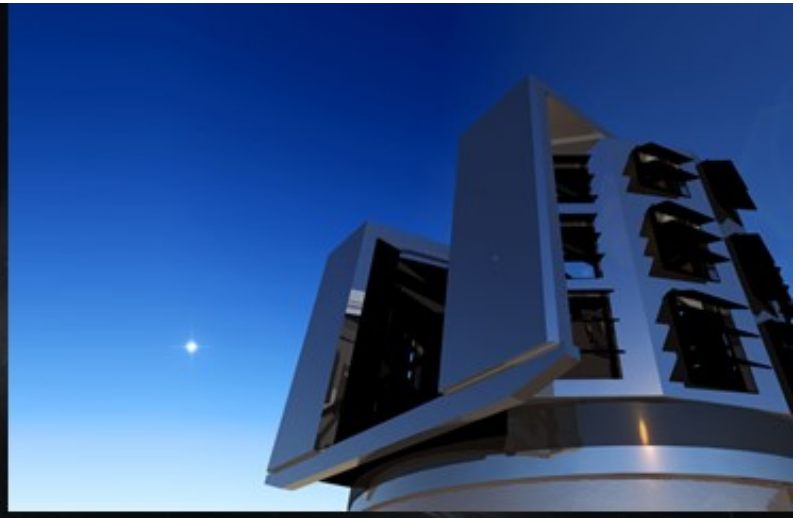


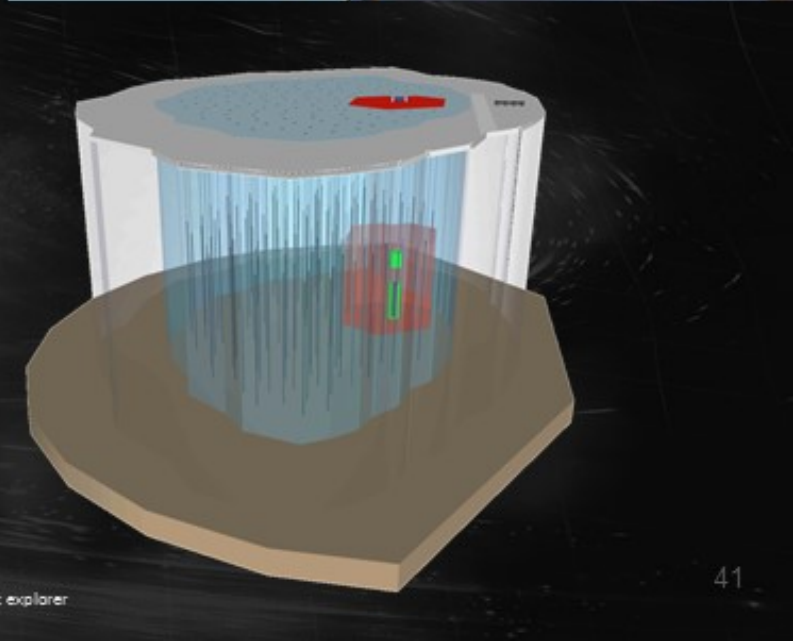

Thank You
39


GWs and Neutrinos
provide early warning
SNEWS

Next generation experiments



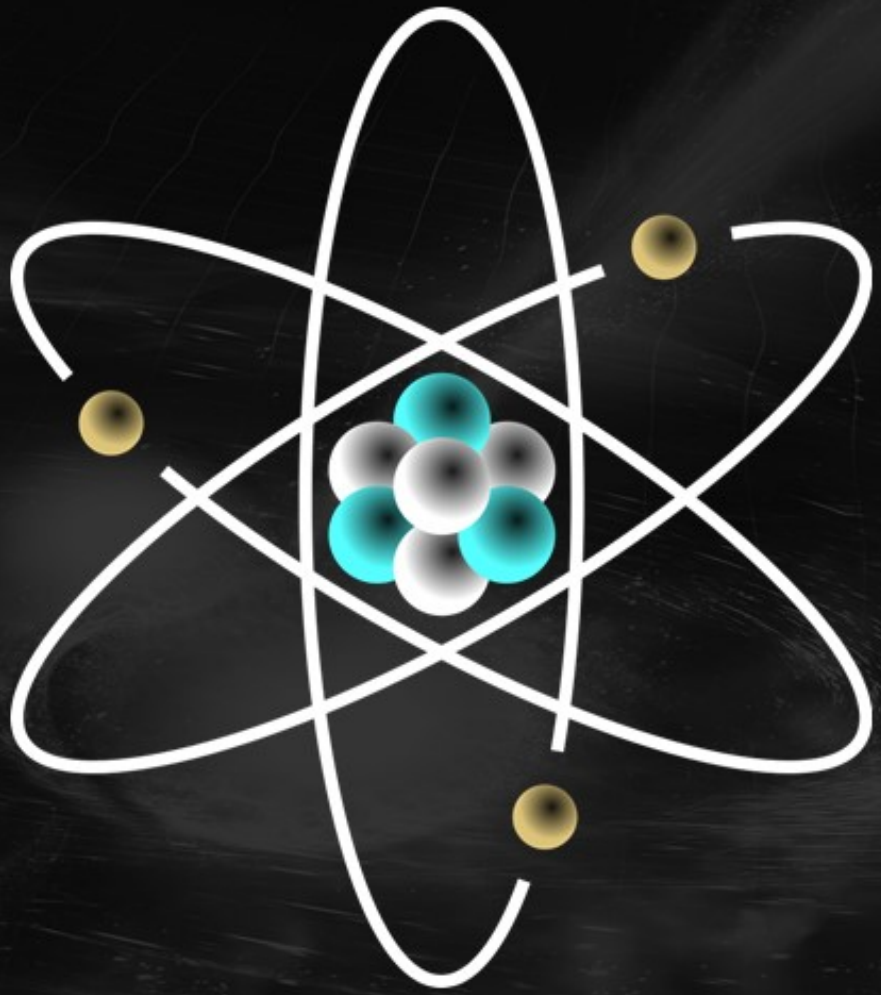




Icecube / lscr / cosmic explorer

The Atom

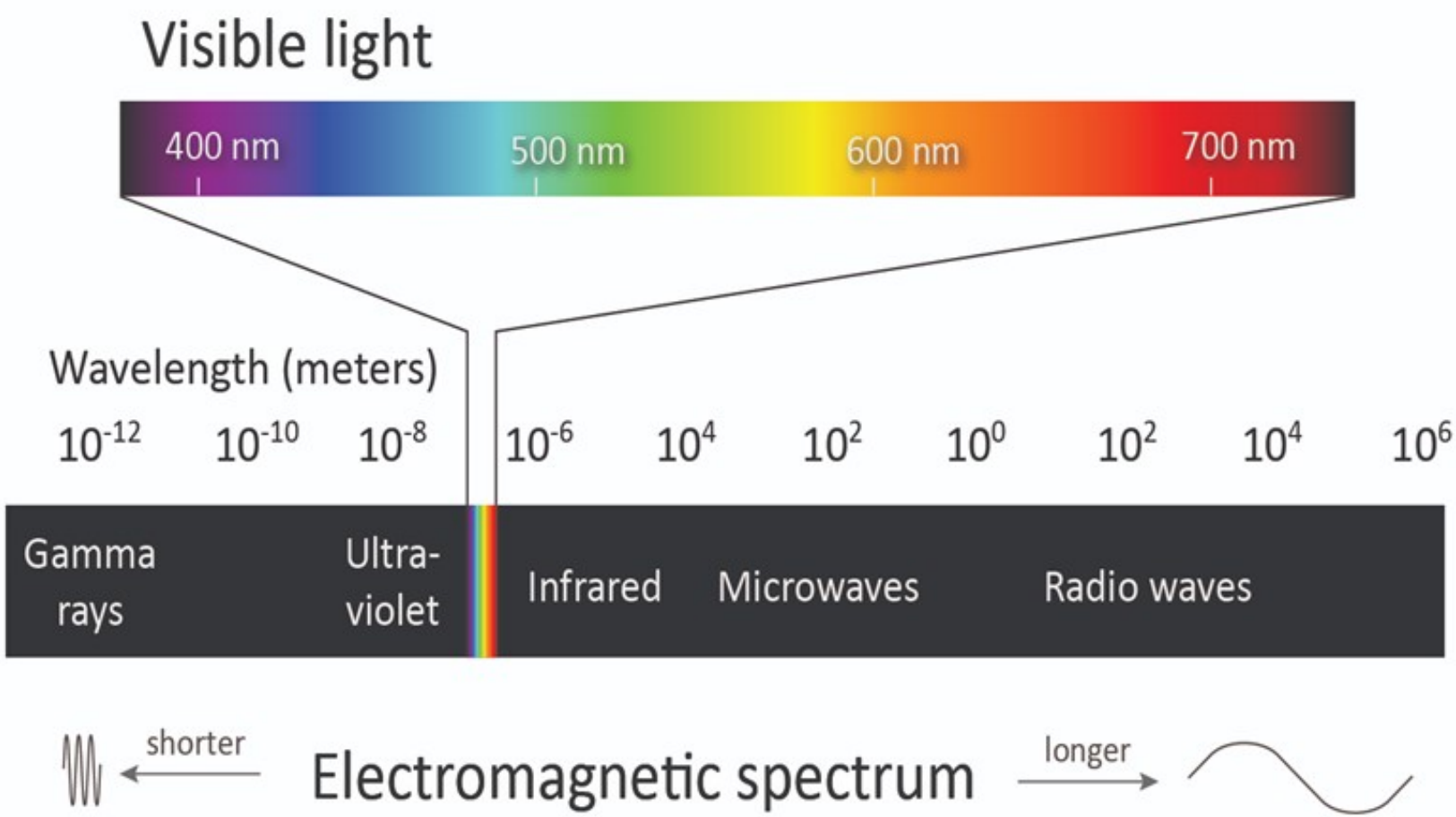
20th Century



IR

SVG by Indolences.Recoloring and ironing out some glitches done by Rainer Klute. (CC BY-SA 3.0 (http://creativecommons.org/licenses/by-sa/3.0/)

1915



From the film "Interstellar"

Outline

- A brief history of astronomy
- The ~20th century revolution - discovery of electromagnetic spectrum, quantum mechanics, relativity, predictions of compact objects, the neutrino, etc
- Pushing the boundaries with new instruments, etc
- SN1987a
- GW170817
- TXS
- What we learn?
- The potential and prospects