

Ondas Gravitacionales



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Generando ondas mecánicas



Photograph: Michael Ochs Archives

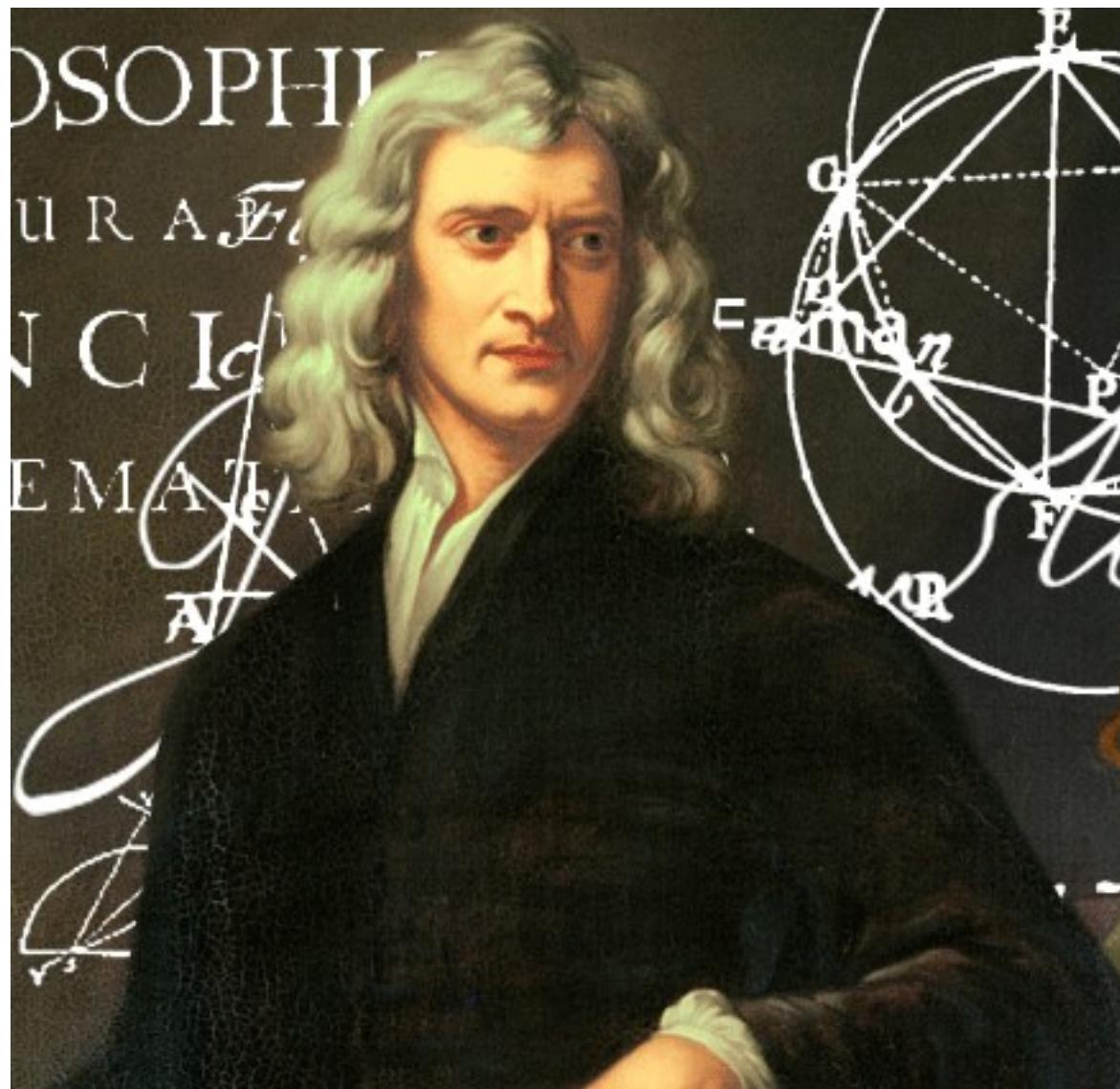


Generando ondas electromagnéticas





Gravedad (Newton - 1680)



Gravedad (Laplace - 1800)



Relatividad Especial (Einstein -1905)

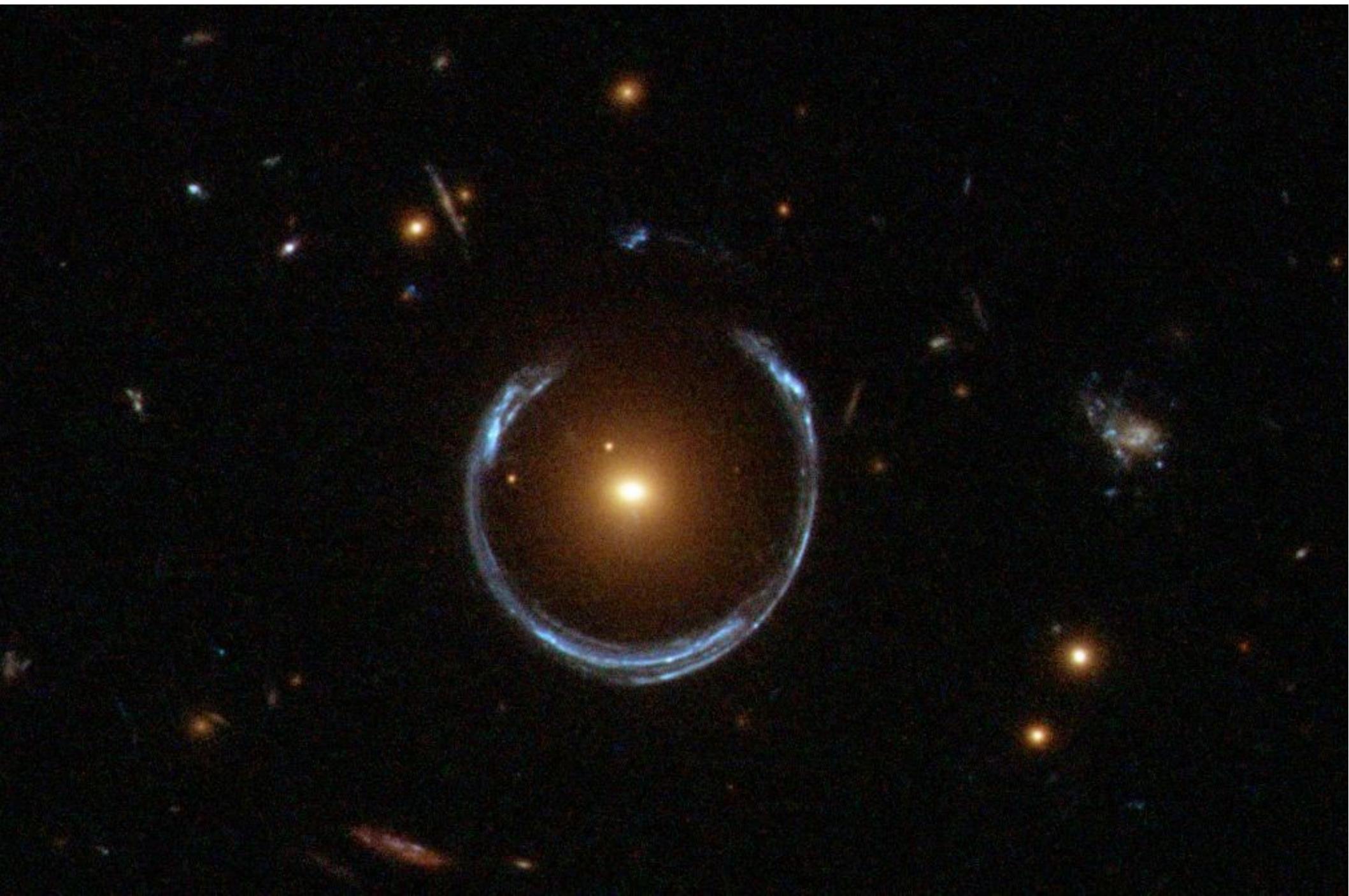


Relatividad General (Einstein y amigos, 1915)



Grossmann, Einstein: ETH-Bibliothek Zürich/Bildarchiv; Besso: Besso Family/AIP Emilio Segre Visual Archives

Éxitos de la Relatividad General



LIGHTS ALL ASKEW, IN THE HEAVENS

Men of Science More or Less
Agog Over Results of Eclipse
Observations.

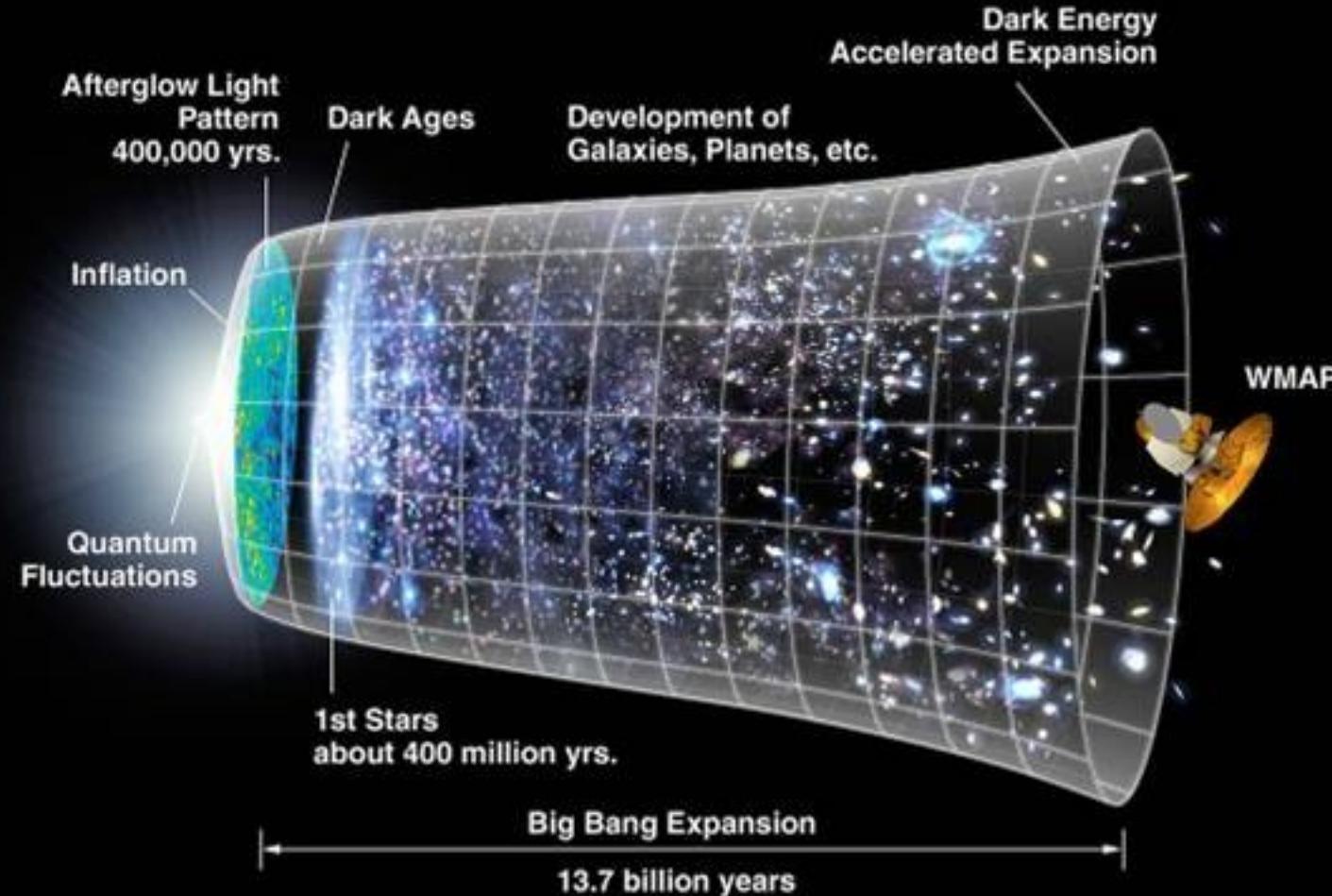
EINSTEIN THEORY TRIUMPHS

Stars Not Where They Seemed
or Were Calculated to be,
but Nobody Need Worry.

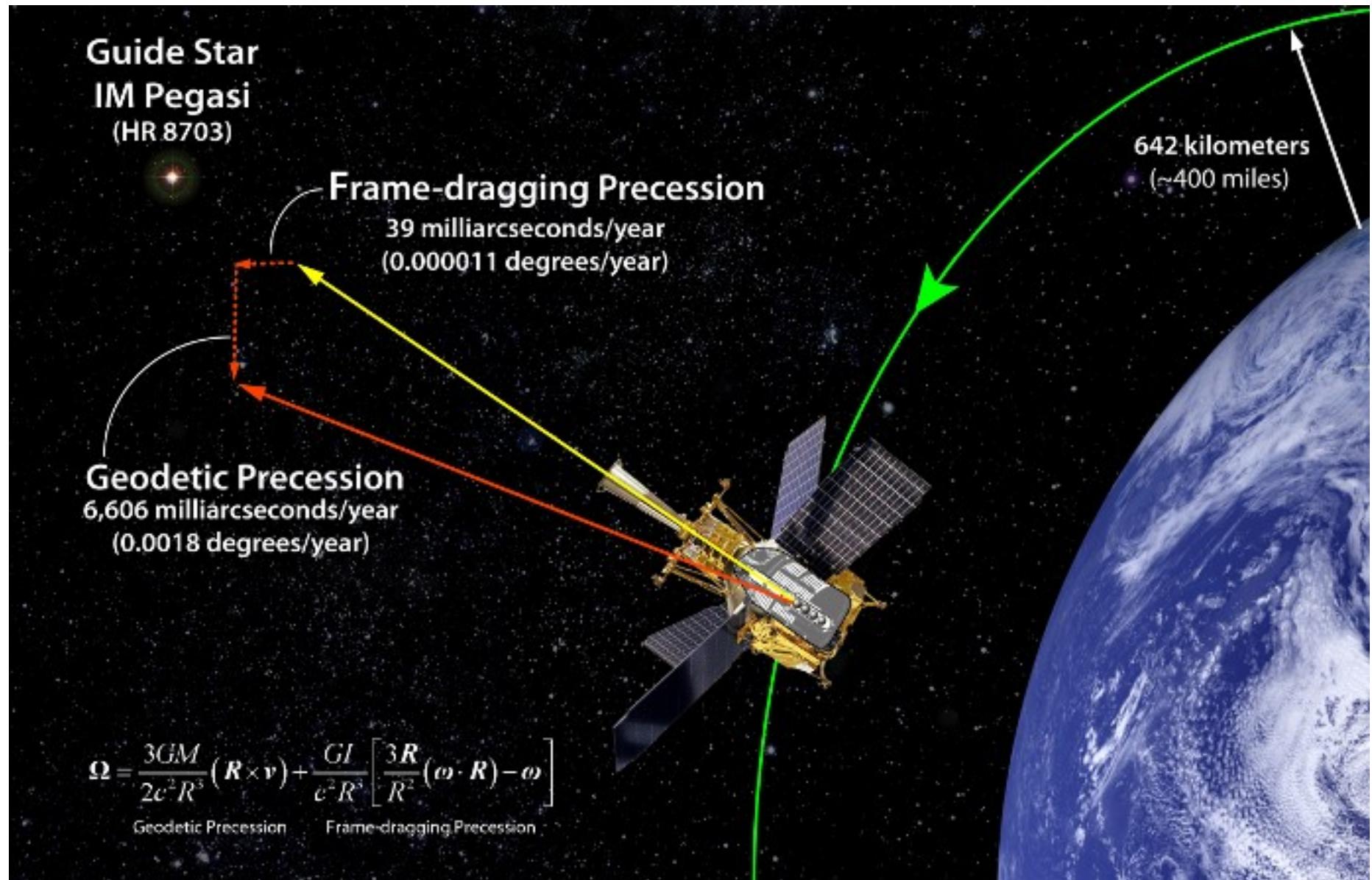
A BOOK FOR 12 WISE MEN

No More in All the World Could
Comprehend It, Said Einstein When
His Daring Publishers Accepted It.

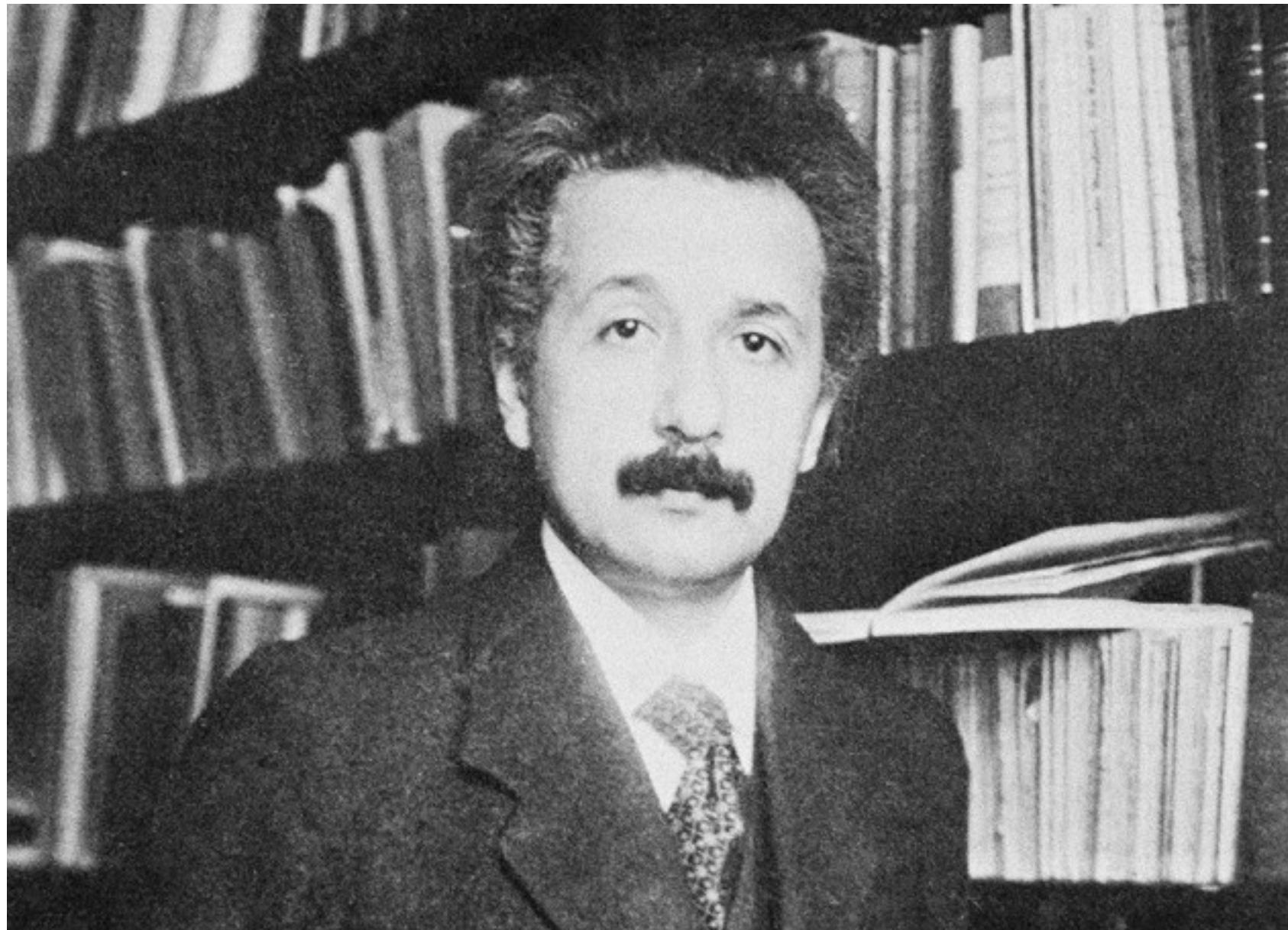
Éxitos de la Relatividad General



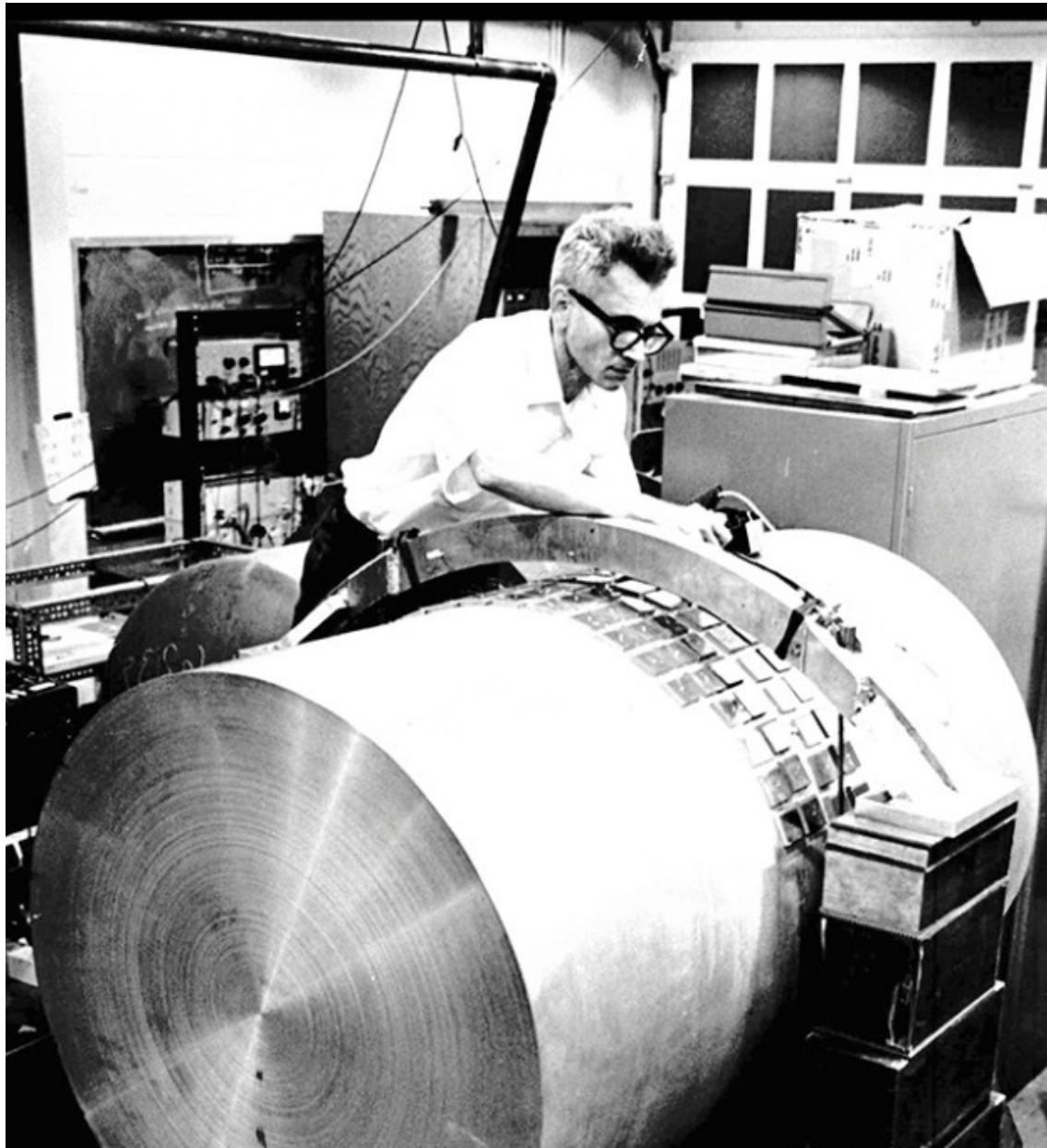
Éxitos de la Relatividad General



Junio 1916: Predicción (Einstein)

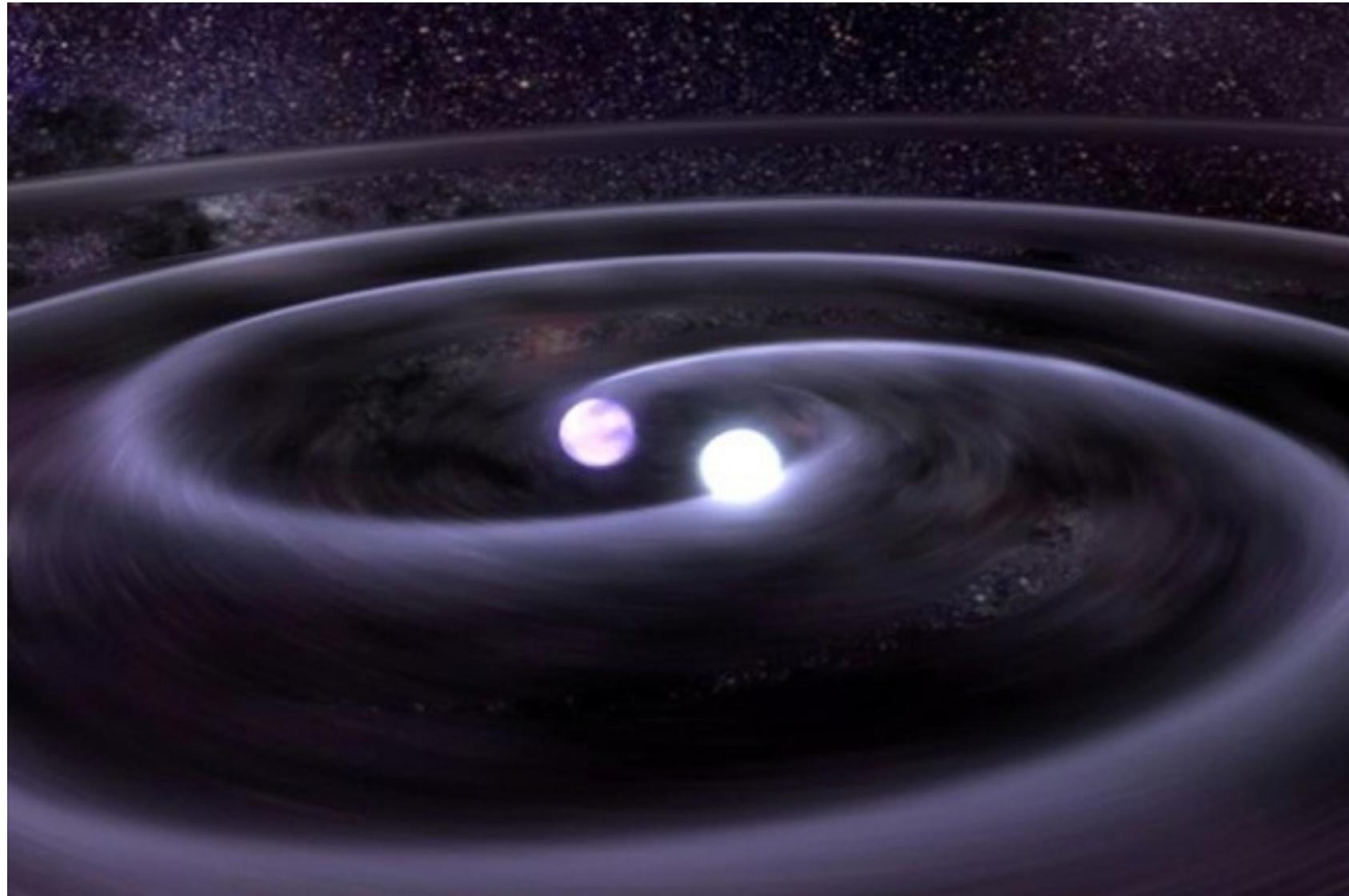


Junio 1969: primer anuncio de detección (Weber)

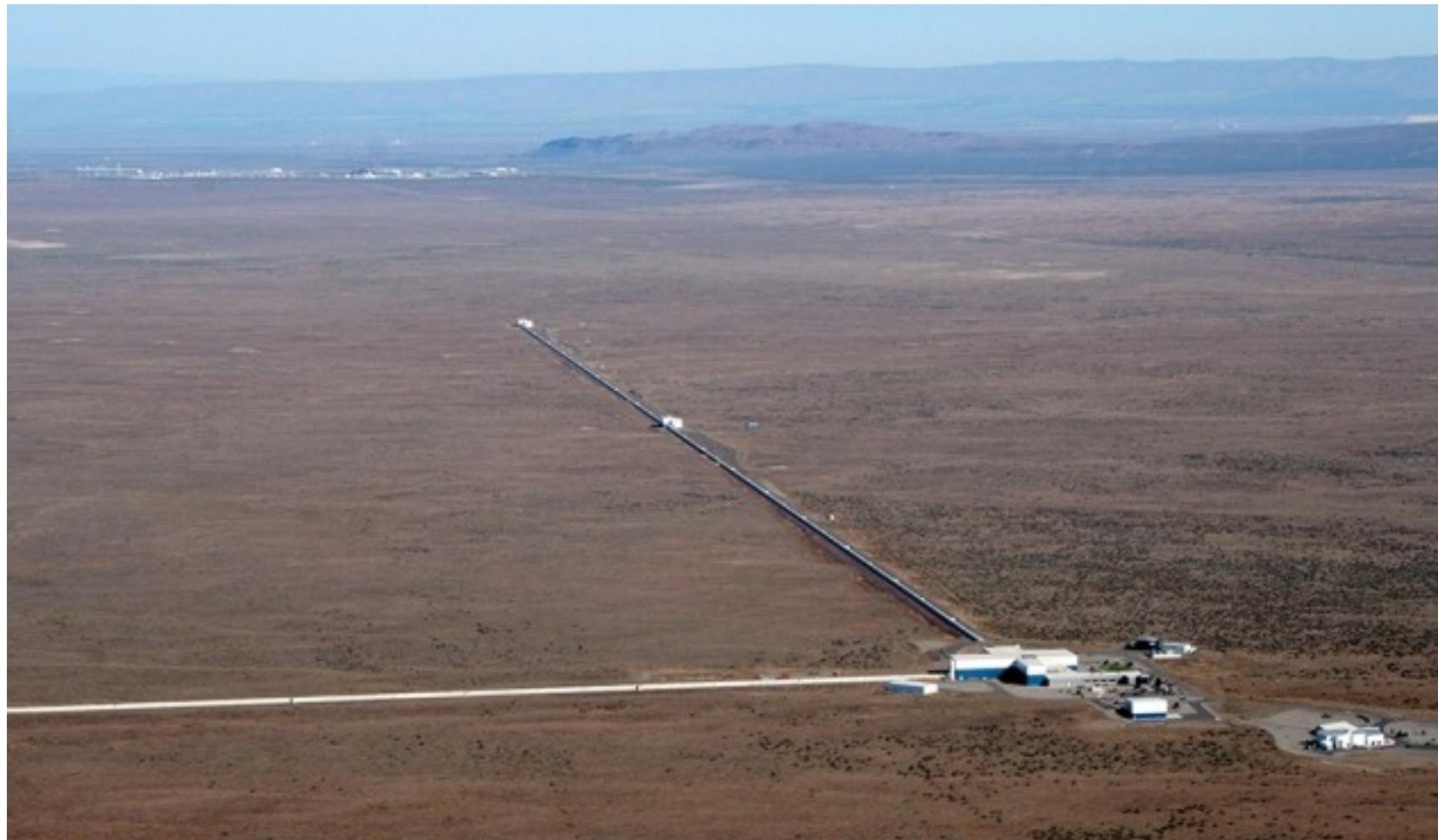


VOLKER STEGER/SCIENCE PHOTO LIBRARY

1974: estrellas de Neutrones (Taylor & Hulse, Nobel 1993)



1990: Empieza LIGO (Caltech - MIT)



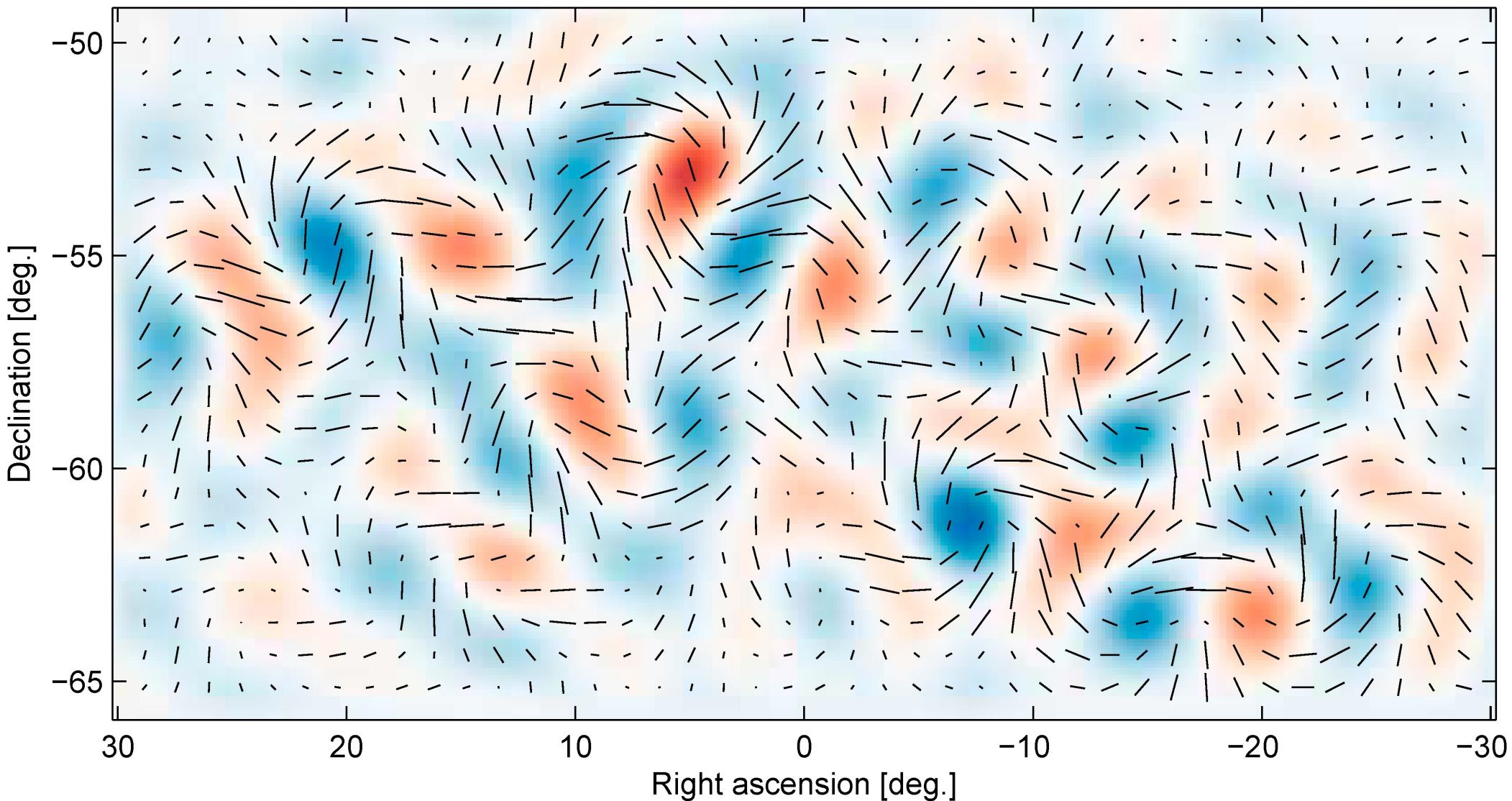
LIGO Laboratory

Marzo 2014: ondas gravitacionales primordiales (BICEP2)



Marzo 2014: ondas gravitacionales primordiales (BICEP2)

BICEP2 B-mode signal



Septiembre 2015: Advanced LIGO

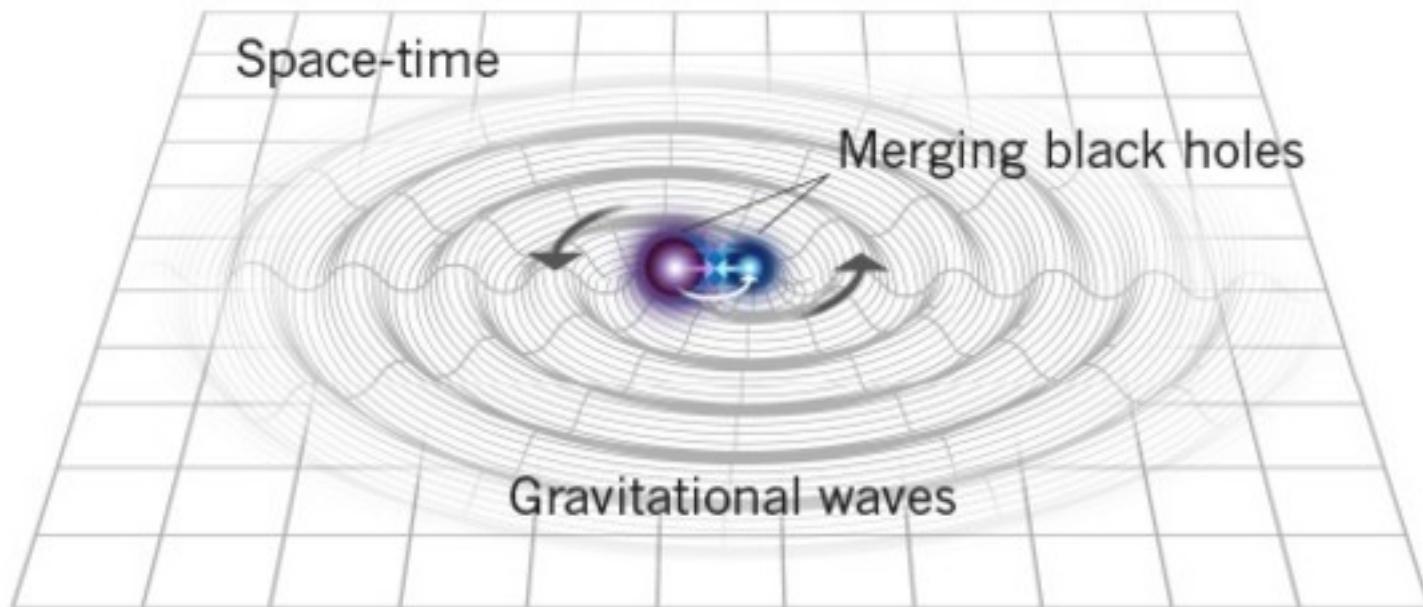


Febrero 2016: LIGO anuncia la detección de ondas gravitacionales



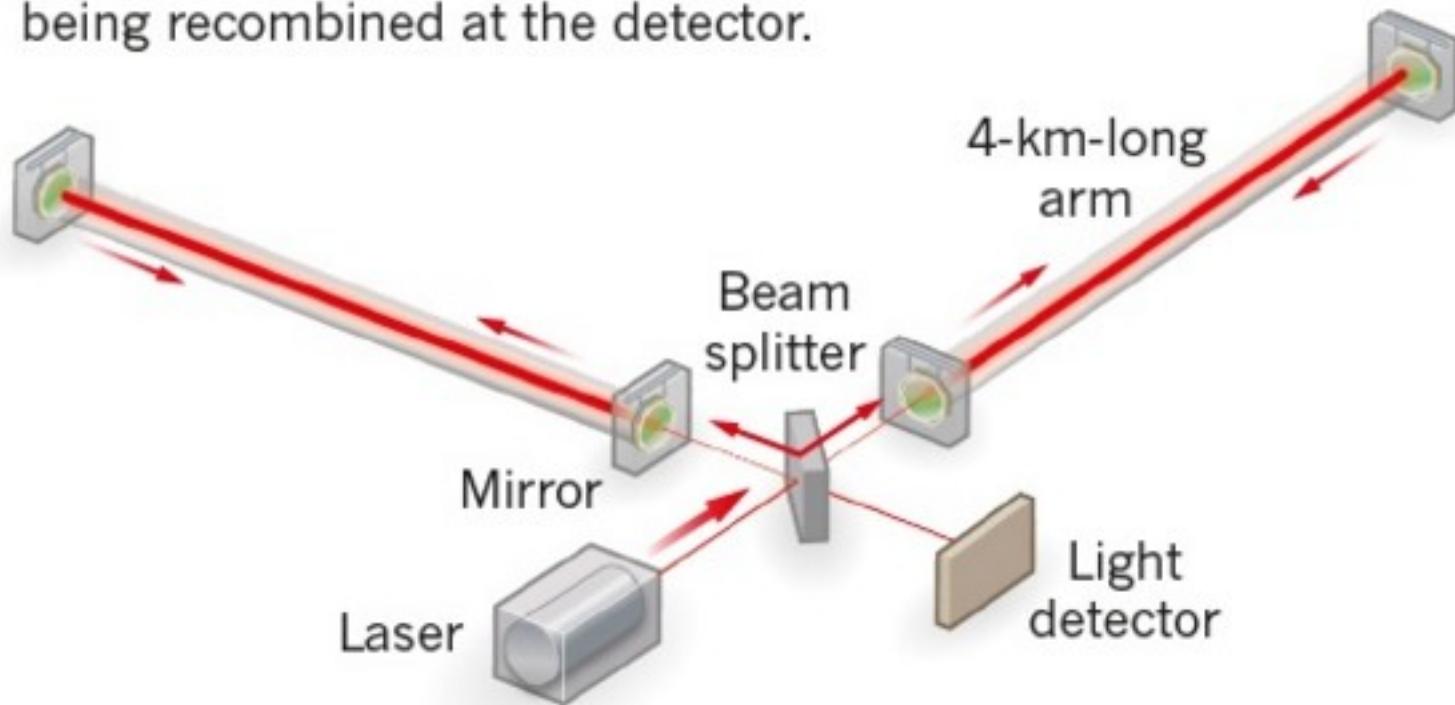
En la foto: Gabriela Gonzalez, Rainer Weiss y Kip Thorne

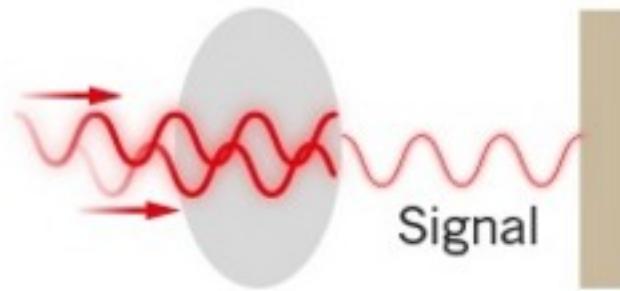
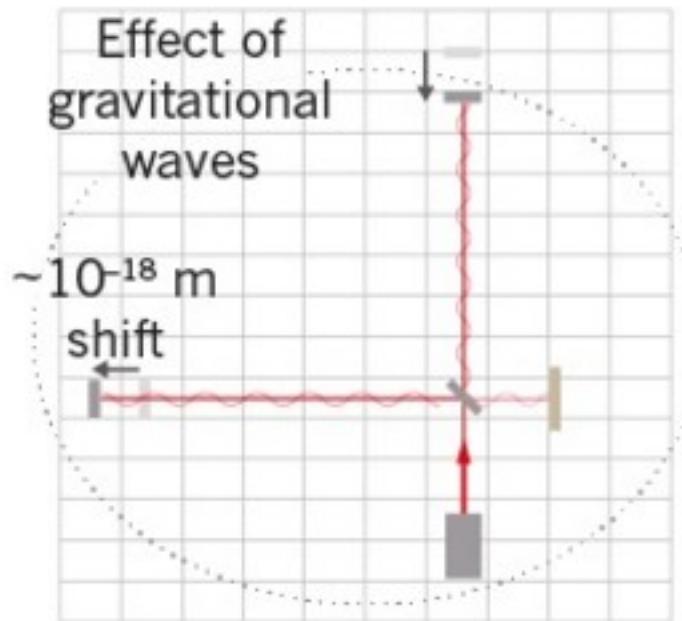
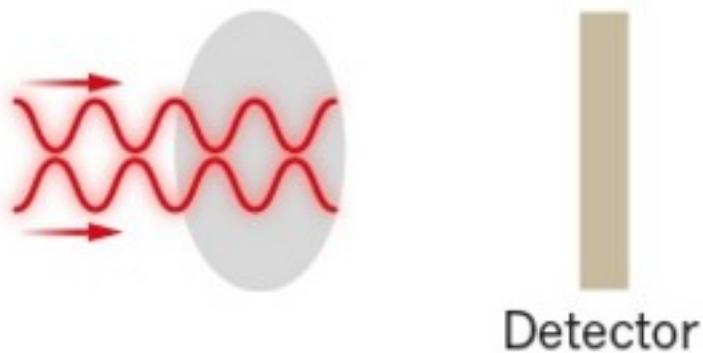
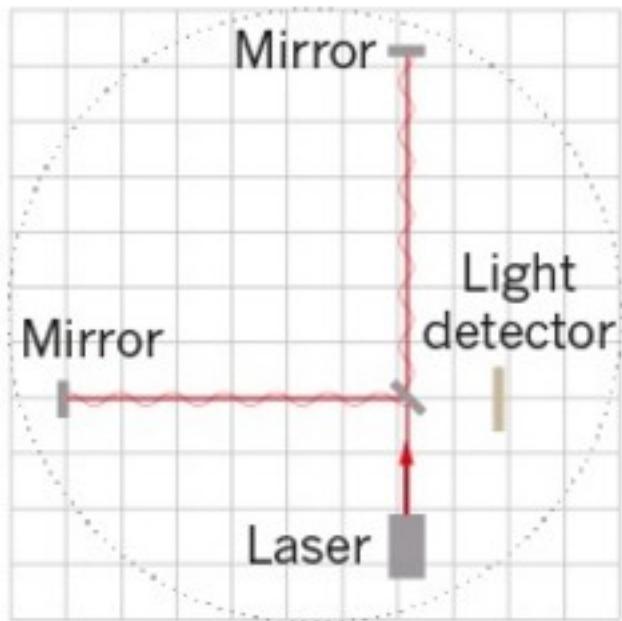
Chris Maddaloni/Nature

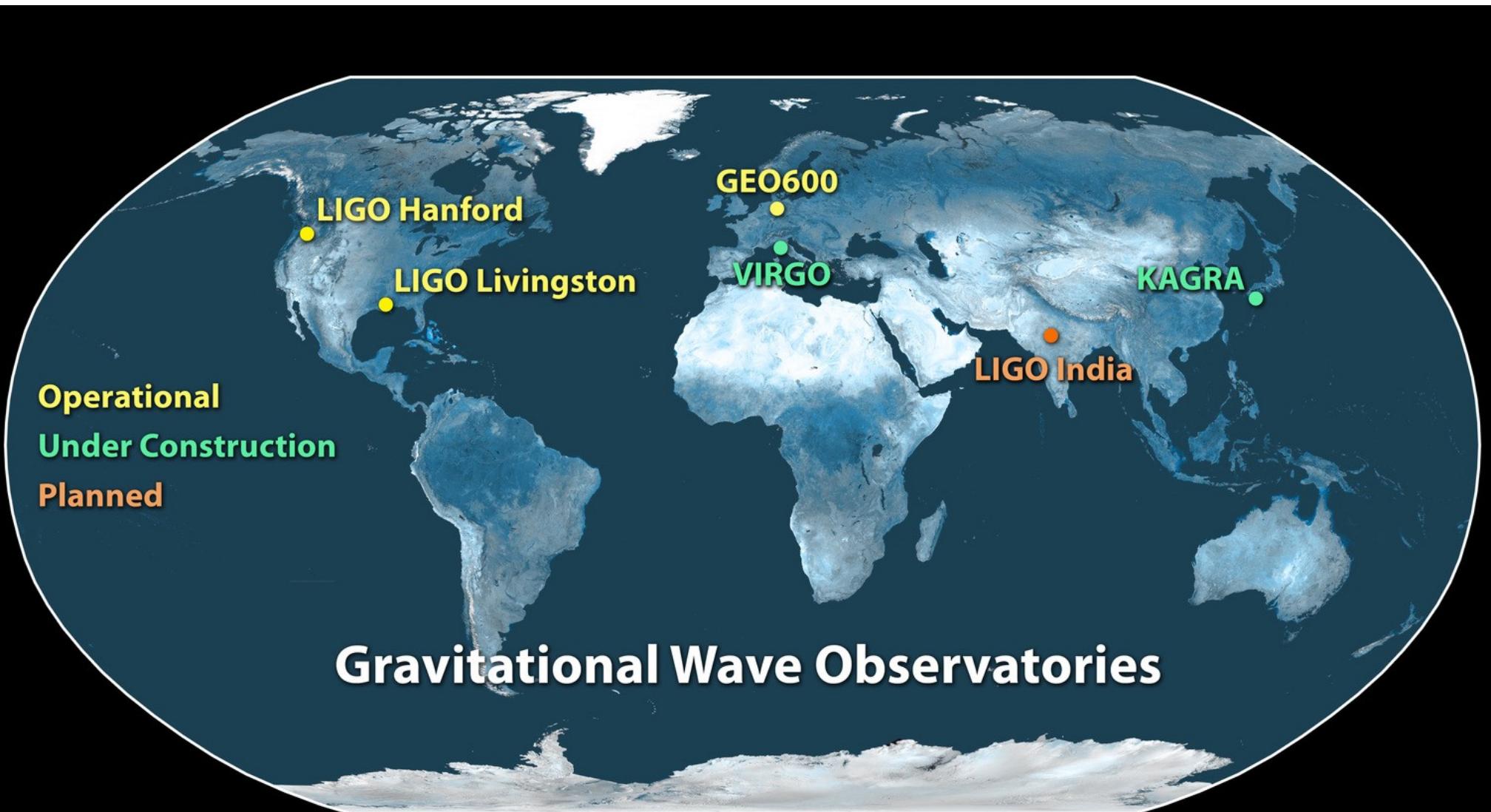


The gravitational waves were produced when two black holes — one weighing 36 solar masses and the other 29 — spiralled towards each other and merged, distorting the space-time around them in the process.

In the LIGO facility, a laser beam is split to travel down two perpendicular 4-kilometre tunnels. The beams then reflect back and forth before being recombined at the detector.

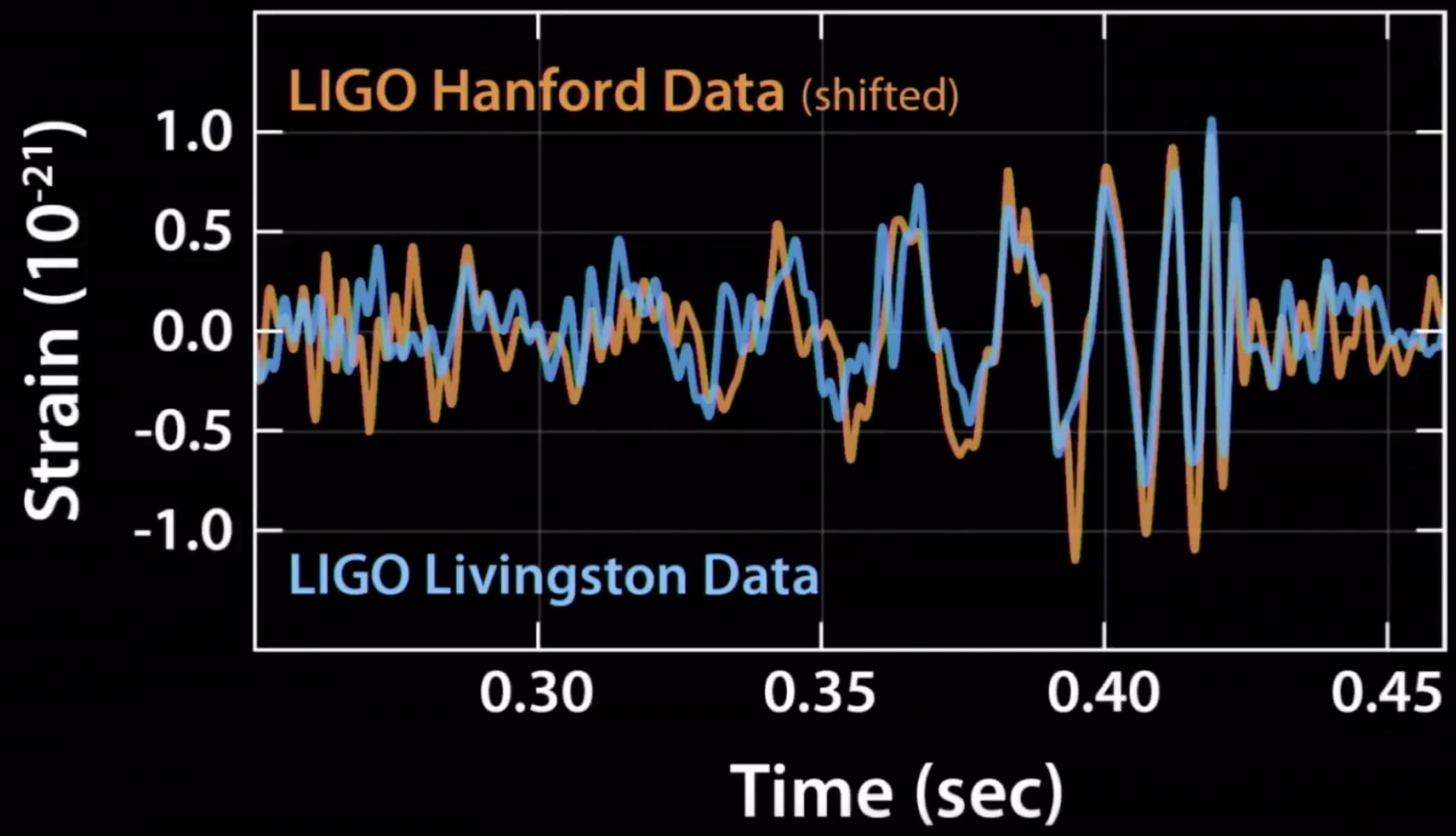






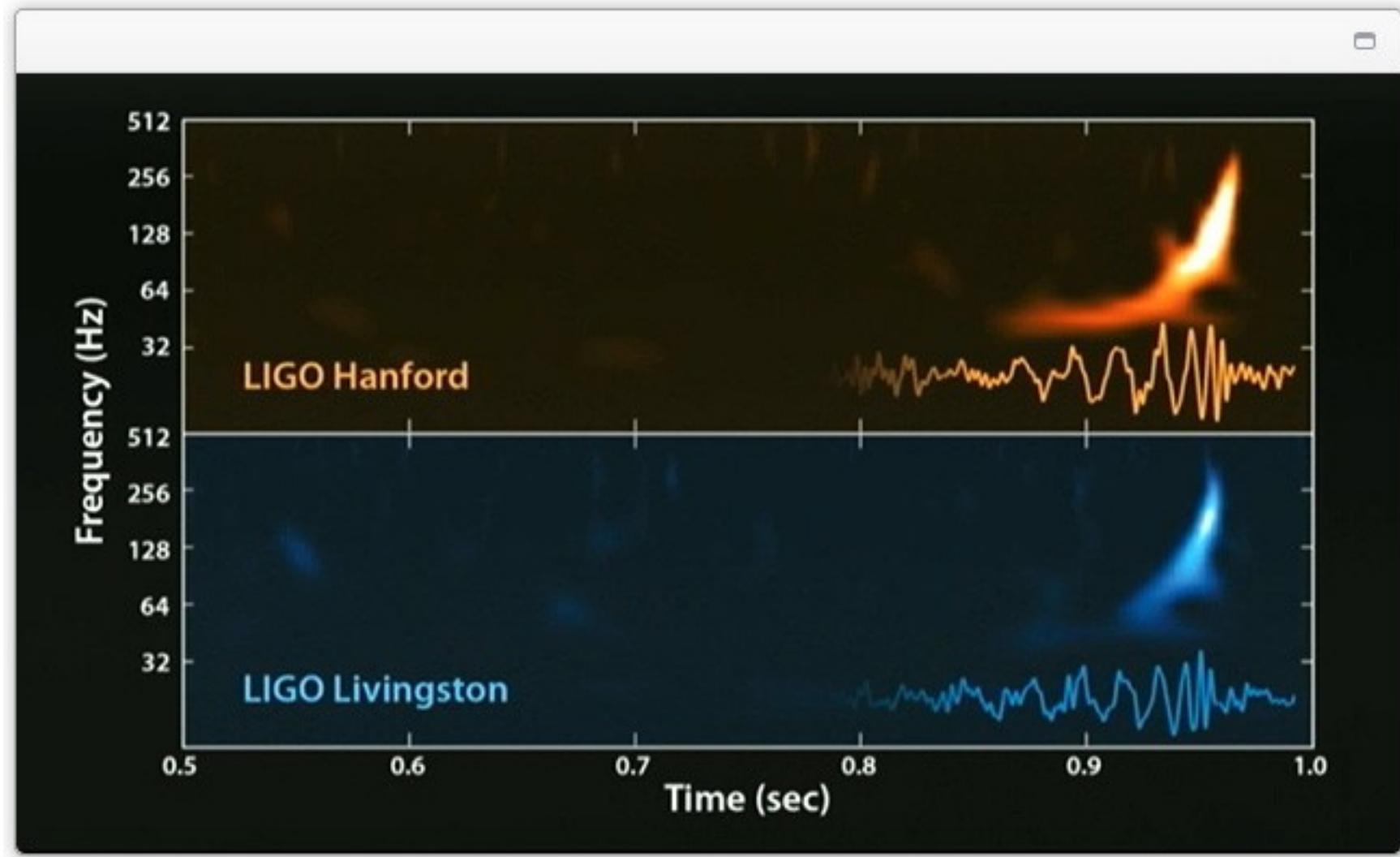


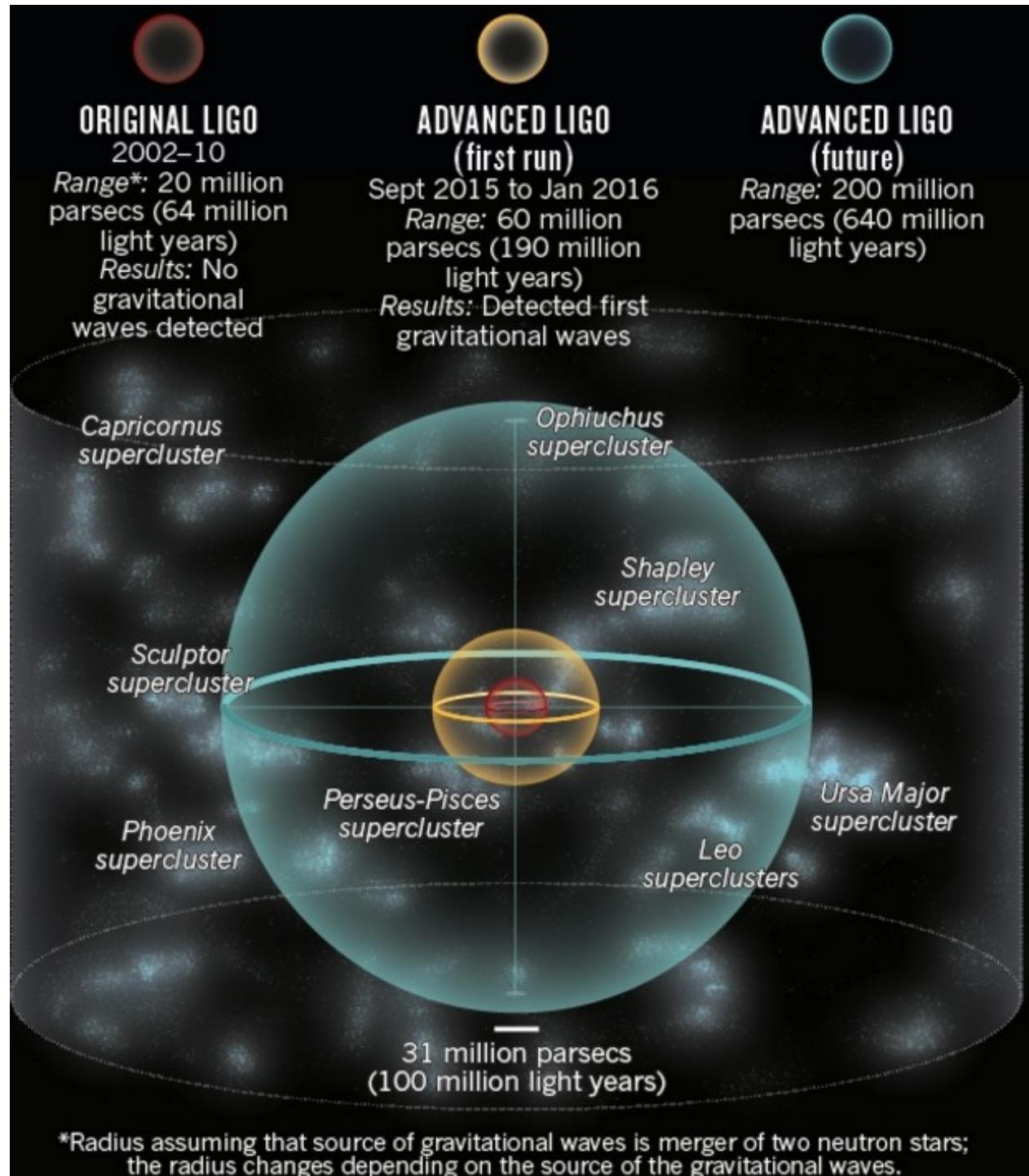
Exterior of a section of one of the arms of the LIGO interferometer on Hanford Reservation in Washington. [Umptanum, CC BY-SA](#)



Source: NSF/LIGO

LIGO Update on the Search for Gravitational Waves

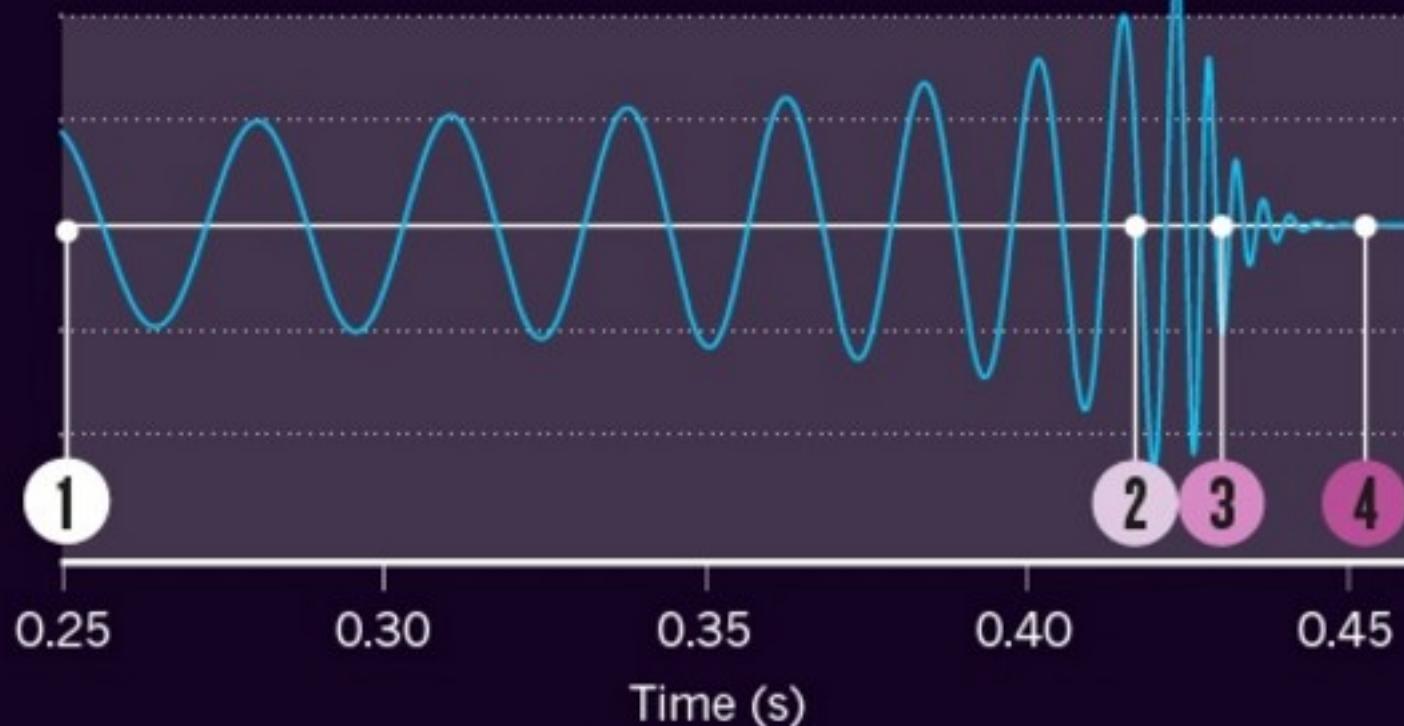




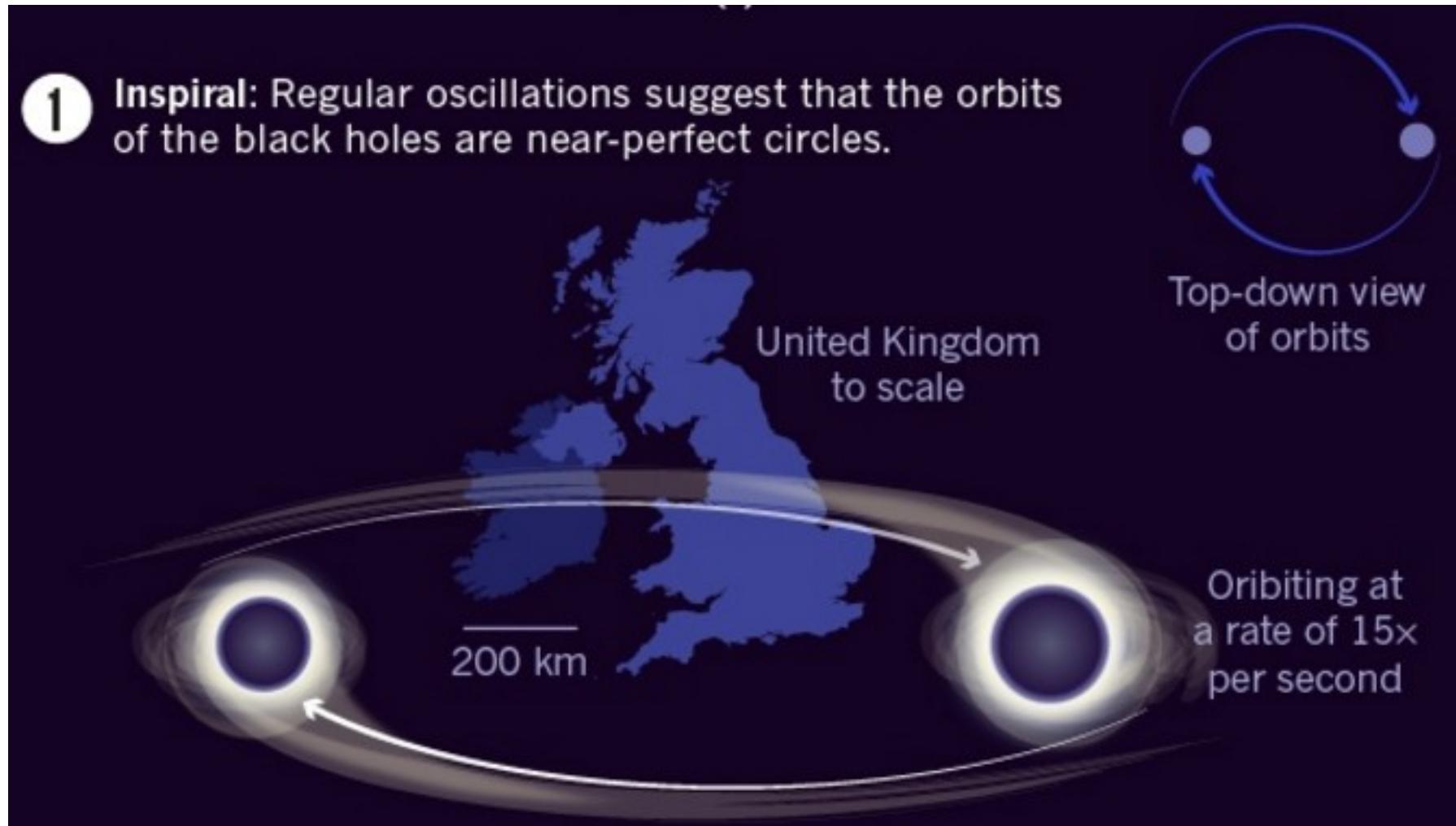
Adapted from
Andrew Z. Colvin
/CC-BY-SA 3.0

Lo que produjo la onda

This simulation is a close fit to the LIGO signal, which was hidden by background noise until about 0.2 seconds before the black holes merged.



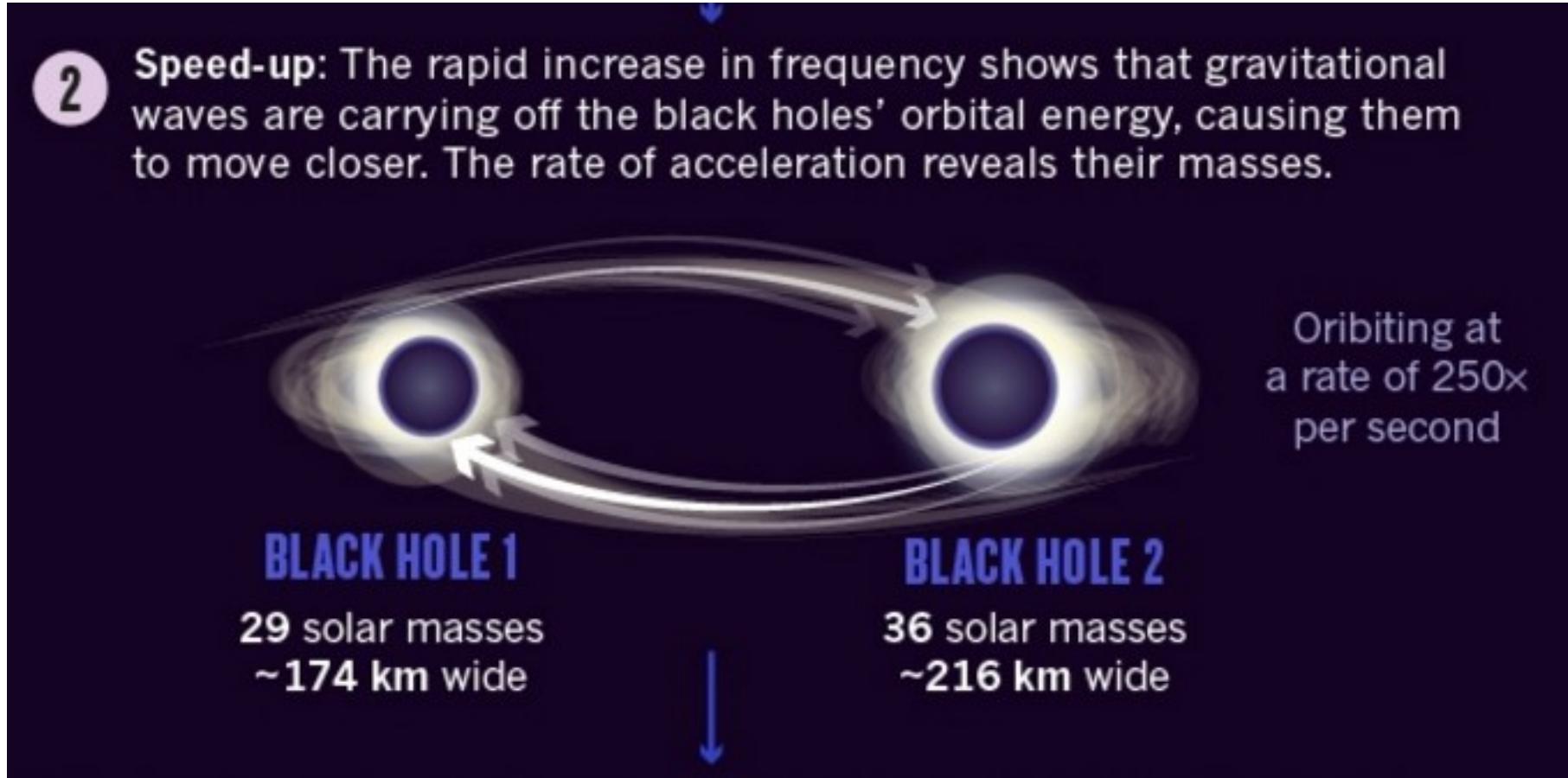
Acercamiento



Nik Spencer/Nature

Aceleración

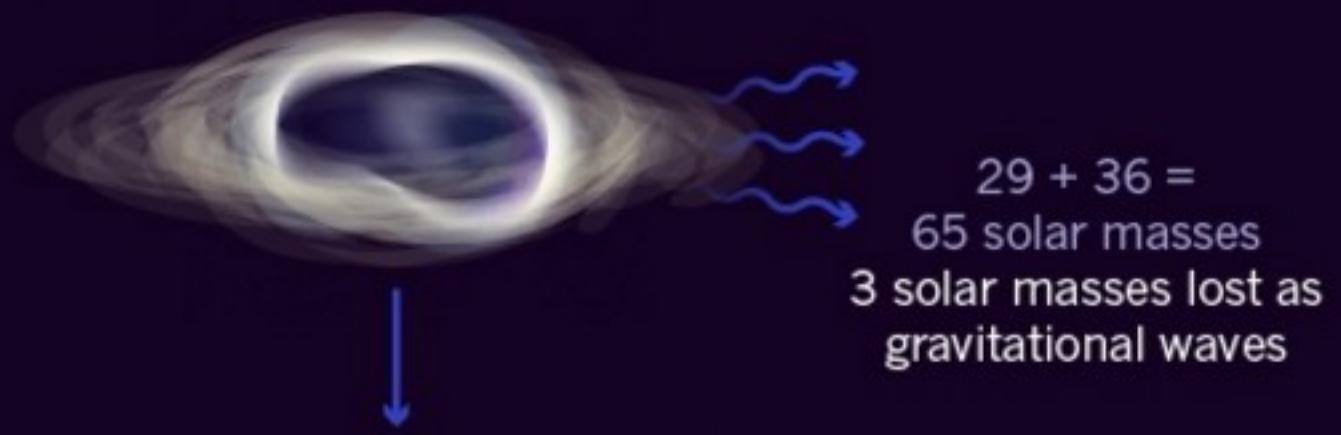
- 2 Speed-up: The rapid increase in frequency shows that gravitational waves are carrying off the black holes' orbital energy, causing them to move closer. The rate of acceleration reveals their masses.



Decaimiento

3

Ringdown: A rapid falloff in the signal shows that the objects have coalesced into a single black hole that is radiating huge amounts of energy as gravitational waves.



Fusión

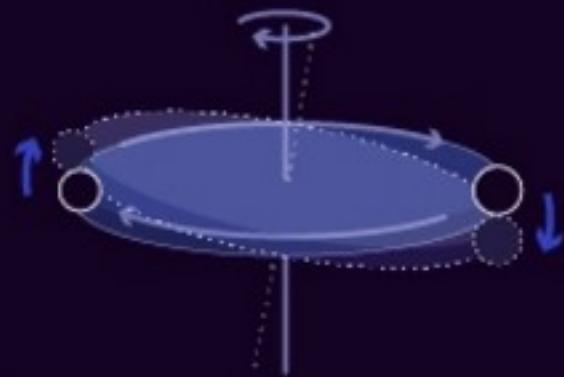
4

Merger: The vanishing signal indicates that the merged black hole has settled into a new, stable equilibrium.



MERGED BLACK HOLE

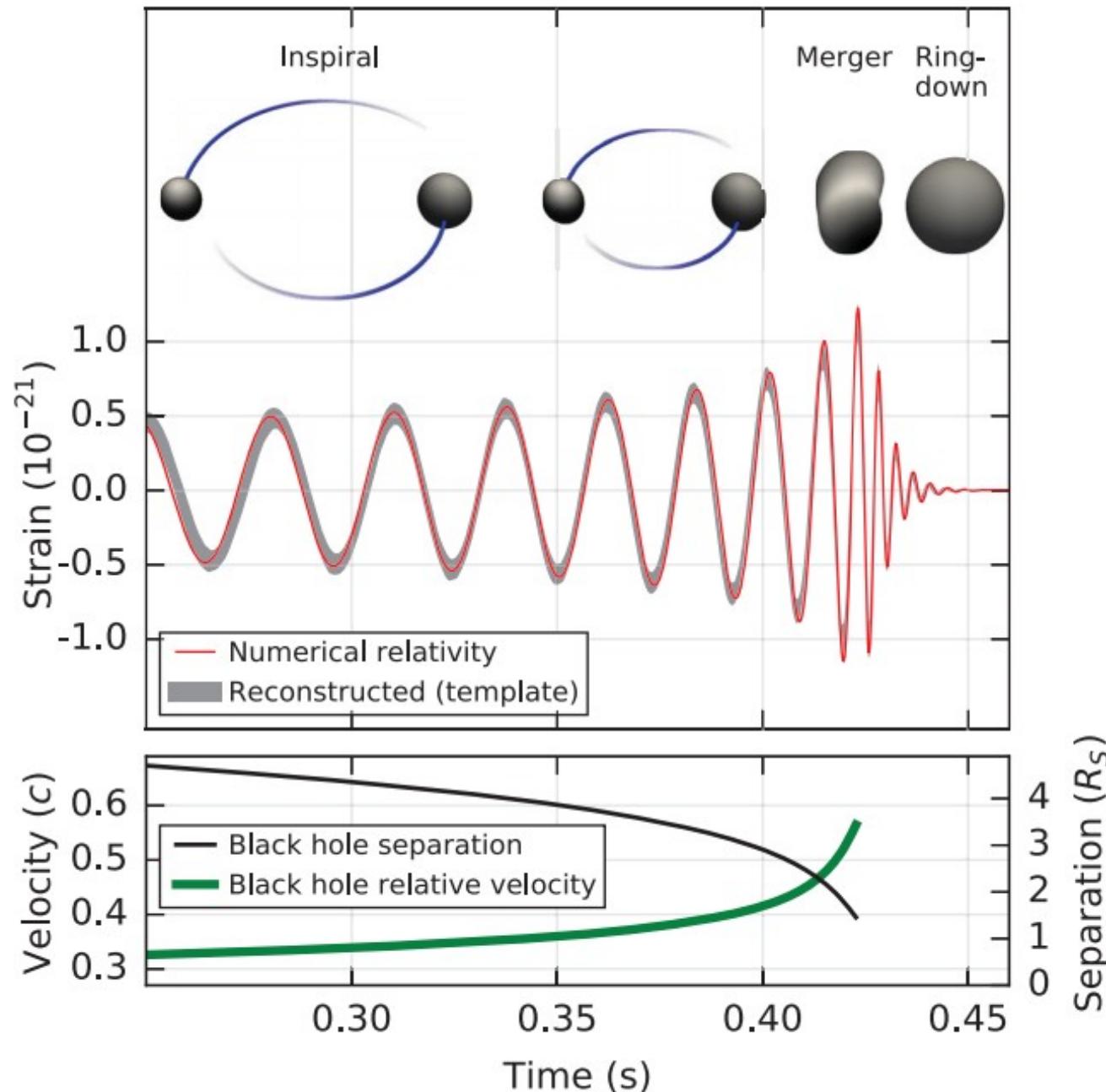
62 solar masses
~372 km wide



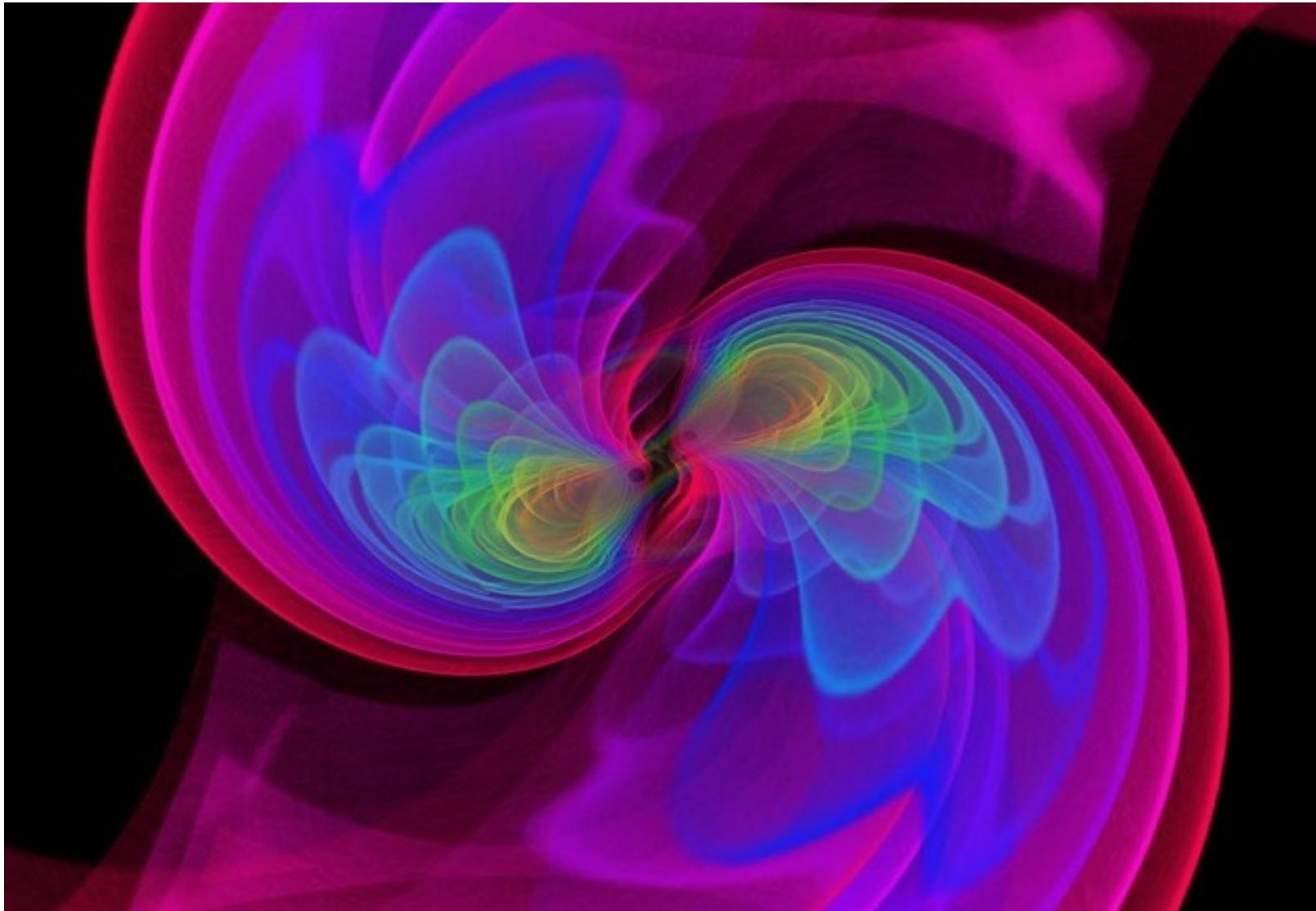
Future LIGO observations may see signals altered by precession: a rotation of the orbital plane.

©nature

Nik Spencer/Nature

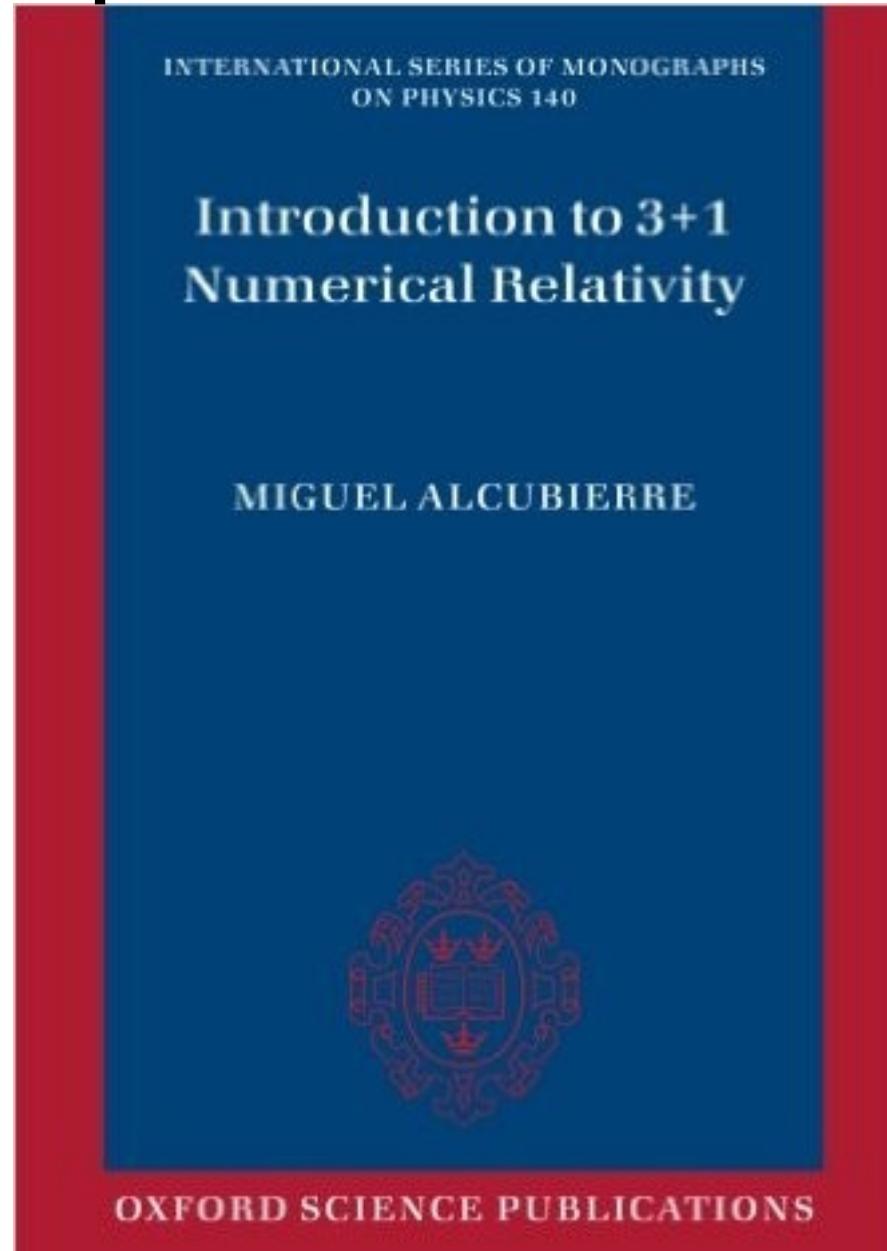


Simulaciones son necesarias para la interpretación de los datos



S. Ossokine, A. Buonanno (Max Planck Inst. Gravitational Phys.). Scientific VisualiZation: W. Benger (Airborne Hydro Mapping)

Simulaciones son necesarias para la interpretación de los datos



Casi 1000 autores en 130 instituciones

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Preguntas que las ondas gravitacionales pueden responder

- ¿Existen realmente los agujeros negros?
- ¿Cuál es la velocidad de propagación de las ondas gravitacionales?
- ¿Existen las cuerdas cósmicas?
- ¿Cómo explota una estrella?
- ¿Qué tan rápido se expande el Universo?

¿Quién debería recibir el Premio Nobel este año?

