











**REVOLUTION IN  
SCIENCE.**

**NEW THEORY OF THE  
UNIVERSE.**

**NEWTONIAN IDEAS  
OVERTHROWN.**

Yesterday afternoon in the rooms of the Royal Society, at a joint session of the Royal and Astronomical Societies, the results obtained by British observers of the total solar eclipse of May 29 were discussed.

The greatest possible interest had been aroused in scientific circles by the hope that rival theories of a fundamental physical problem would be put to the test, and there was a very large attendance of astronomers and physicists. It was generally accepted that the observations were decisive in the verifying of the prediction of the famous physicist, Einstein, stated by the President of the Royal Society as being the most remarkable scientific event since the discovery of the predicted existence of the planet Neptune. But there was differ-

Abhandlung [8]

**Die Feldgleichungen der Gravitation**

Albert Einstein, Sitzungsberichte der Preußischen Akademie  
der Wissenschaften 1915, 844-847

In zwei vor kurzem erschienenen Mitteilungen<sup>1</sup> habe ich gezeigt, wie man zu Feldgleichungen der Gravitation gelangen kann, die dem Postulat allgemeiner Relativität entsprechen, d. h. die in ihrer allgemeinen Fassung beliebigen Substitutionen der Raumzeitvariablen gegenüber kovariant sind. 844

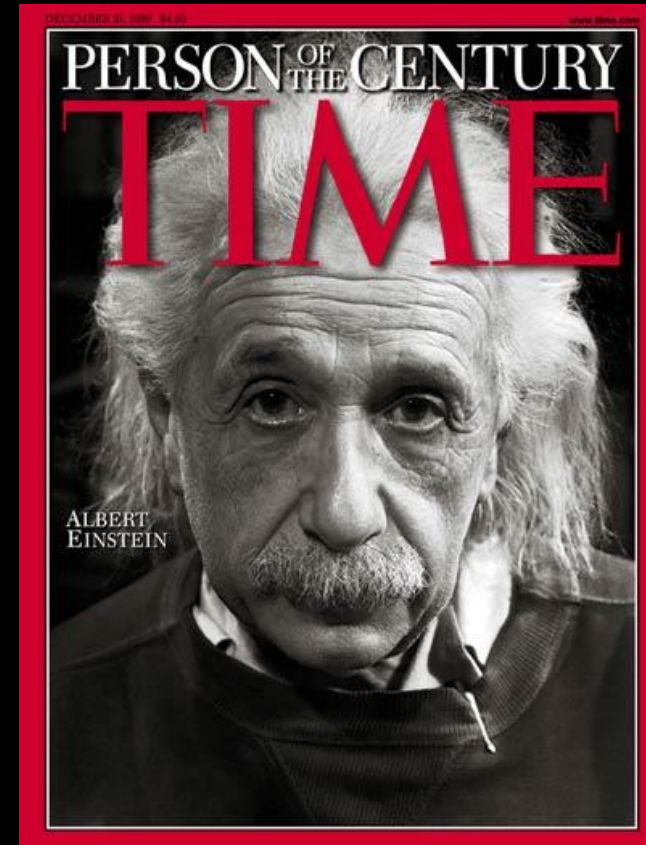
Der Entwicklungsgang war dabei folgender. Zunächst fand ich Gleichungen, welche die Newtonsche Theorie als Näherung enthalten und beliebigen Substitutionen von der Determinante  $\epsilon$  gegenüber kovariant waren. Hierauf fand ich, daß diesen Gleichungen allgemein kovariante entsprechen, falls der Skalar des Energietensors der „Materie“ verschwindet. Das Koordinatensystem war dann nach der einfachen Regel zu spezialisieren, daß  $\sqrt{-g}$  zu 1 gemacht wird, wodurch die Gleichungen der Theorie eine eminente Vereinfachung erfahren. Dabei mußte aber, wie erwähnt, die Hypothese eingeführt werden, daß der Skalar des Energietensors der Materie verschwinde.

Neuerdings finde ich nun, daß man ohne Hypothese über den Energietensor der Materie auskommen kann, wenn man den Energietensor der Materie in etwas anderer Weise in die Feldgleichungen einsetzt, als dies in meinen beiden früheren Mitteilungen geschehen ist. Die Feldgleichungen für das Vakuum, auf welche ich die Erklärung der Perihelbewegung des Merkur gegründet habe, bleiben von dieser Modifikation unberührt. Ich gebe hier nochmals die ganze Betrachtung, damit der Leser nicht genötigt ist, die früheren Mitteilungen unausgesetzt heranzuziehen.

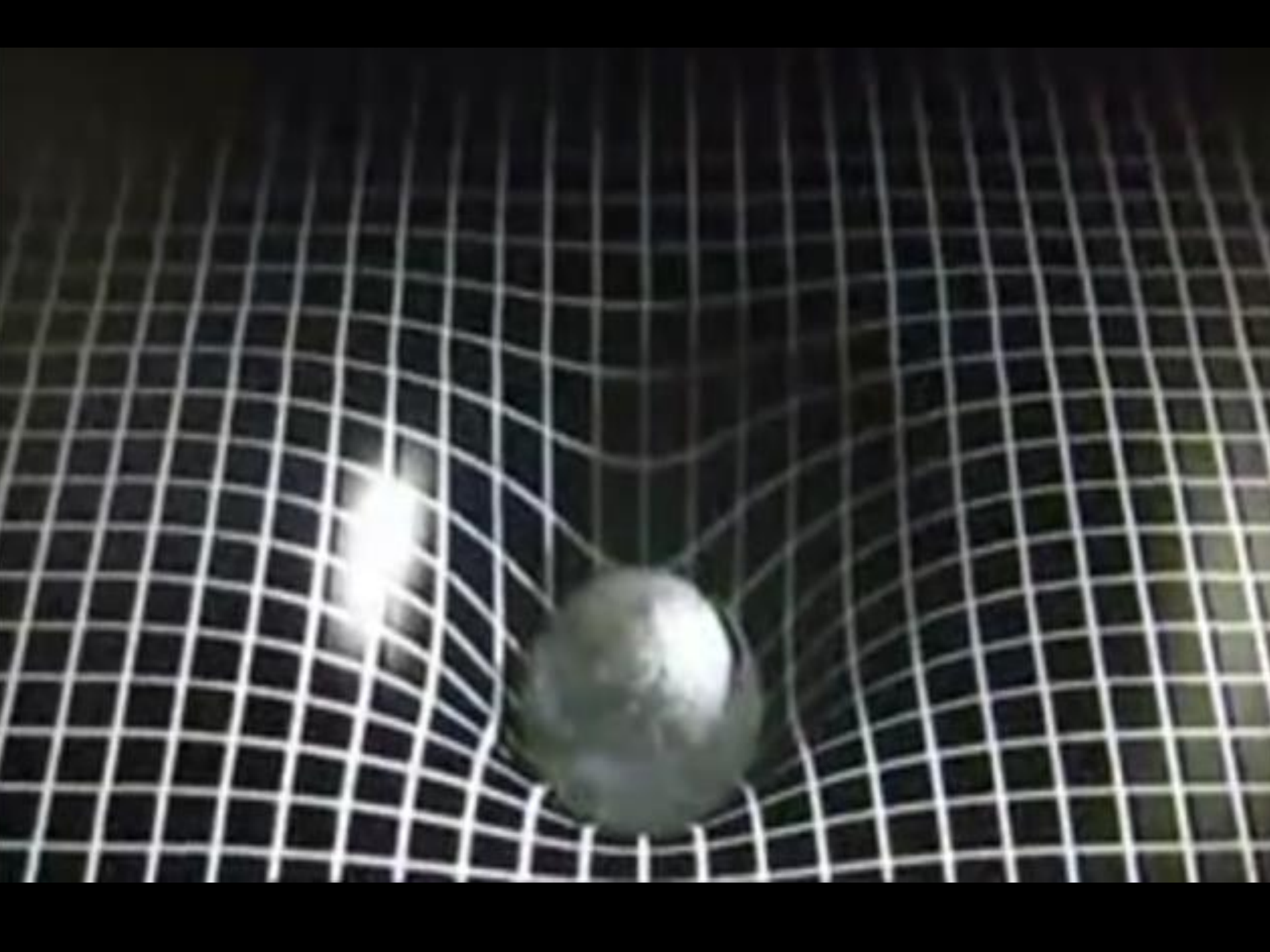
<sup>1</sup> Sitzungsber. XLIV, S. 778 und XLVI, S. 799, 1915.

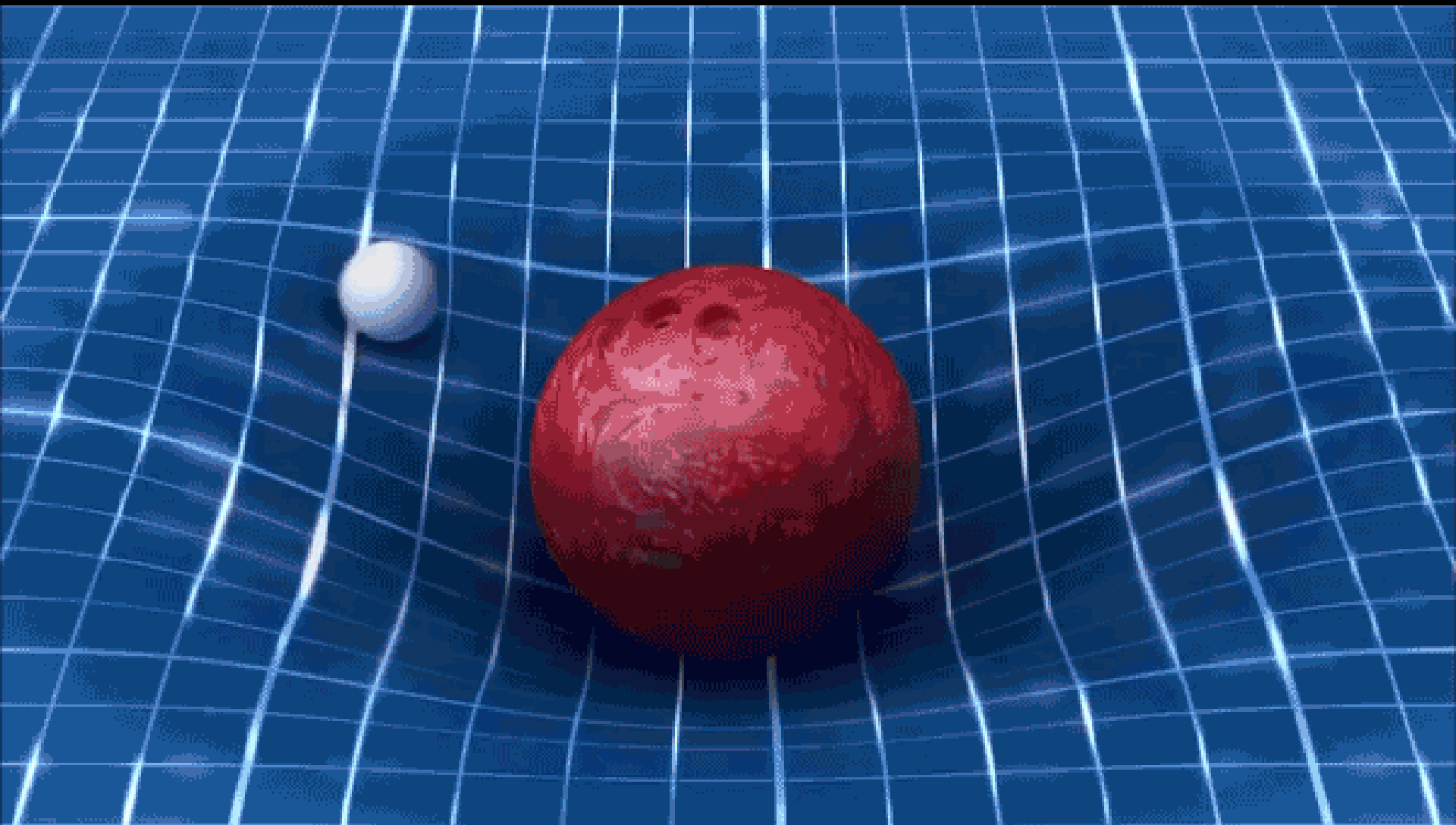
K. von Meyenn (ed.), *Albert Einsteins Relativitätstheorie*  
© Friedr. Vieweg & Sohn Verlagsgesellschaft mbH, Braunschweig 1990

London Times, 6  
Novembre 1919









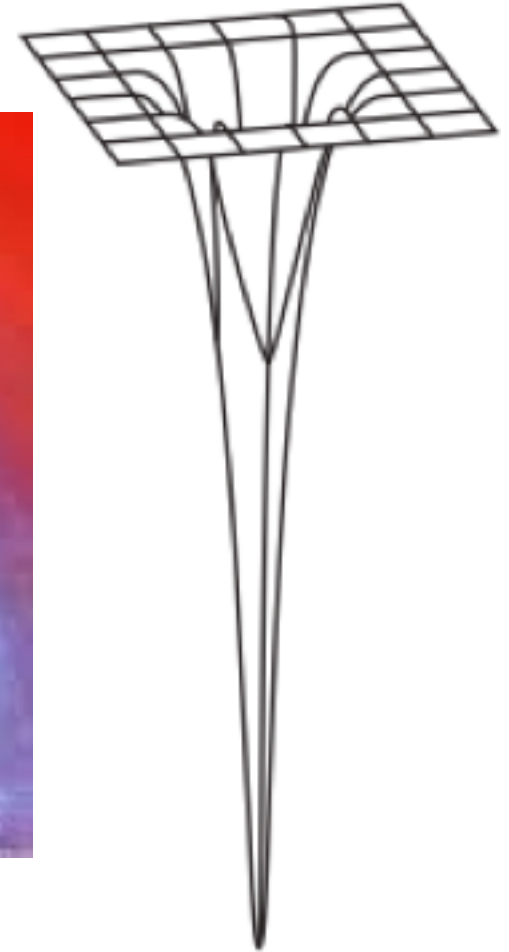
Sole



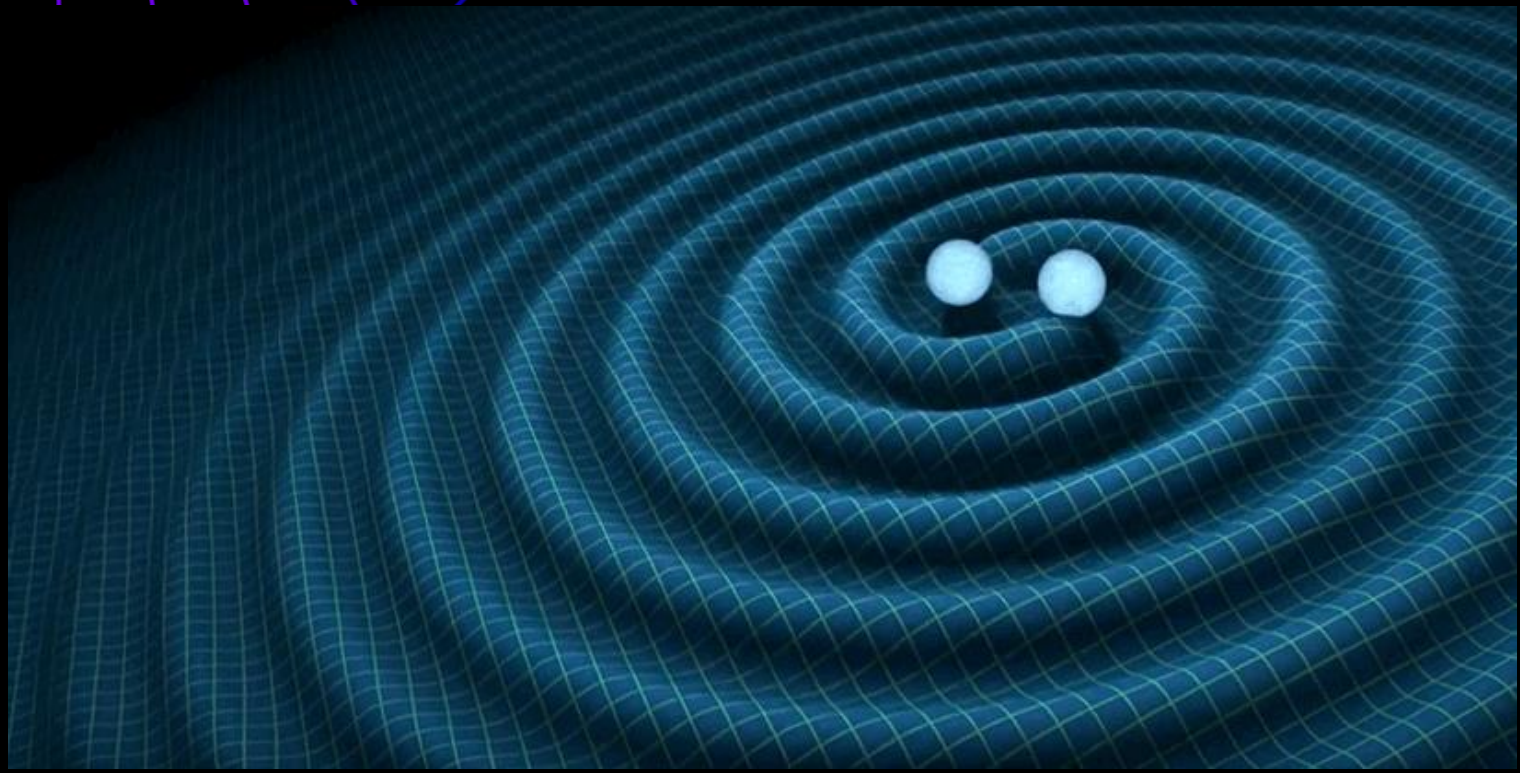
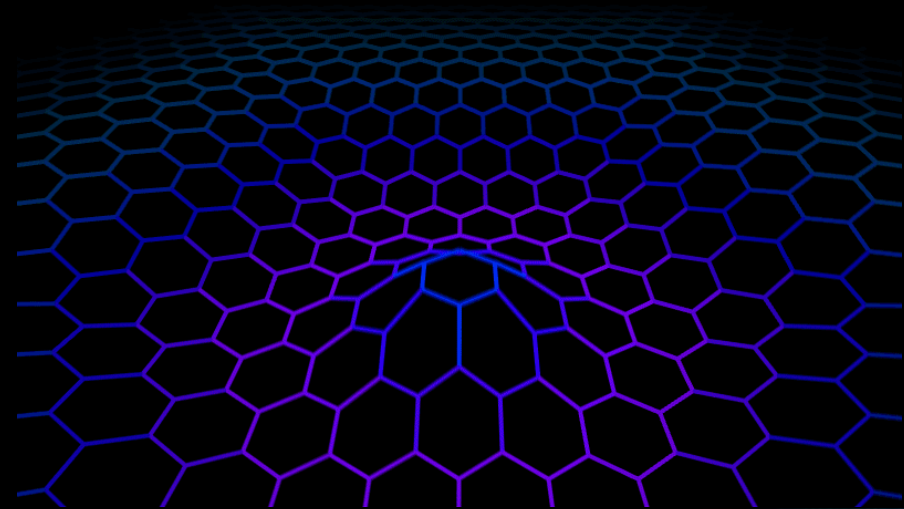
Stella di neutroni

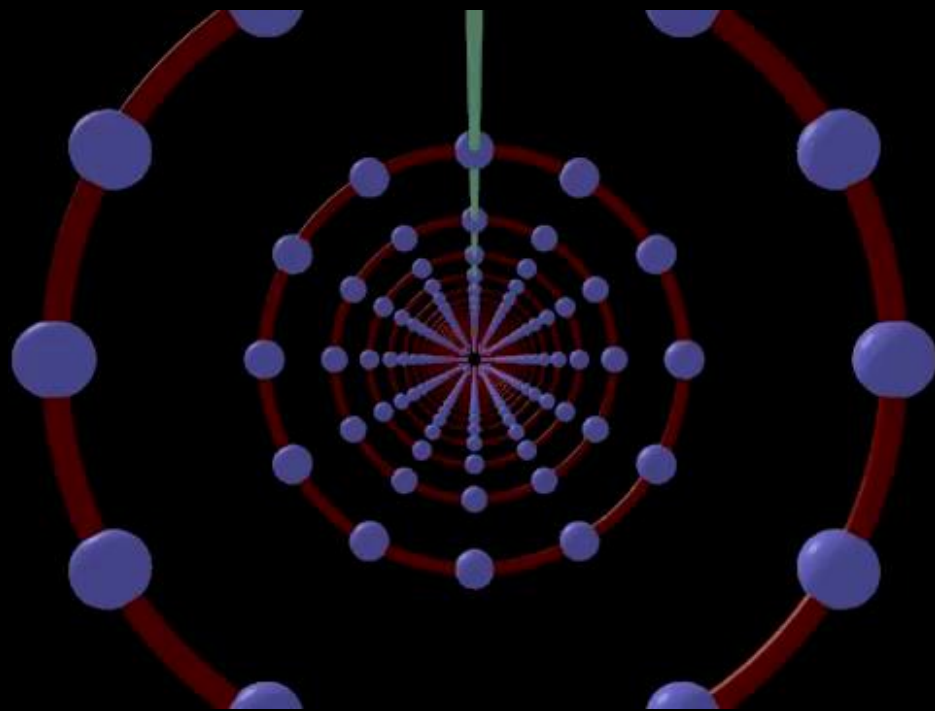


Buco nero









# Rivelare le onde gravitazionali con la luce

## QUARTERLY PROGRESS REPORT

No. 105

APRIL 15, 1972

MASSACHUSETTS INSTITUTE OF TECHNOLOGY  
RESEARCH LABORATORY OF ELECTRONICS  
CAMBRIDGE, MASSACHUSETTS 02139

*Proposal to the National Science Foundation*

## A LASER INTERFEROMETER GRAVITATIONAL-WAVE OBSERVATORY (LIGO)

LIGO-M890001-00-M

**VOLUME 1:**  
*LIGO Science and Concepts*

December 1989

CALIFORNIA INSTITUTE OF TECHNOLOGY  
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

## LIGO PROJECT

12 Maggio 1987

INFN P1/AE 87/1

Proposta di

## Antenna interferometrica a grande base per la ricerca di Onde Gravitazionali

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Salvatore SOLIMENO

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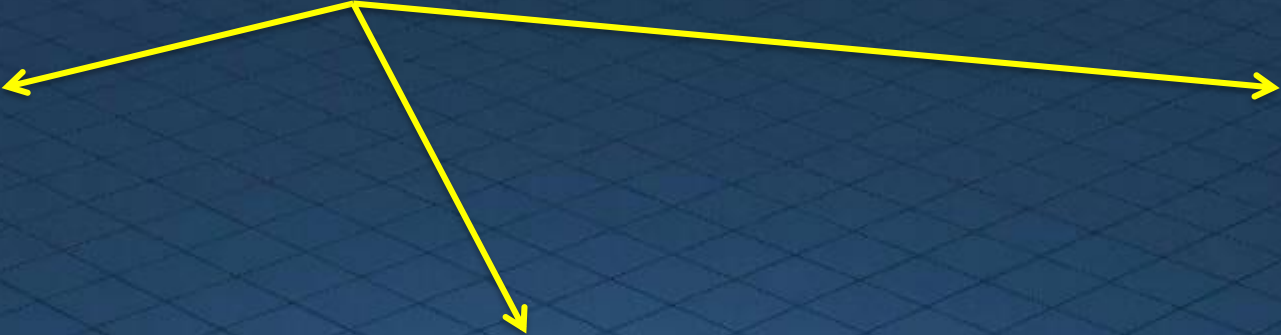
Universita' di Salerno

Innocenzo PINTO

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CNRS-Univ. Pierre et Marie Curie

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C. Nary MAN  
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Specchi



Laser

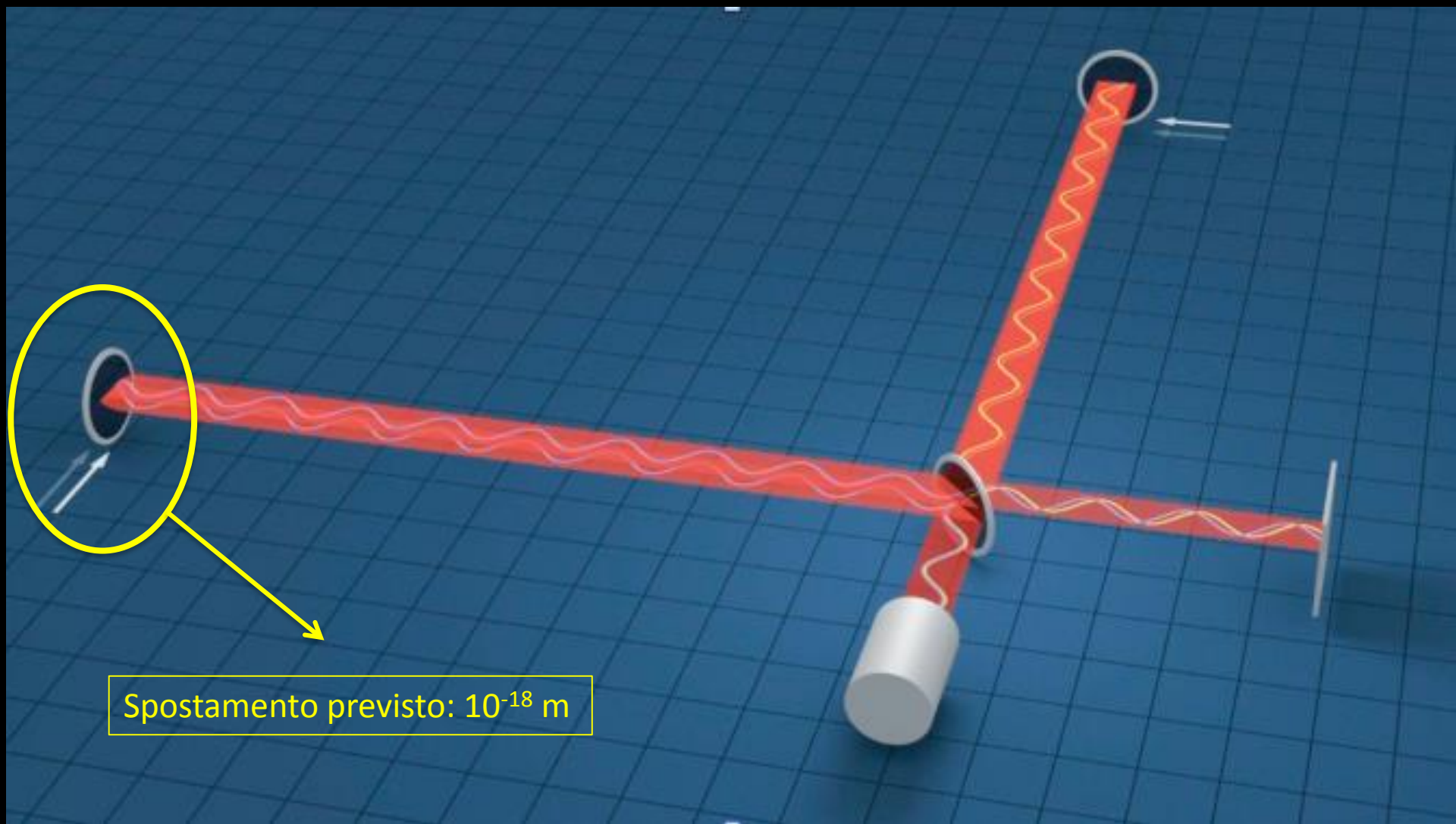


Fotodiodo





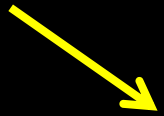




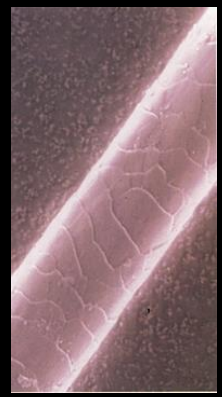
Spostamento previsto:  $10^{-18}$  m

1 m

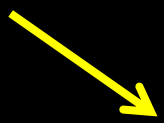
÷ 10.000



$10^{-4}$  m



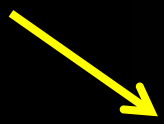
÷ 100



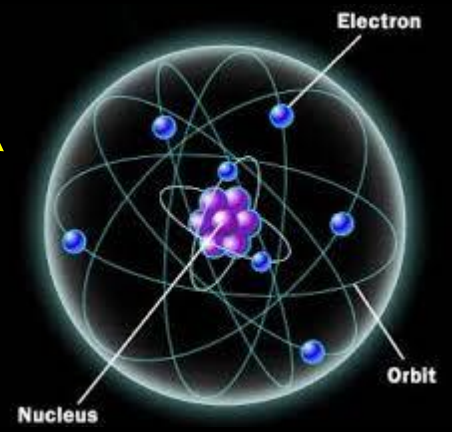
$10^{-6}$  m

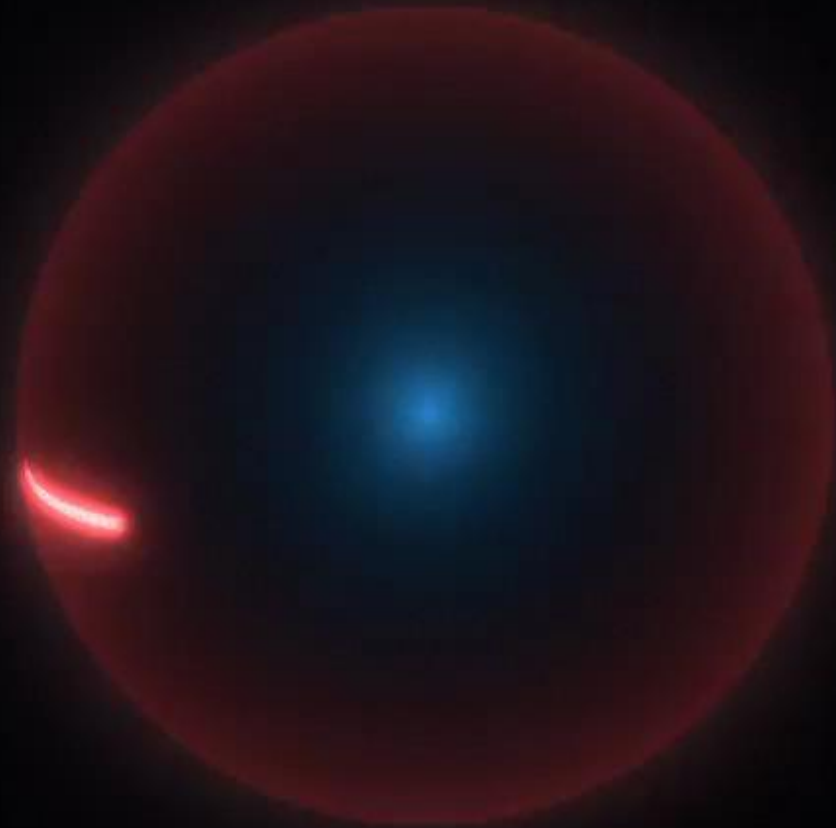


÷ 10.000



$10^{-10}$  m







Germania  
GEO600

# LE ANTENNE GRAVITAZIONALI NEL MONDO



LIGO India  
(recentemente  
approvato)

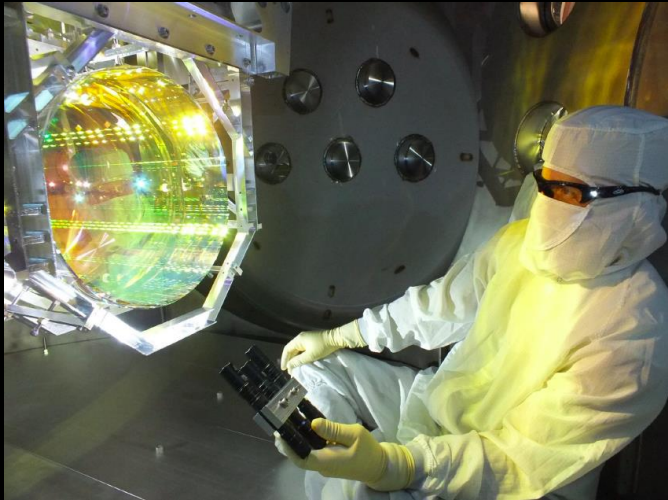
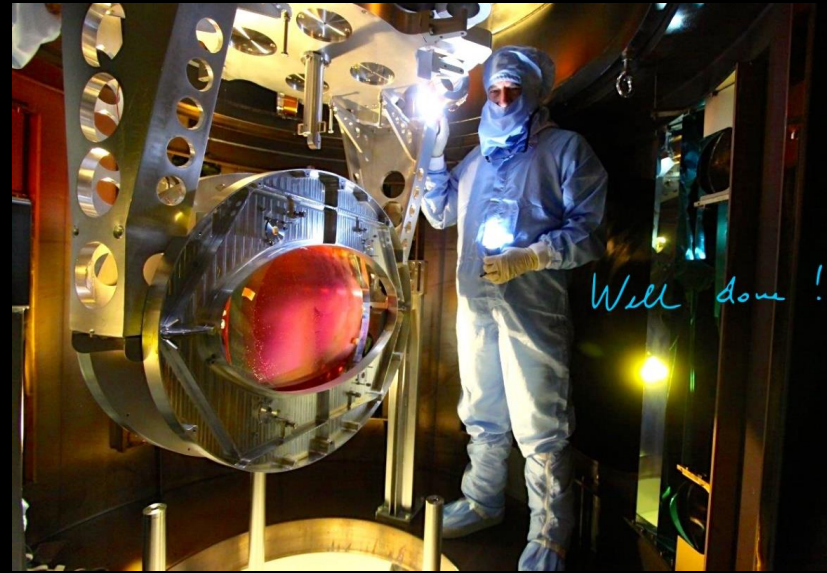
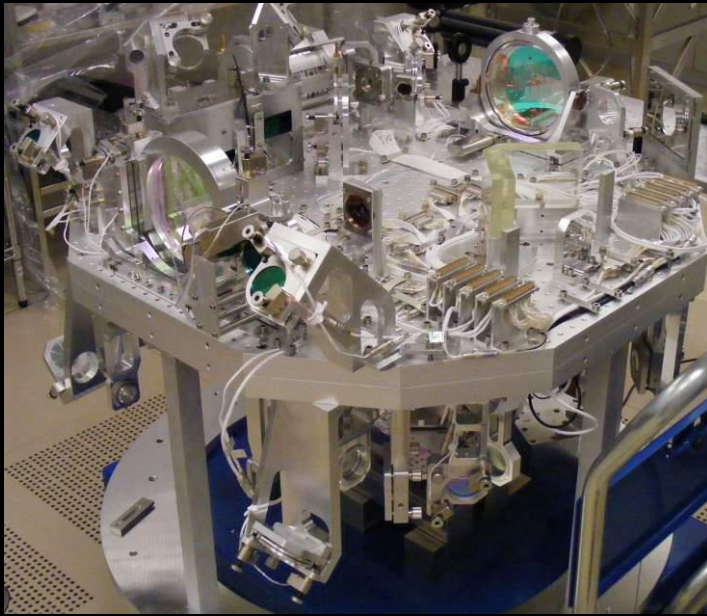


Giappone  
KAGRA  
(in costruzione)



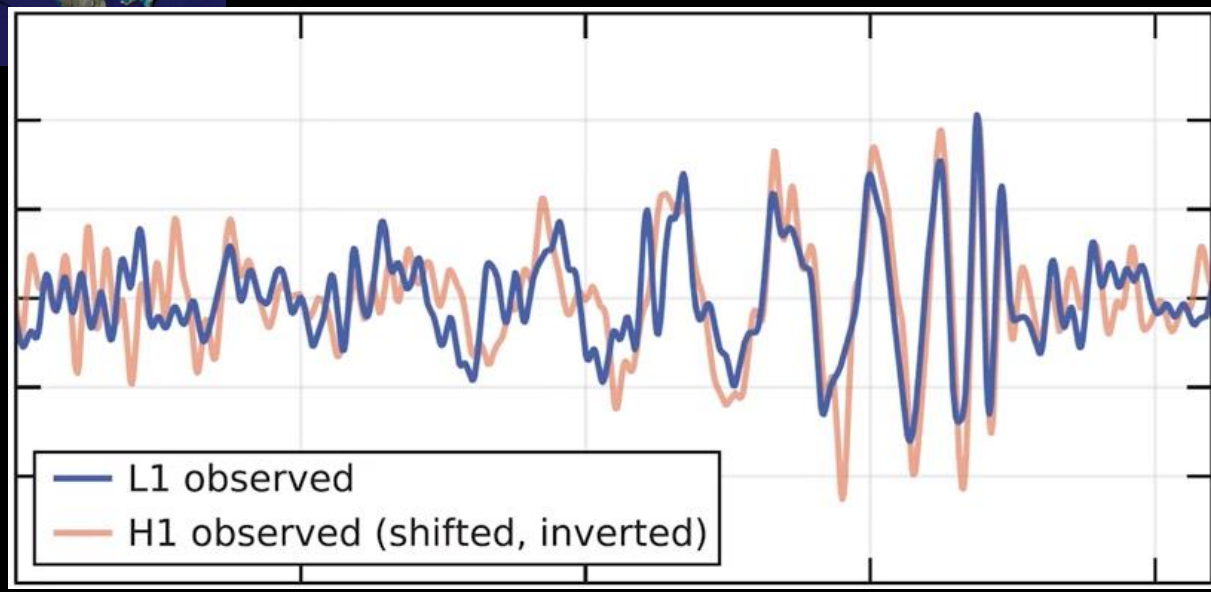
Cascina VIRGO  
(Pisa)



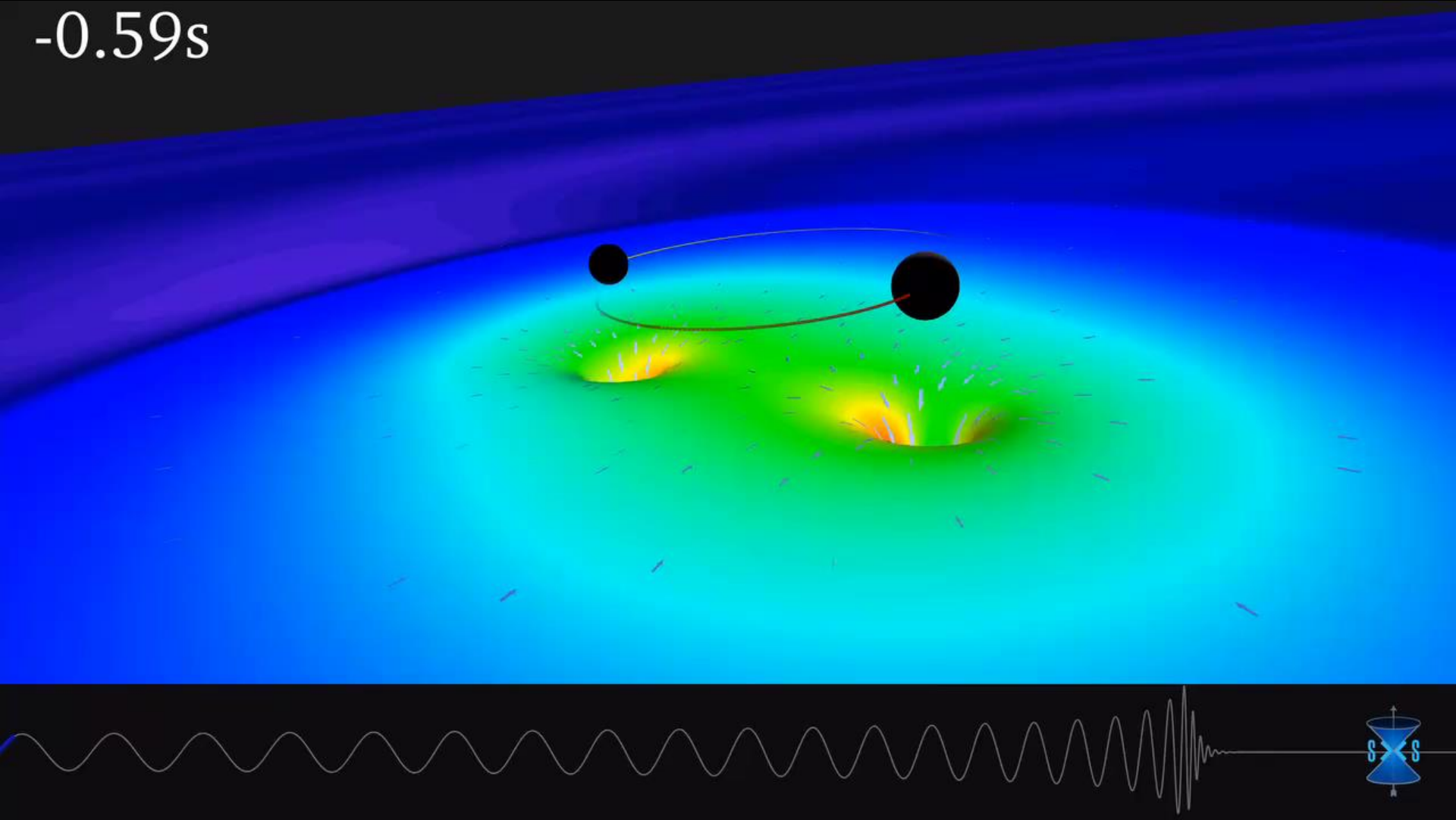




# 14 Settembre 2015 alle 11:50:45 ora Italiana



-0.59s



- Masse iniziali dei due buchi neri:  $36 M_{\text{sol}}$  e  $29 M_{\text{sol}}$
- Massa finale =  $62 M_{\text{sol}}$
- 3 masse solari si sono trasformate in energia

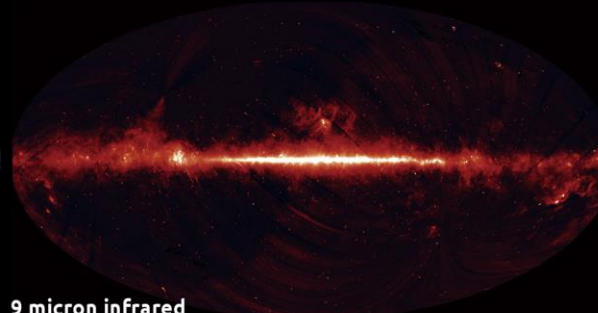
$$E = mc^2$$

50 volte la luce emessa da tutte le stelle dell'Universo  
in pochi decimi di secondo

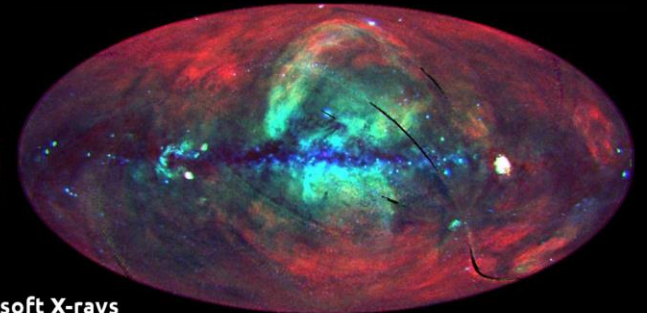
- Distanza = 1,3 miliardi di anni luce



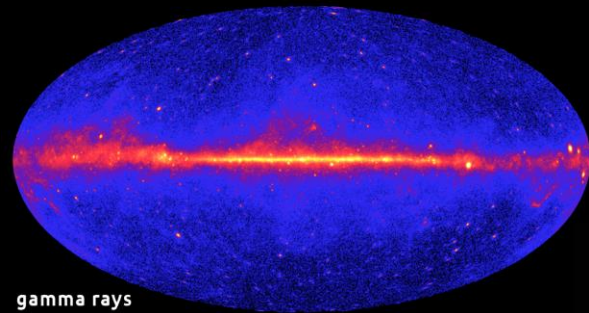
Visible



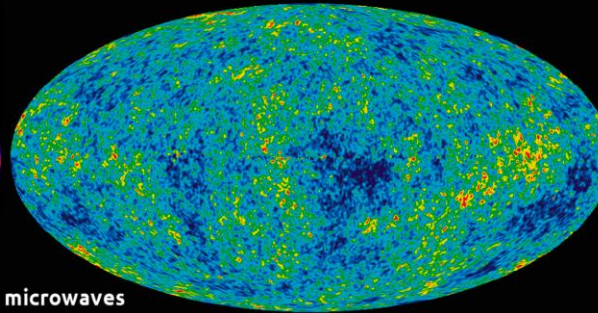
9 micron infrared



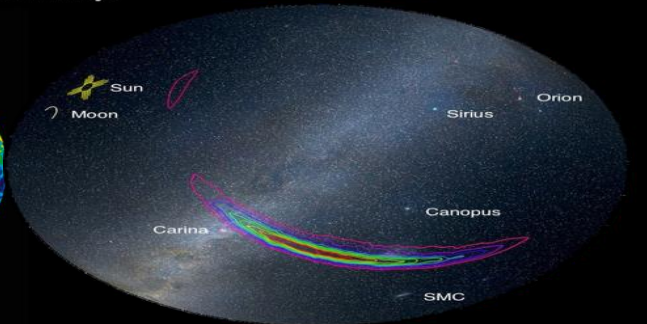
soft X-rays



gamma rays

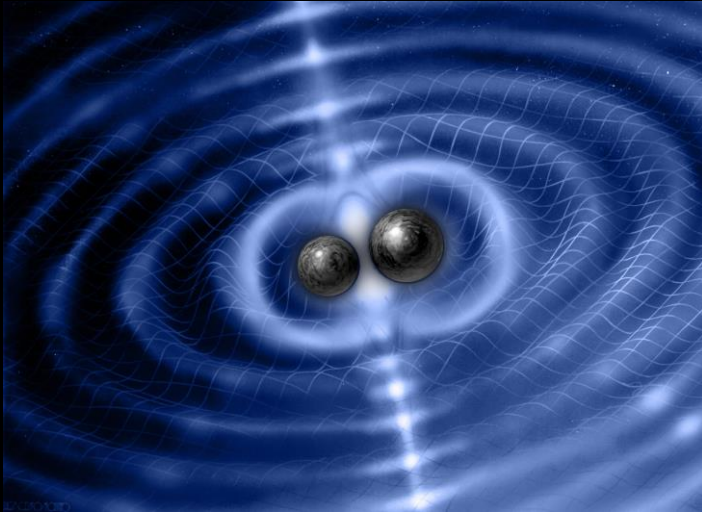


microwaves

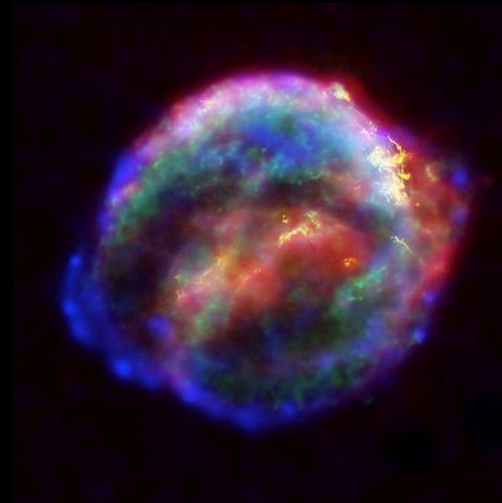


*Le Onde Gravitazionali sono in grado di rivelare caratteristiche delle sorgenti che non possono essere ricavate da altre osservazioni*

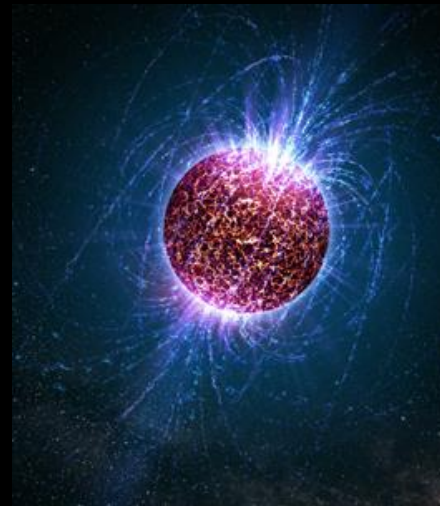




Sistemi binari (sia buchi neri che stelle di neutroni)



Esplosioni di Supernove

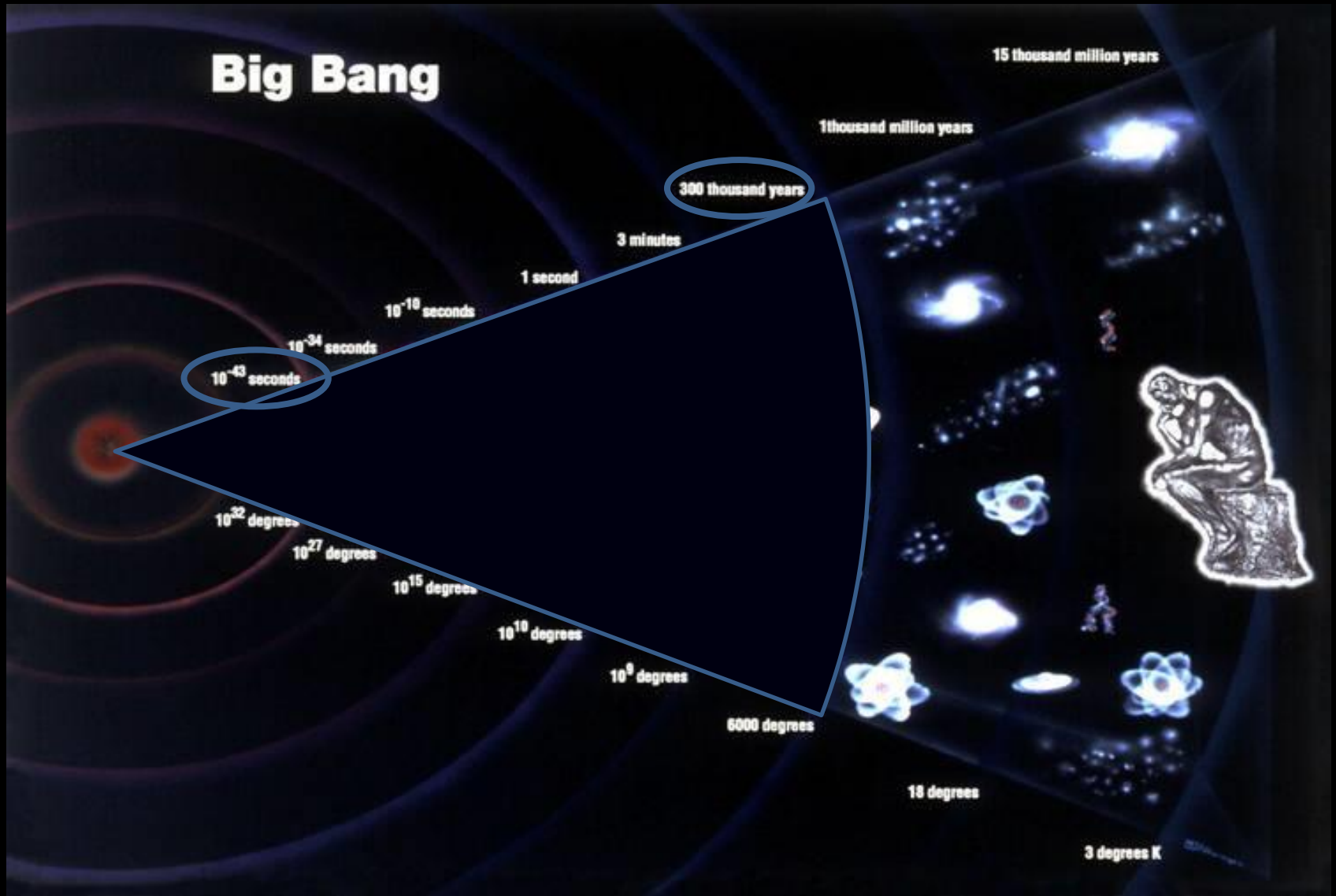


Stelle di neutroni in rapida rotazione (Pulsar)

Casey Reed, Penn State



# Big Bang



“... fino ad arrivare là dove nessuno è  
mai giunto prima.”

(James Tiberius Kirk)



*“Pensate al futuro che vi aspetta,  
pensate a quello che potete fare,  
e non temete niente”*

*Rita Levi Montalcini*