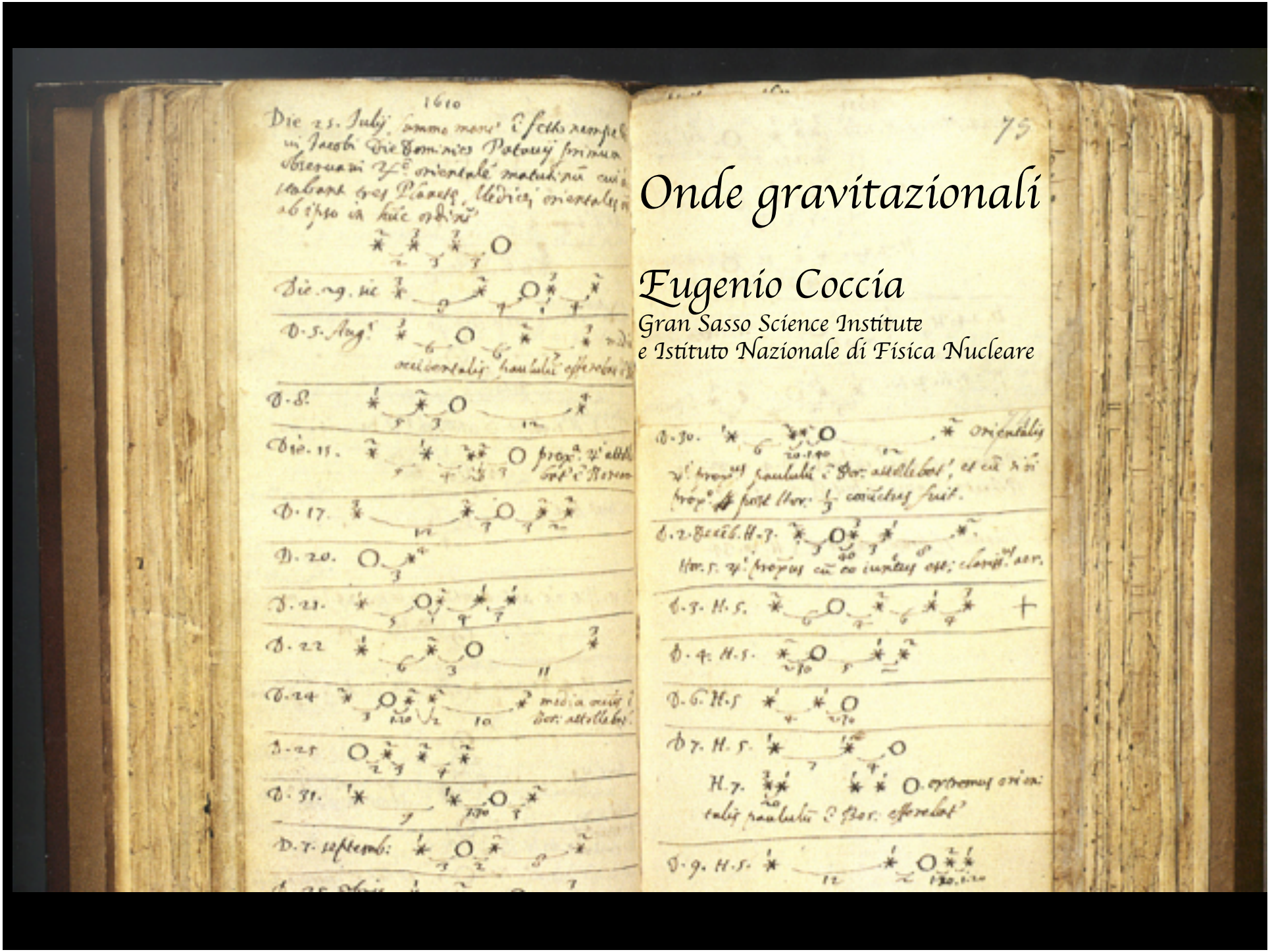


Onde gravitazionali

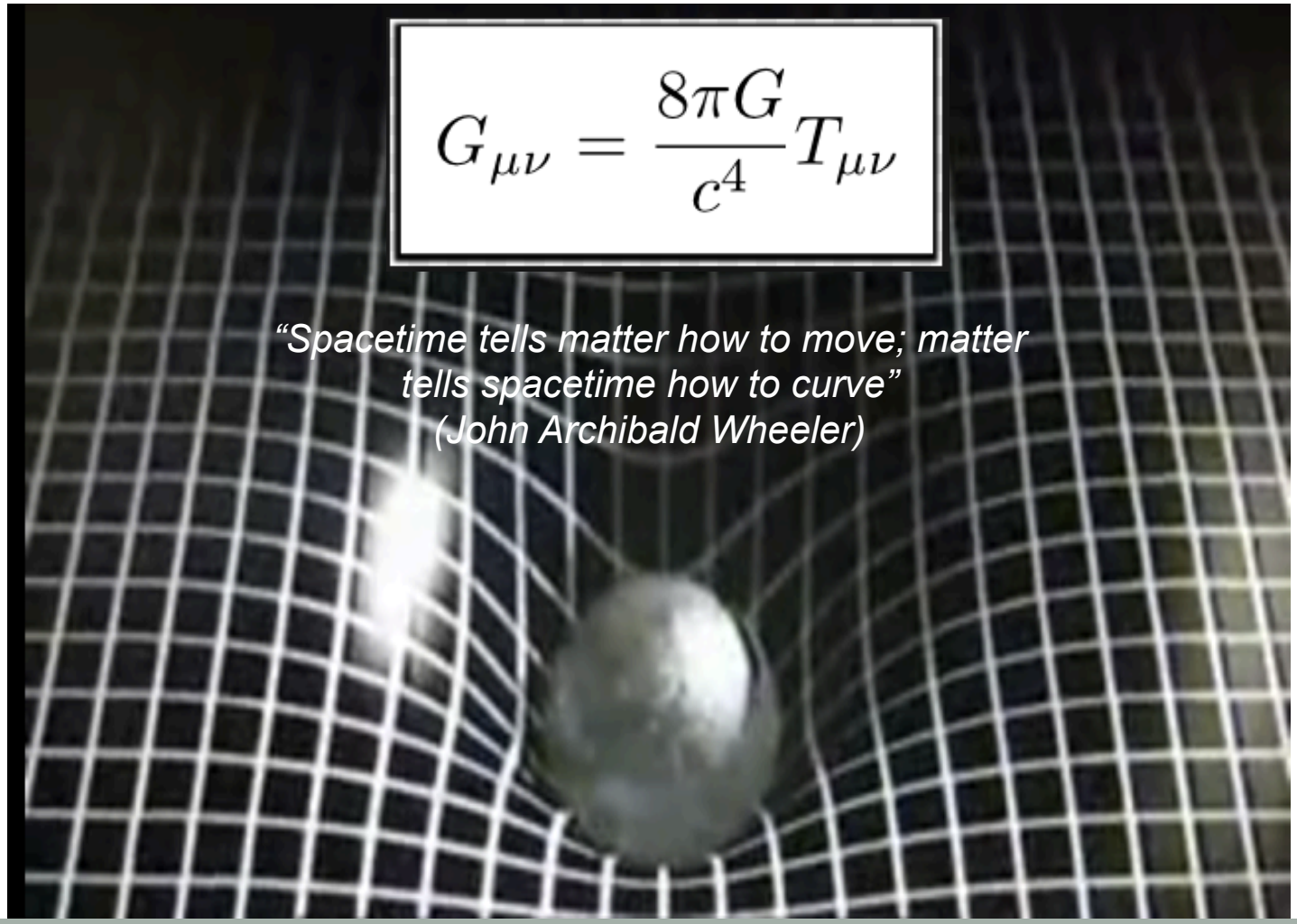
Eugenio Coccia

Gran Sasso Science Institute
e Istituto Nazionale di Fisica Nucleare

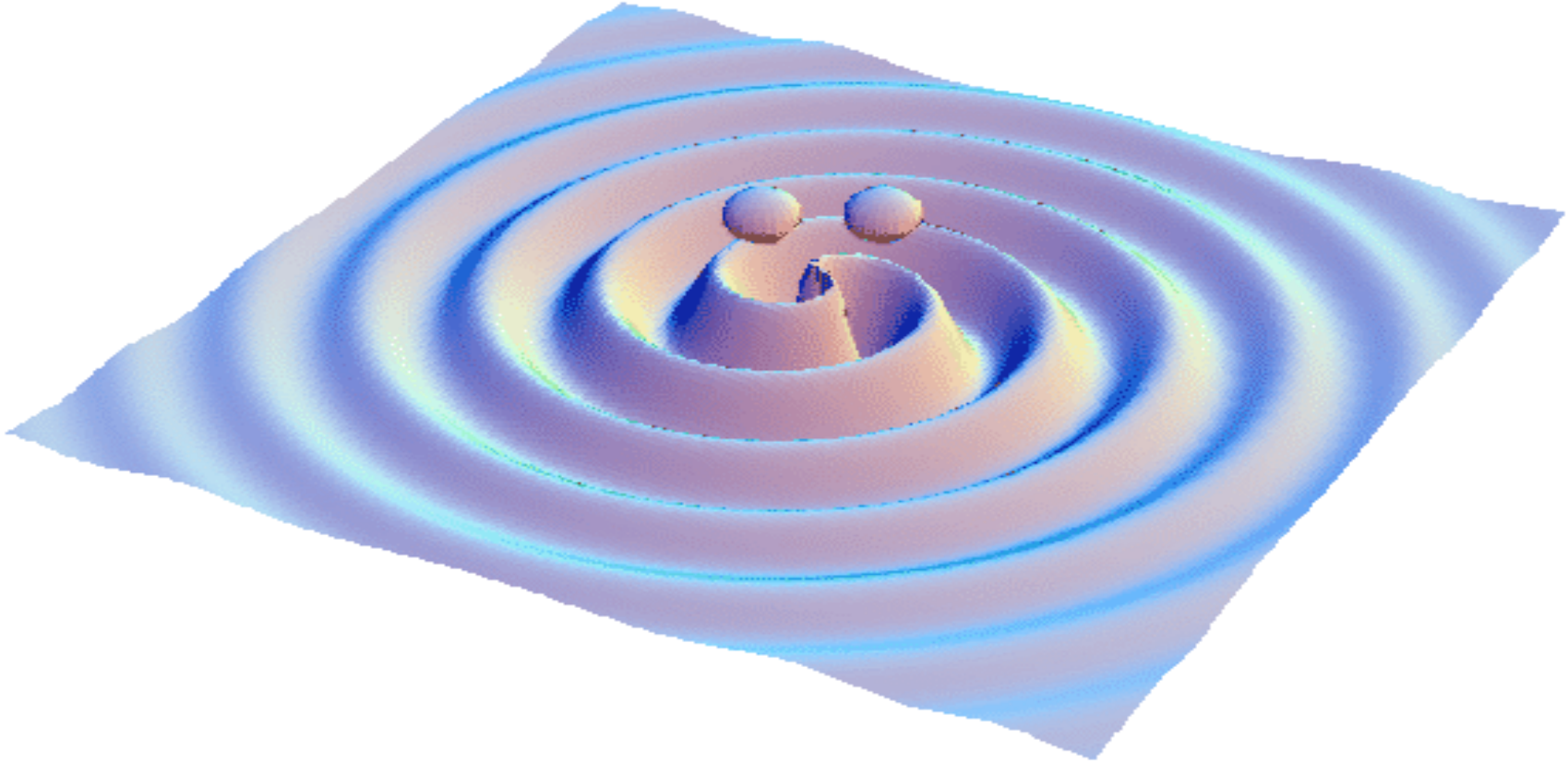
$$\vec{F} = G\frac{Mm}{r^2}\vec{u}_r$$

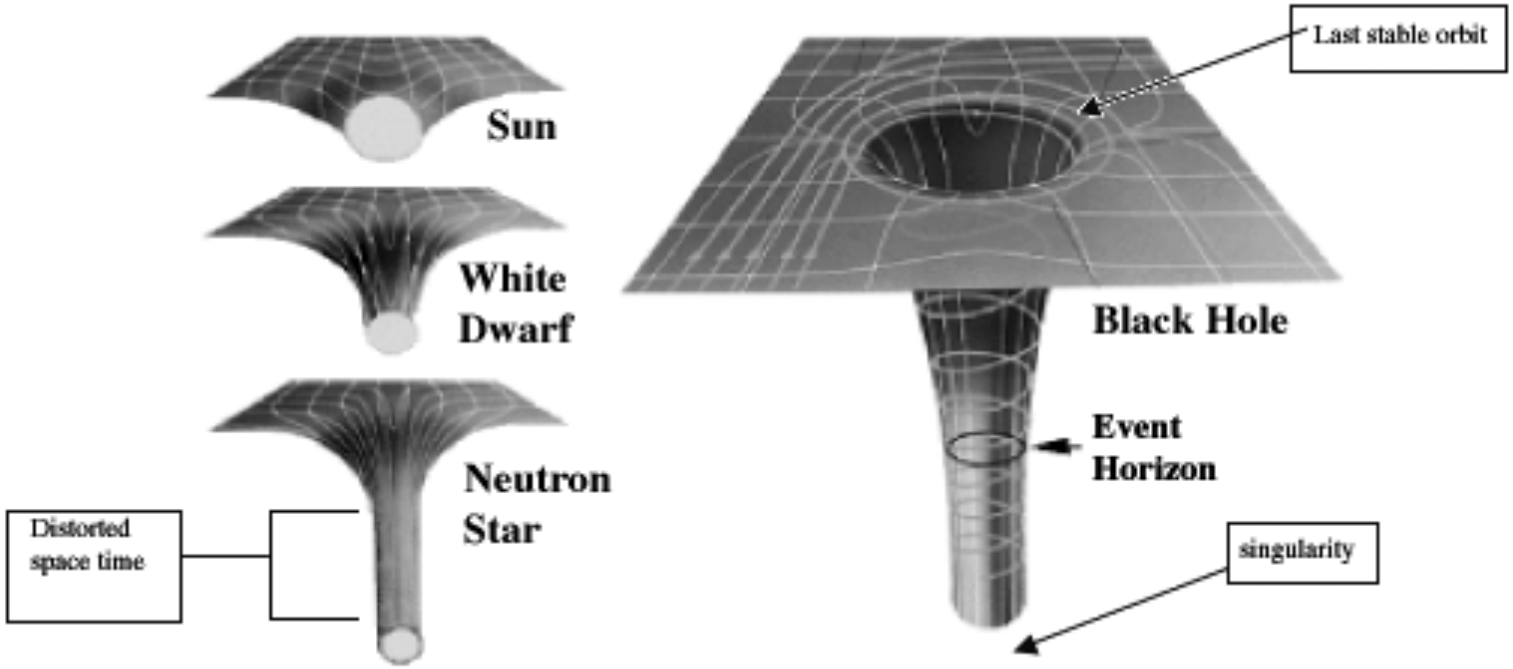
Einstein's Theory of Gravitation

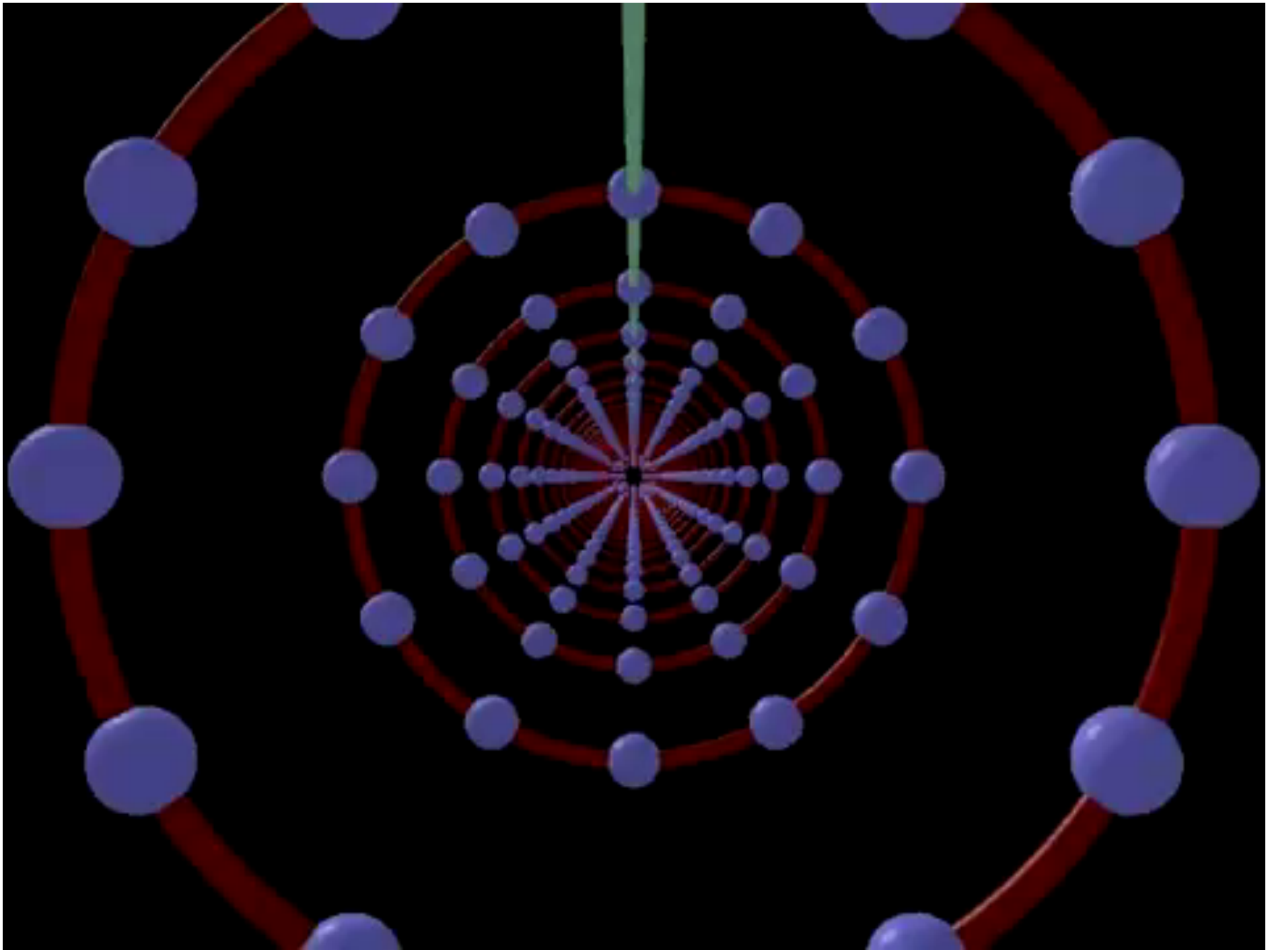
Gravity is a manifestation of spacetime curvature induced by mass-energy



Gravitational Waves



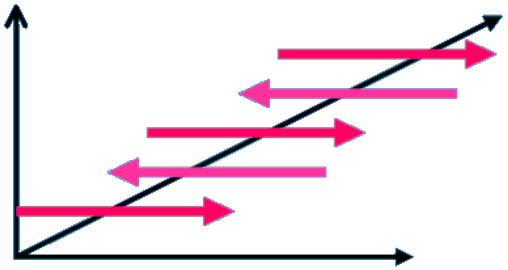

Sun
White
Dwarf
Neutron
Star
Distorted
space time
Last stable orbit
Black Hole
Event
Horizon
singularity



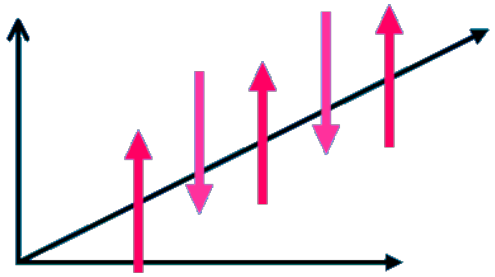
Gravitational Waves

Comparison with electromagnetic waves

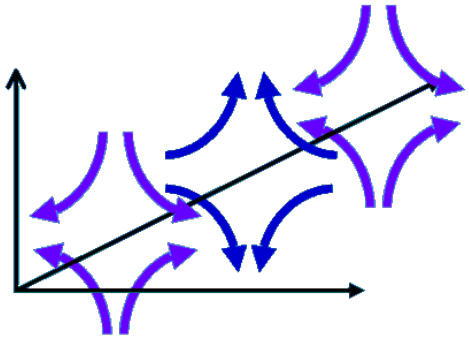
Horizontal polarization



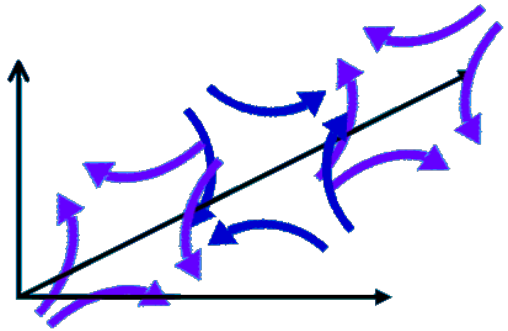
Vertical polarization



Plus polarization

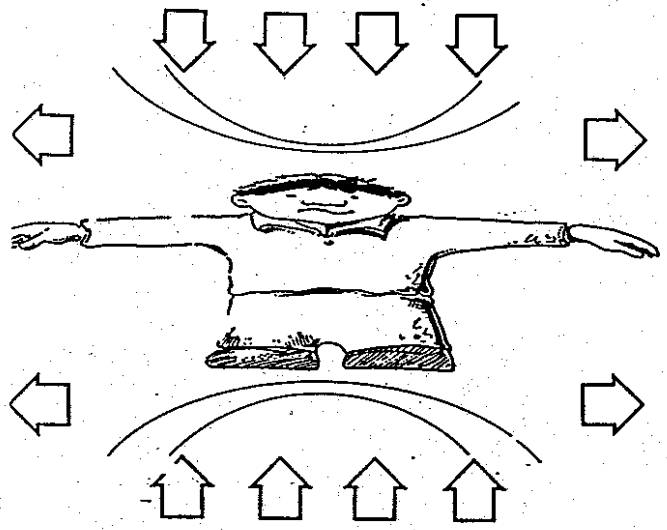


Cross polarization



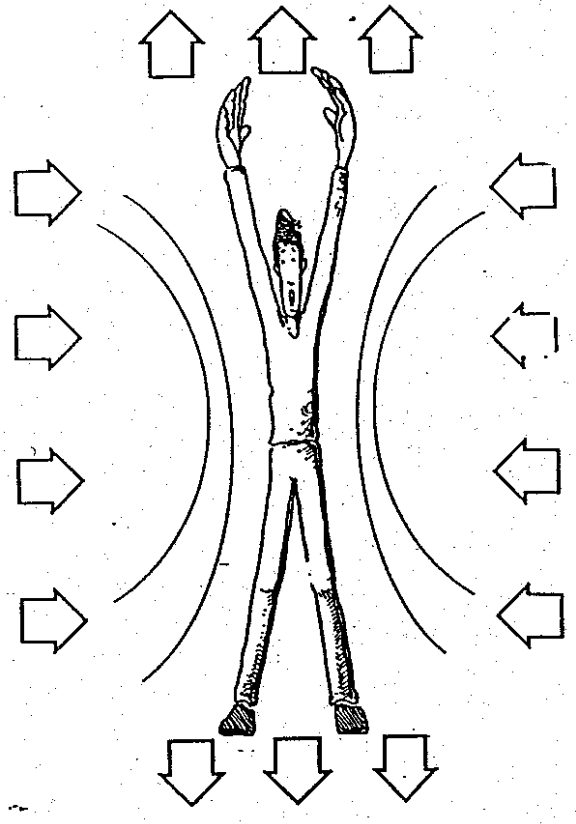
The so-called “electromagnetic theory of light” has not helped us hitherto . . it seems to me that it is rather a backward step . . . the one thing about it that seems intelligible to me, I do not think is admissible . . That there should be an electric displacement perpendicular to the line of propagation’ **Lord Kelvin**

CAUTION: GRAVITATIONAL RADIATION



MAY BE DANGEROUS
TO YOUR HEALTH

CAUTION: GRAVITATIONAL RADIATION



MAY BE DANGEROUS
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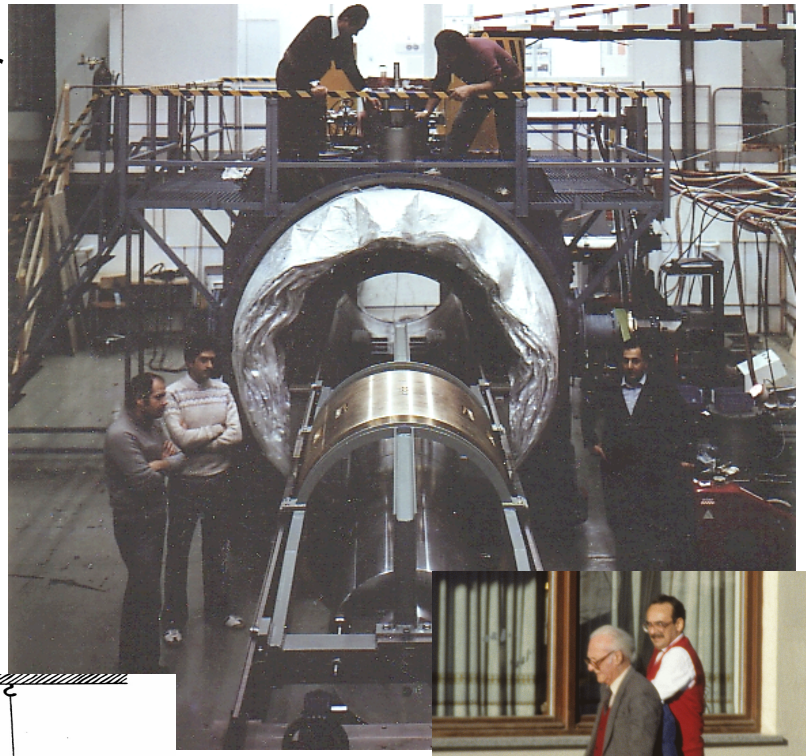
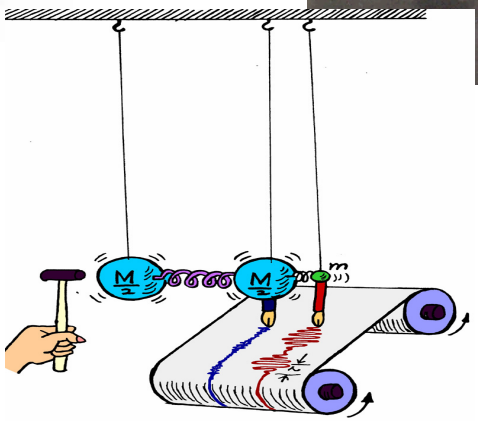
Weber

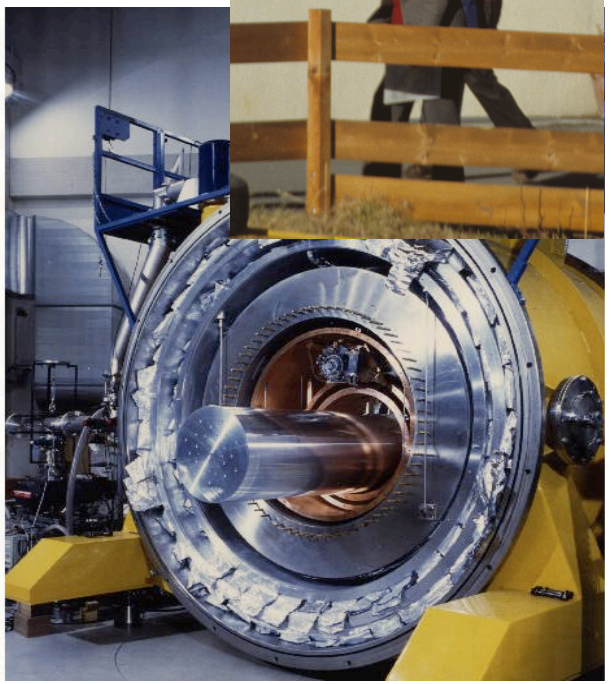
Una immagine di Joseph Weber, pioniere della ricerca delle onde gravitazionali, intento ad incollare le ceramiche piezoelettriche su una delle prime antenne a temperatura ambiente.

Explorer
CERN



Nautilus, LNF



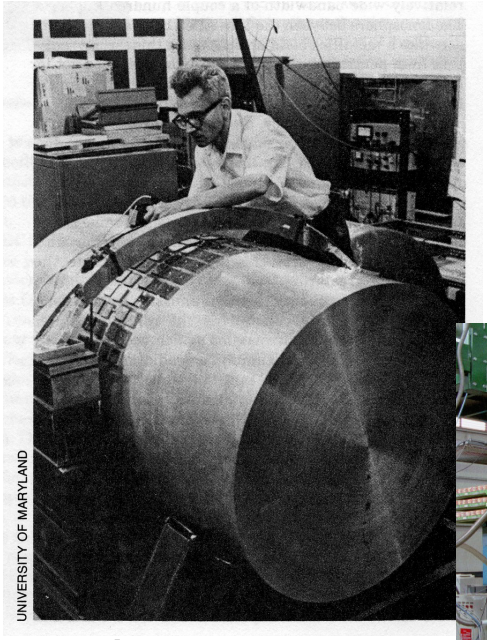


Auriga, LNL

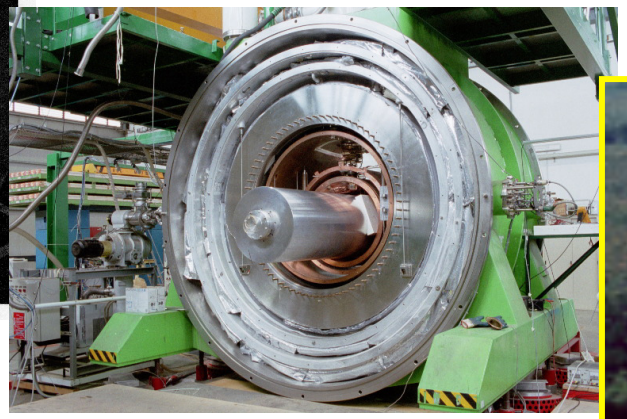
Roma 1988

Some perspective: 50 years of attempts at detection:

Since the pioneering work of Joseph Weber in the ‘60, the search for Gravitational Waves has never stopped, with an increasing effort of manpower and ingenuity:



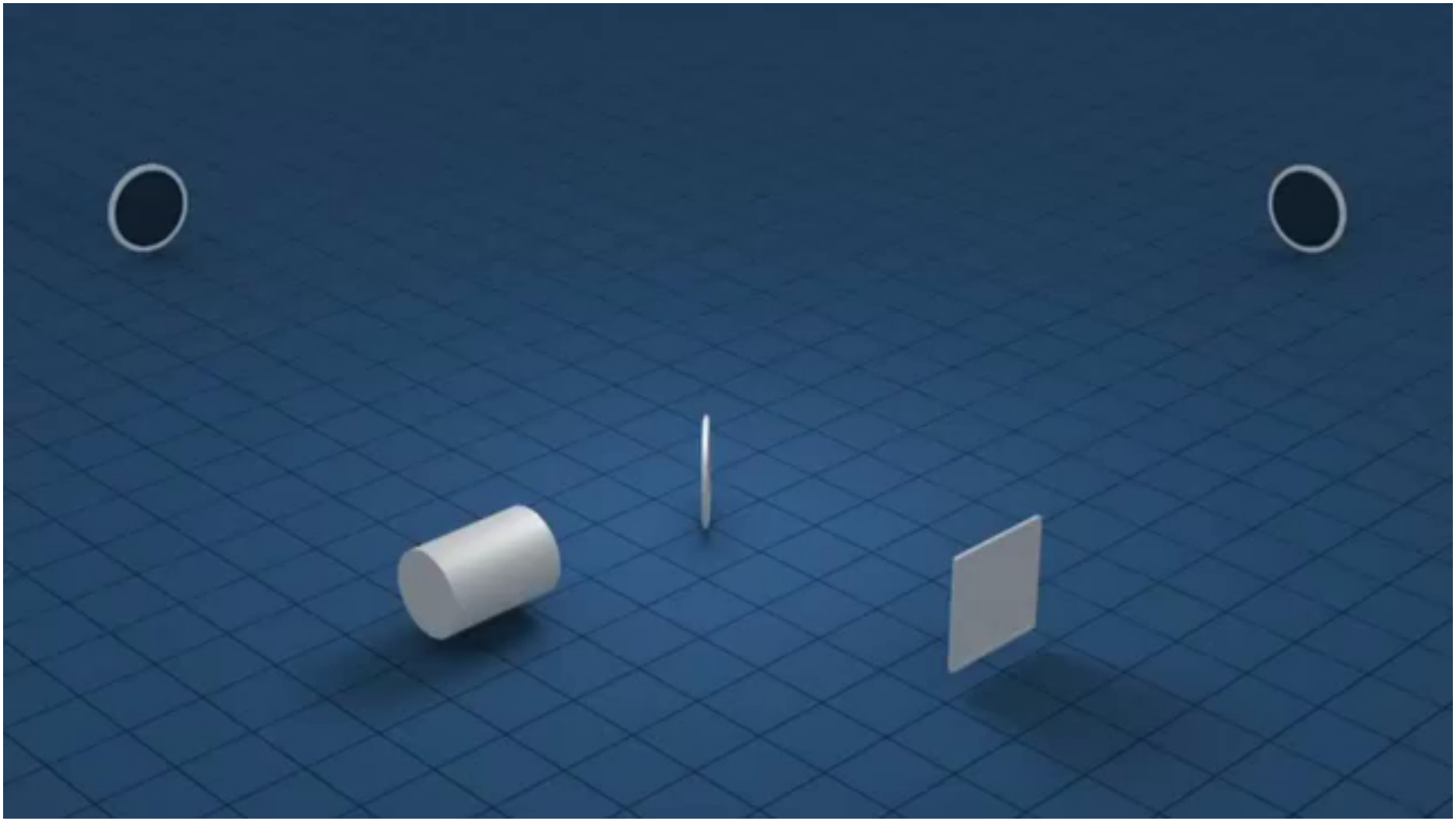
60’: Joe Weber pioneering work



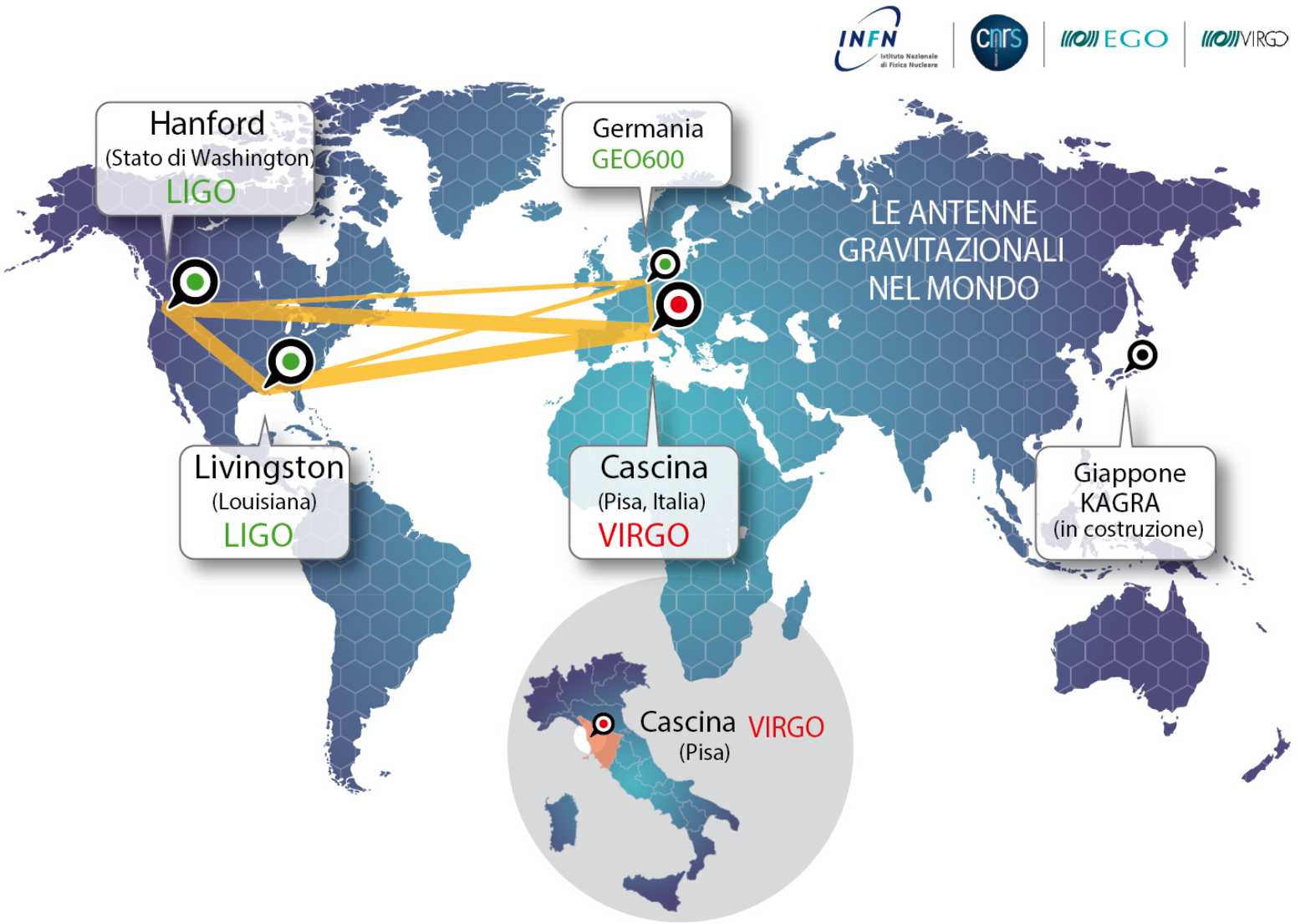
90’: Cryogenic Bars

2000’ - : Large Interferometers

1997: GWIC was formed



Global Network of Detectors



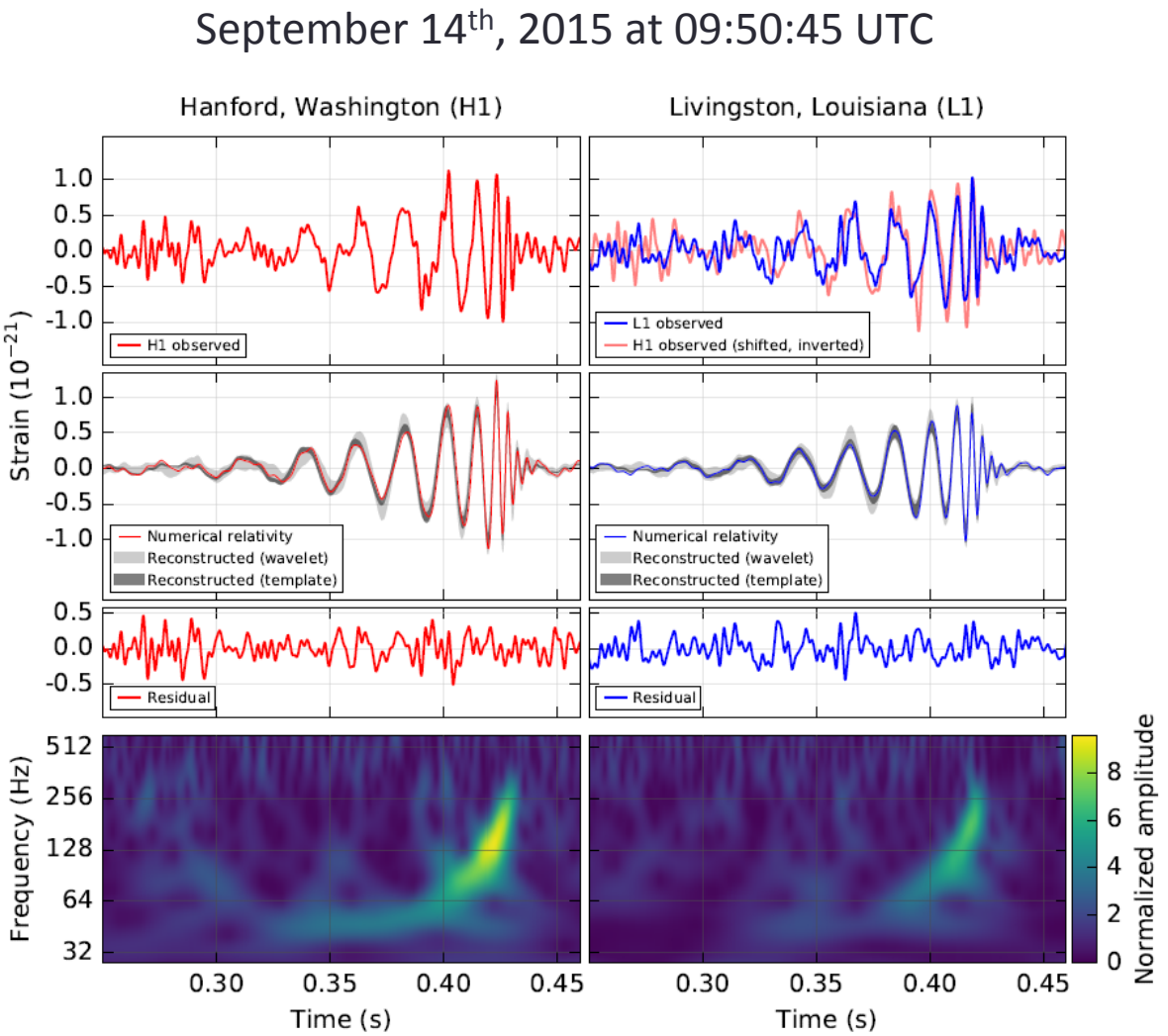
GW150914: the signal

- Top row left – Hanford
- Top row right – Livingston
- Time difference ~ 6.9 ms with Livingston first

- Second row – calculated GW strain using Numerical Relativity Waveforms for quoted parameters compared to reconstructed waveforms (Shaded)

- Third Row –residuals

- Bottom row – time frequency plot showing frequency increases with time (chirp)

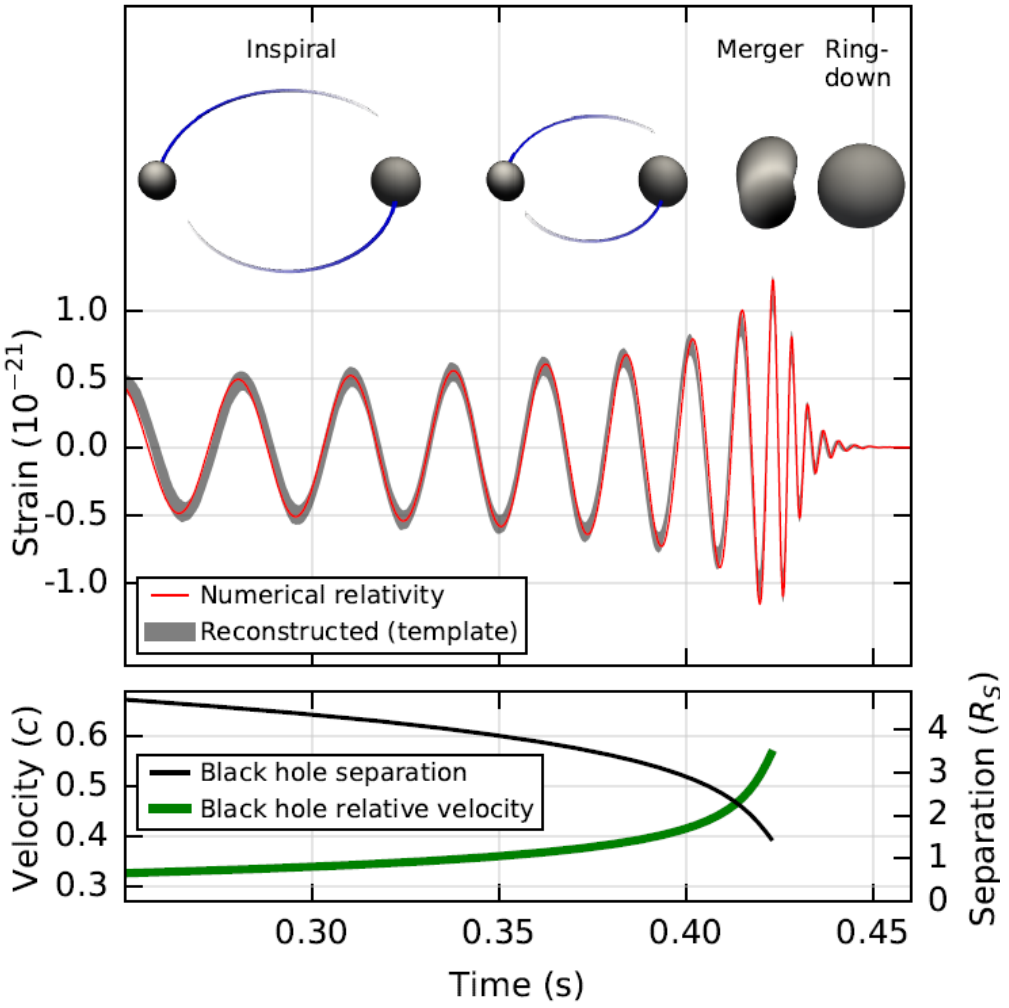


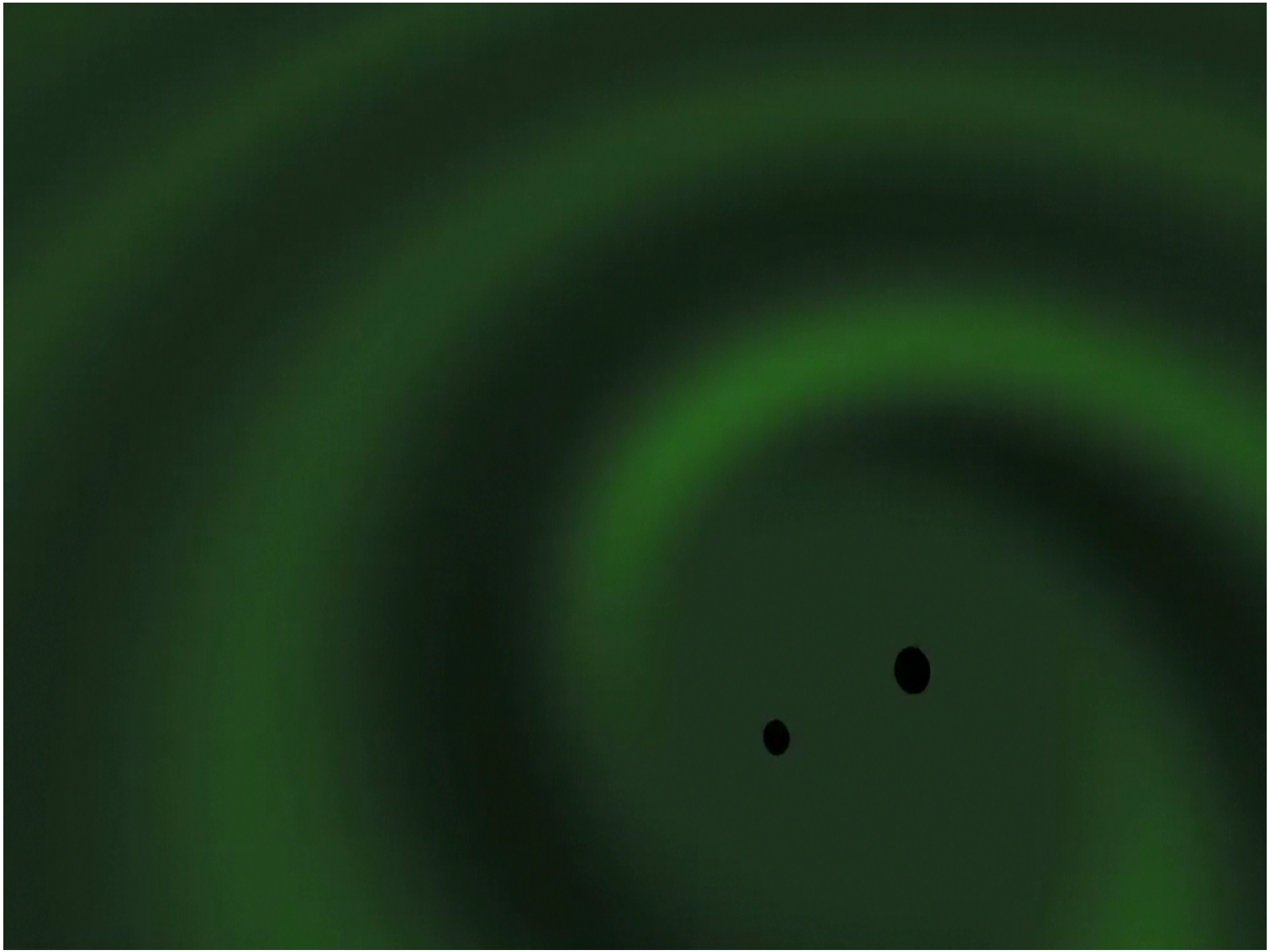
GW150914: Estimated Strain Amplitude

$$\mathcal{M} = \frac{(m_1 m_2)^{3/5}}{(m_1 + m_2)^{1/5}} = \frac{c^3}{G}\left[\frac{5}{96}\pi^{-8/3} f^{-11/3}\dot{f}\right]^{3/5}$$

- Numerical relativity models of black hole horizons during coalescence
- Effective black hole separation in units of Schwarzschild radius (R_s=2GM$_{tot}$/c^2=210km); and effective relative velocities given by post-Newtonian parameter v/c = (GM$_{tot}\pi f_{GW}$/c^3)$^{1/3}$

Binary Black Hole System
- M1 = 36 +5/-4 M$_{sol}$
- M2 = 29 +/- 4 M$_{sol}$
- Final Mass = 62 +/- 4 M$_{sol}$
- distance=410 +160/-180 MPc (redshift z = 0.09)





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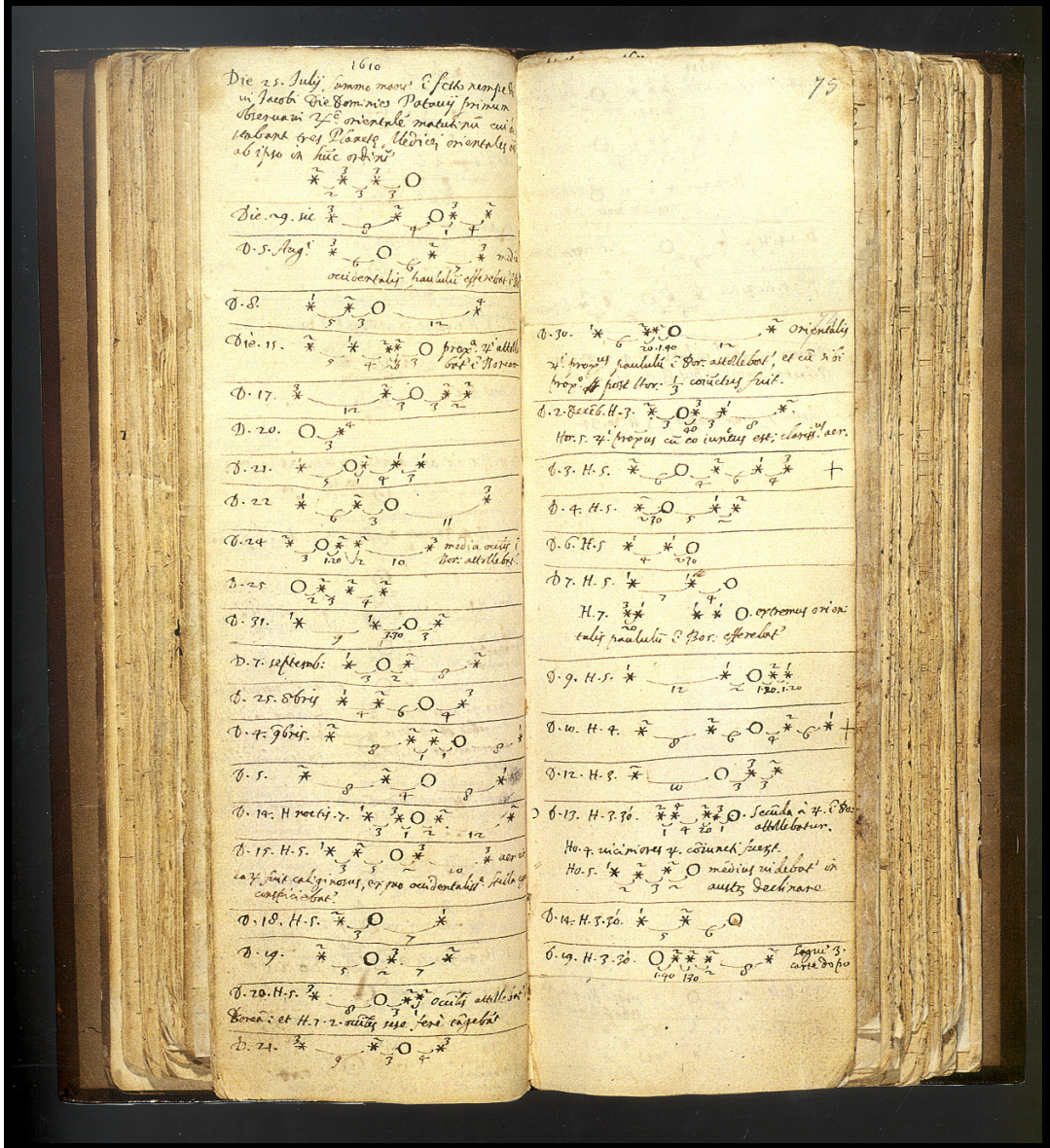

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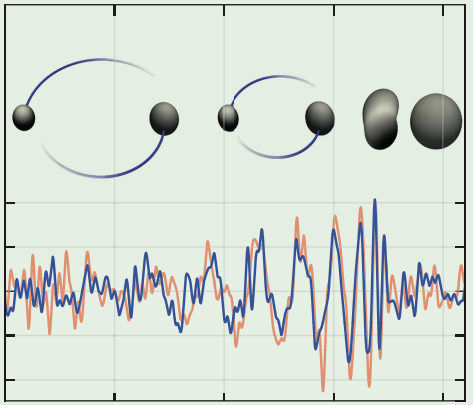

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Volume 116, Number 6

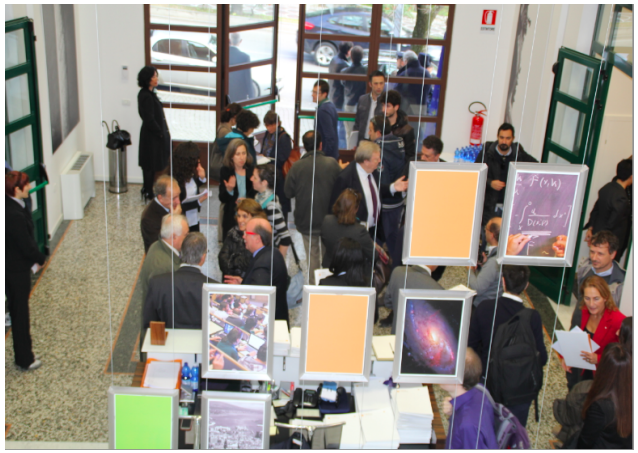
La Collaborazione Virgo

Laborato
lazionali del Gran Sasso

GRAN SASSO SCIENCE INSTITUTE

CENTER FOR ADVANCED STUDIES
Istituto Nazionale di Fisica Nucleare

The international PhD school *Gran Sasso Science Institute* has started its educational and scientific activities in 2013, and is now at the end of its third year of life.



4 courses:

- *Astroparticle Physics*
- *Mathematics in Natural, Social and Life Science*
- *Computer Science*
- *Urban Studies*

36 PhD students selected in the first year 2013-2014
40 PhD students selected for the second year 2014-2015
40 PhD students selected for the third year 2015-2016
Also appointed: 28 Post-docs with two-years research grants

Director: E. Coccia
Coordinators: F. Vissani (INFN), P. Marcati (L'Aquila), R. De Nicola (IMT) , A. Calafati (Ancona).

Scientific Committee: F. Barca (MEF, Italy, Chair); R. Barbieri (SNS, Italy); B. Barish (Caltech, USA); S. Iammarino (London School of Economics, UK); A. Quarteroni (Politech. Losanna, CH); A. Sangiovanni Vincentelli (Berkley, USA).

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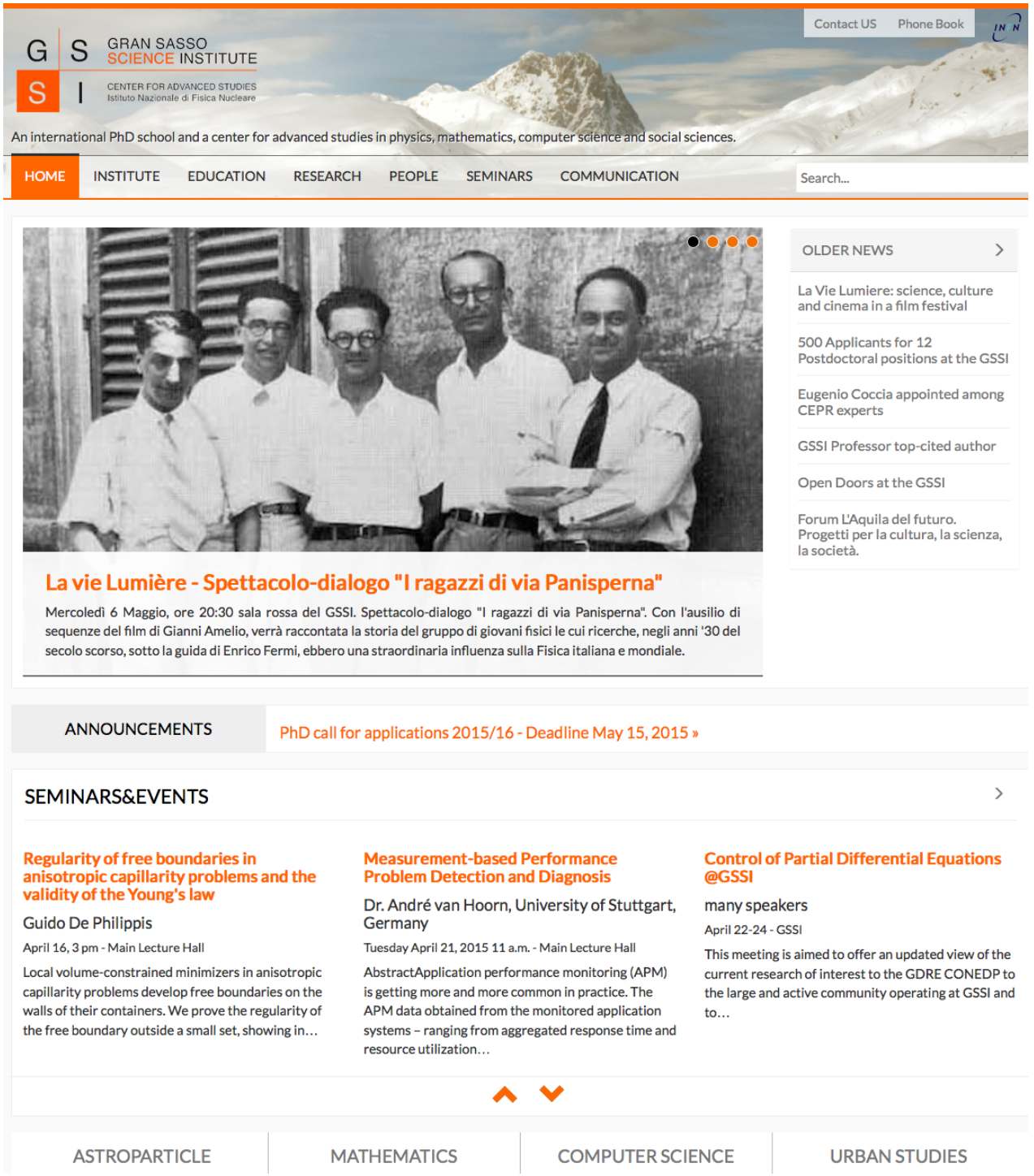
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La vie Lumière - Spettacolo-dialogo "I ragazzi di via Panisperna"
Mercoledì 6 Maggio, ore 20:30 sala rossa del GSSI. Spettacolo-dialogo "I ragazzi di via Panisperna". Con l'ausilio di sequenze del film di Gianni Amelio, verrà raccontata la storia del gruppo di giovani fisici le cui ricerche, negli anni '30 del secolo scorso, sotto la guida di Enrico Fermi, ebbero una straordinaria influenza sulla Fisica italiana e mondiale.
OLDER NEWS
La Vie Lumiere: science, culture and cinema in a film festival
500 Applicants for 12 Postdoctoral positions at the GSSI
Eugenio Coccia appointed among CEPR experts
GSSI Professor top-cited author
Open Doors at the GSSI
Forum L'Aquila del futuro. Progetti per la cultura, la scienza, la società.
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PhD call for applications 2015/16 - Deadline May 15, 2015 »
SEMINARS&EVENTS
Regularity of free boundaries in anisotropic capillarity problems and the validity of the Young's law
Guido De Philippis
April 16, 3 pm - Main Lecture Hall
Local volume-constrained minimizers in anisotropic capillarity problems develop free boundaries on the walls of their containers. We prove the regularity of the free boundary outside a small set, showing in…
Measurement-based Performance Problem Detection and Diagnosis
Dr. André van Hoorn, University of Stuttgart, Germany
Tuesday April 21, 2015 11 a.m. - Main Lecture Hall
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