Professor Martin Hendry
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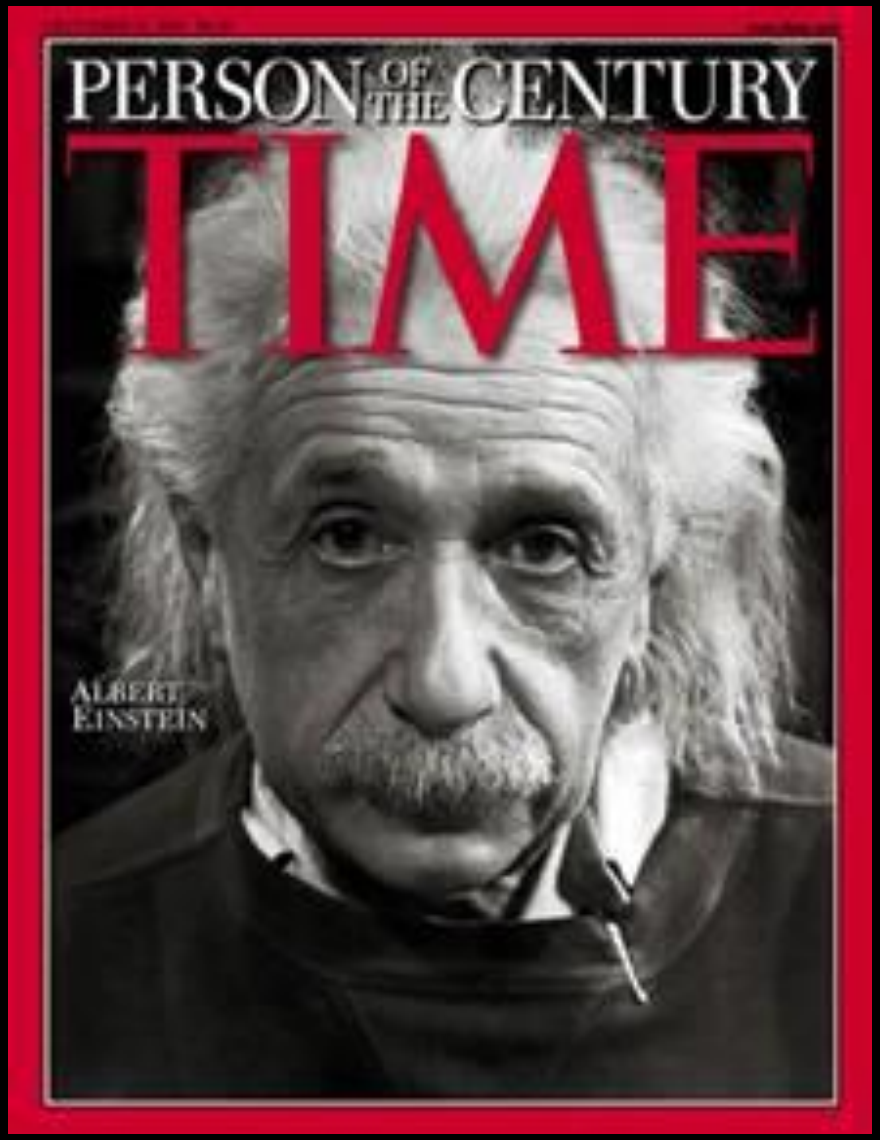
Science & Technology Facilities Council

SDSO



Of the 100 chosen, Albert Einstein was chosen as the Person of the Century, on the grounds that he was the preeminent scientist in a century dominated by science. The editors of *Time* believed the 20th century "will be remembered foremost for its science and technology", and Einstein "serves as a symbol of all the scientists—such as Fermi, Heisenberg, Bohr, Richard Feynman, ...who built upon his work".[1]

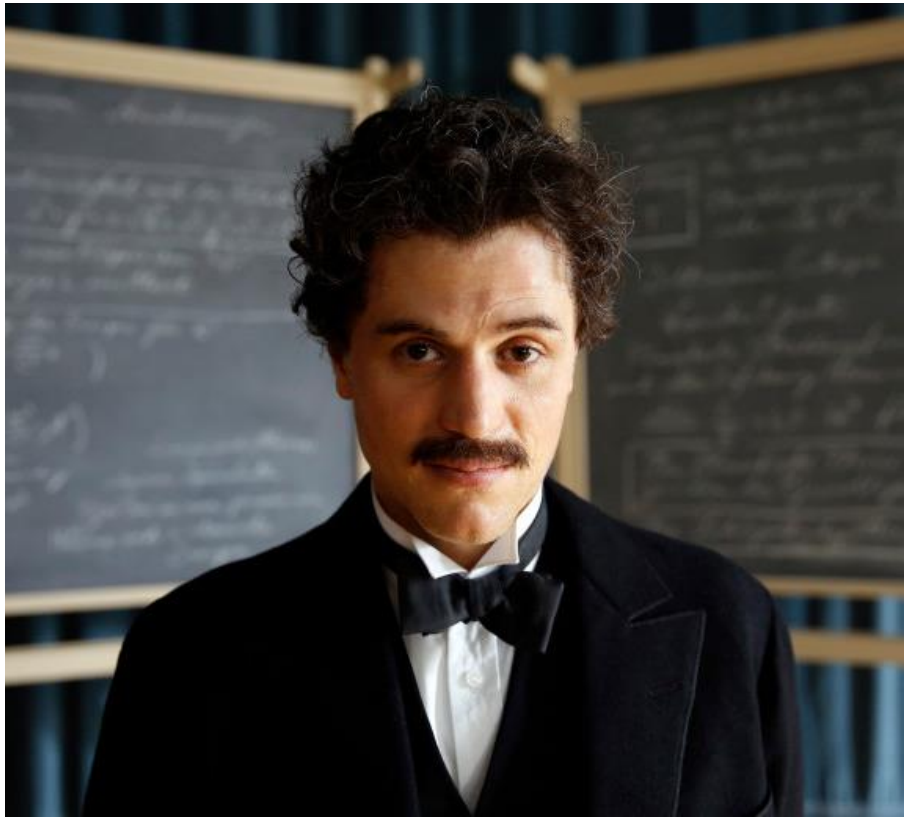
The Person of the Century Poll Results

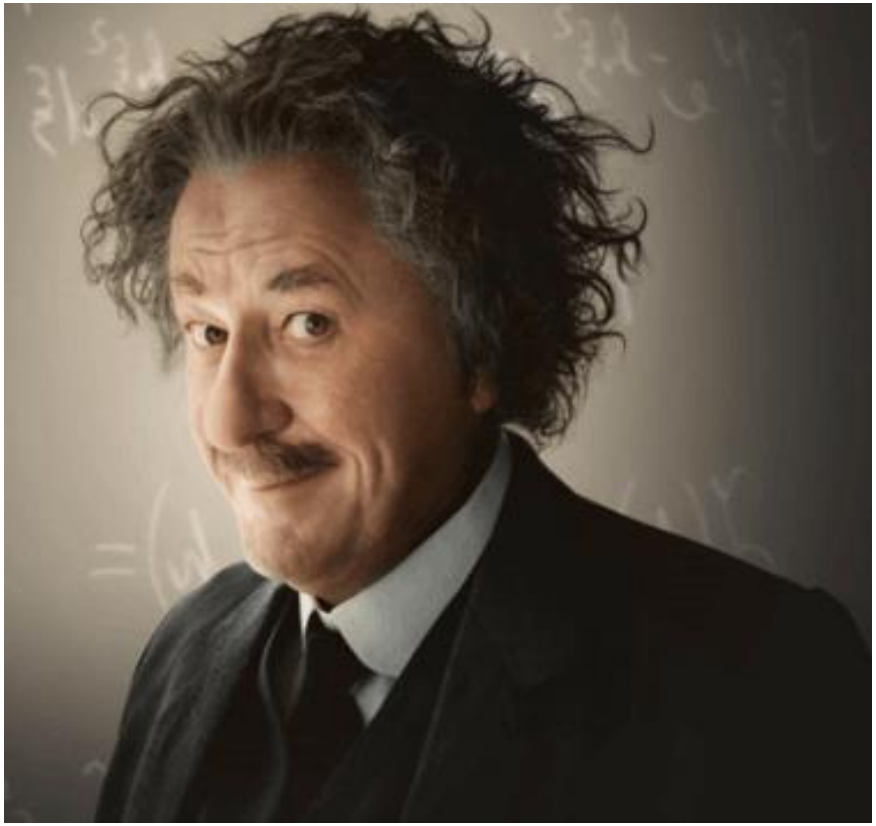
TIME's Person of the Century is that person who, for better or worse, most influenced the course of history over the past 100 years. Using that criteria, TIME's editors named the iconic and transforming scientist, Albert Einstein, as Person of the Century.

The Person of the Century poll is now closed. The ranking below reflects the status of nominees as of January 19, 2000, the last day of voting.

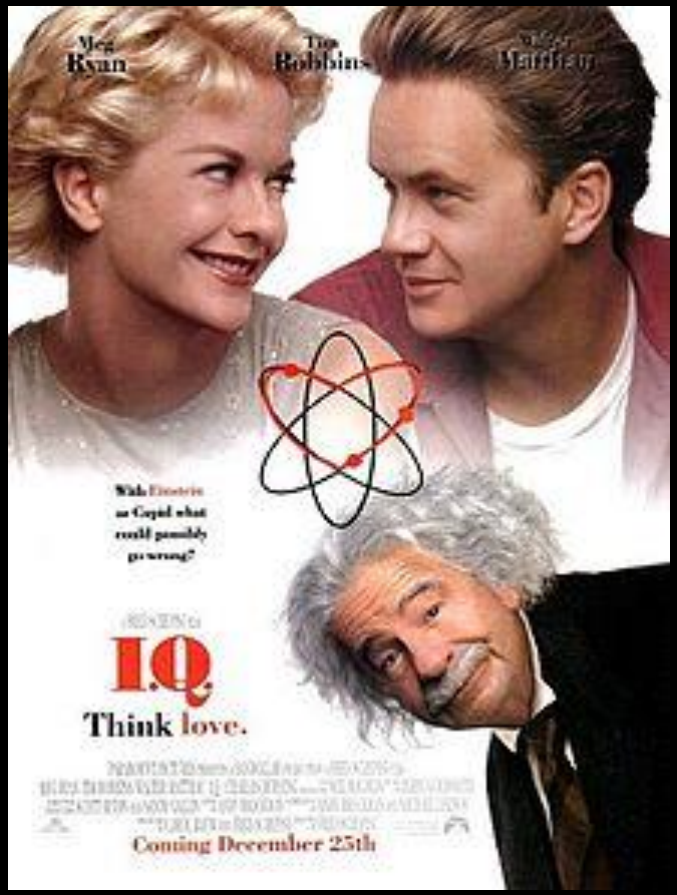
1	Elvis Presley	13.73	625045
2	Yitzhak Rabin	13.17	599473
3	Adolf Hitler	11.36	516926
4	Billy Graham	10.35	471114
5	Albert Einstein	9.78	445218
6	Martin Luther King	8.40	382159
7	Pope John Paul II	8.18	372477
8	Gordon B. Hinckley	5.62	256077
9	Mohandas Gandhi	3.61	164281
10	Ronald Reagan	1.78	81368
11	John Lennon	1.41	64295
12	American GI	1.35	61836
13	Henry Ford	1.22	55696
14	Mother Teresa	1.11	50770
15	Madonna	0.85	38696
16	Winston Churchill	0.83	37930
17	Linus Torvalds	0.53	24146
18	Nelson Mandela	0.47	21640
19	Princess Diana	0.36	16481
20	Pope Paul VI	0.34	15812

From Time magazine's website






E=m


Meg Ryan
Tim Robbins
With Einstein as Cupid what could possibly go wrong?
I.Q.
Think love.
Coming December 25th

Einstein's Miraculous Year

- Relativity
- Atomic physics
- Quantum physics

Einstein's Relativity

"You can't tell if you're moving"

Einstein's Relativity

"You can't tell if you're moving"

Einstein's Relativity

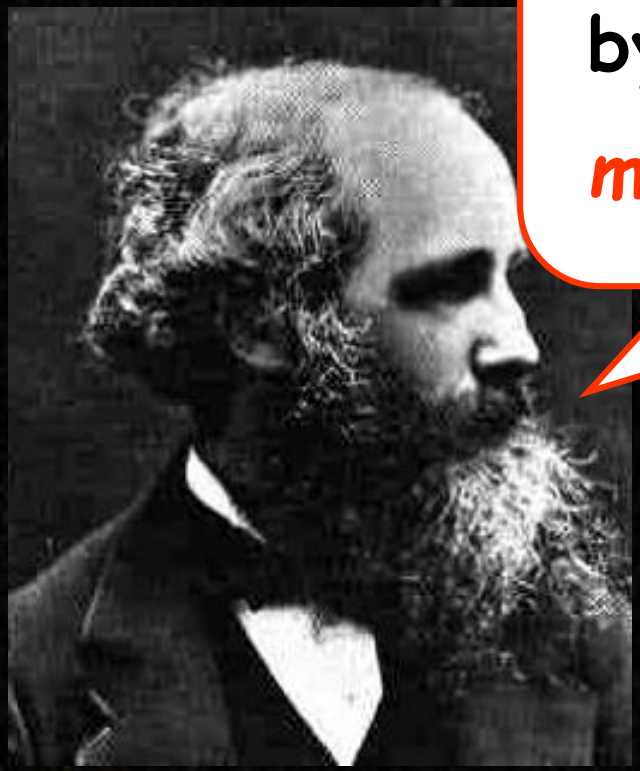
"You can't tell if you're moving"

Viewed from the blue car's rest frame

Einstein's Relativity

"What time does Oxford reach this train?"

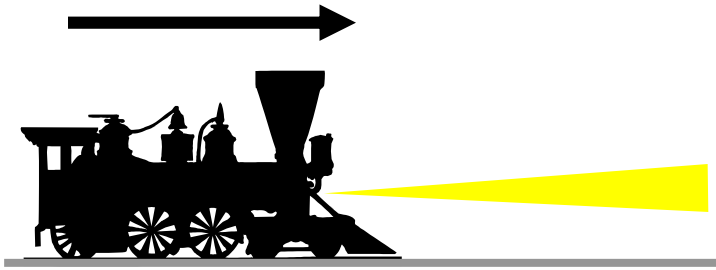
James Clerk Maxwell's theory of light



Light is a *wave* caused by varying *electric* and *magnetic* fields

But what if I travelled *alongside* a light beam? Would it still wave?

50mph



In Einstein's relativity, the speed of light is *unchanged* by the motion of the train

ON THE ELECTRODYNAMICS OF MOVING BODIES

By A. EINSTEIN

June 30, 1905

It is known that Maxwell's electrodynamics—as usually understood at the present time—when applied to moving bodies, leads to asymmetries which do not appear to be inherent in the phenomena. Take, for example, the reciprocal electrodynamic action of a magnet and a conductor. The observable phenomenon here depends only on the relative motion of the conductor and the magnet, whereas the customary view draws a sharp distinction between the two cases in which either the one or the other of these bodies is in motion. For if the magnet is in motion and the conductor at rest, there arises in the neighbourhood of the magnet an electric field with a certain definite energy, producing a current at the places where parts of the conductor are situated. But if the magnet is stationary and the conductor in motion, no electric field arises in the neighbourhood of the magnet. In the conductor, however, we find an electromotive force, to which in itself there is no corresponding energy, but which gives rise—assuming equality of relative motion in the two cases discussed—to electric currents of the same path and intensity as those produced by the electric forces in the former case.

Examples of this sort, together with the unsuccessful attempts to discover any motion of the earth relatively to the "light medium," suggest that the phenomena of electrodynamics as well as of mechanics possess no properties corresponding to the idea of absolute rest. They suggest rather that, as has already been shown to the first order of small quantities, the same laws of electrodynamics and optics will be valid for all frames of reference for which the equations of mechanics hold good.[1] We will raise this conjecture (the purport of which will hereafter be called the "Principle of Relativity") to the status of a postulate, and also introduce another postulate, which is only apparently irreconcilable with the former, namely, that light is always propagated in empty space with a definite velocity c which is independent of the state of motion of the emitting body. These two postulates suffice for the attainment of a simple and consistent theory of the electrodynamics of moving bodies based on Maxwell's theory for stationary bodies. The introduction of a "luminiferous ether" will prove to be superfluous inasmuch as the view here to be developed will not require an "absolutely stationary space" provided with special properties, nor

[1]The preceding memoir by Lorentz was not at this time known to the author.

1

- Measurements of space and time are ***relative*** and depend on our motion
- Unified ***spacetime*** - only measurements of the ***spacetime*** interval are invariant
- Equivalence of **matter** and **energy**

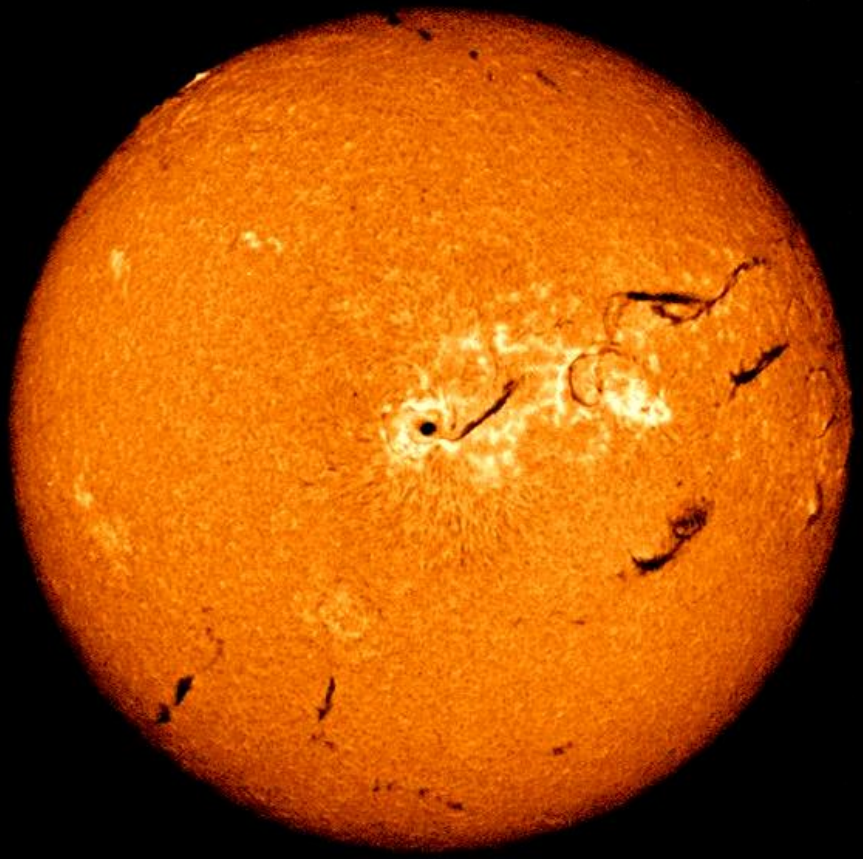
$$E = mc^2$$

Einstein's Relativity

THE HITCHHIKER'S GUIDE TO THE GALAXY

NOW PLAYING!


KAMINSKY V.F.



The distance from the Earth to the Sun is **150 million km**.

It takes sunlight more than **eight minutes** to travel this distance.

The light from the *next* nearest star, Alpha Centauri, takes more than **four years** to reach the Earth.

THE MILKY WAY

NATIONAL GEOGRAPHIC

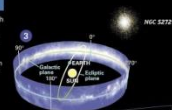
Home galaxy of Earth, the Milky Way is a spiral-shaped system of a few hundred billion stars. Bright regions of recently formed stars highlight its arms, while older stars explode or expel their outer layers as beautiful planetary nebulae, then fade away and die. A thick swarm of orange and red stars marks the galactic bulge, encapsulating the star-packed galactic center. At its core may lie a black hole, a region so dense that not even light can escape its gravitational pull. All objects in the Milky Way orbit the galactic center, much like planets in Earth's solar system revolve around the sun. But the scale is staggering: Light from a star at one edge of the galaxy takes about 100,000 years to reach the opposite side.

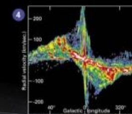
GUIDE TO THE GALAXY

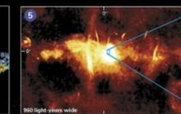
1 Far beyond the galactic disk, yet drawn by its gravity, lone stars and globular clusters wander the galaxy's halo. Regions of dark matter—unseen but felt through its gravitational effects—extend beyond that.

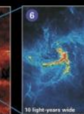
2 Vast clouds of interstellar dust block much of our night sky view of the Milky Way, which from our position in the flat galactic disk appears as a fuzzy band of light. Infrared satellites can see through the dust to reveal the galaxy's structure.

3 Earth's orbit around the sun lies at a severe angle to the galactic plane.







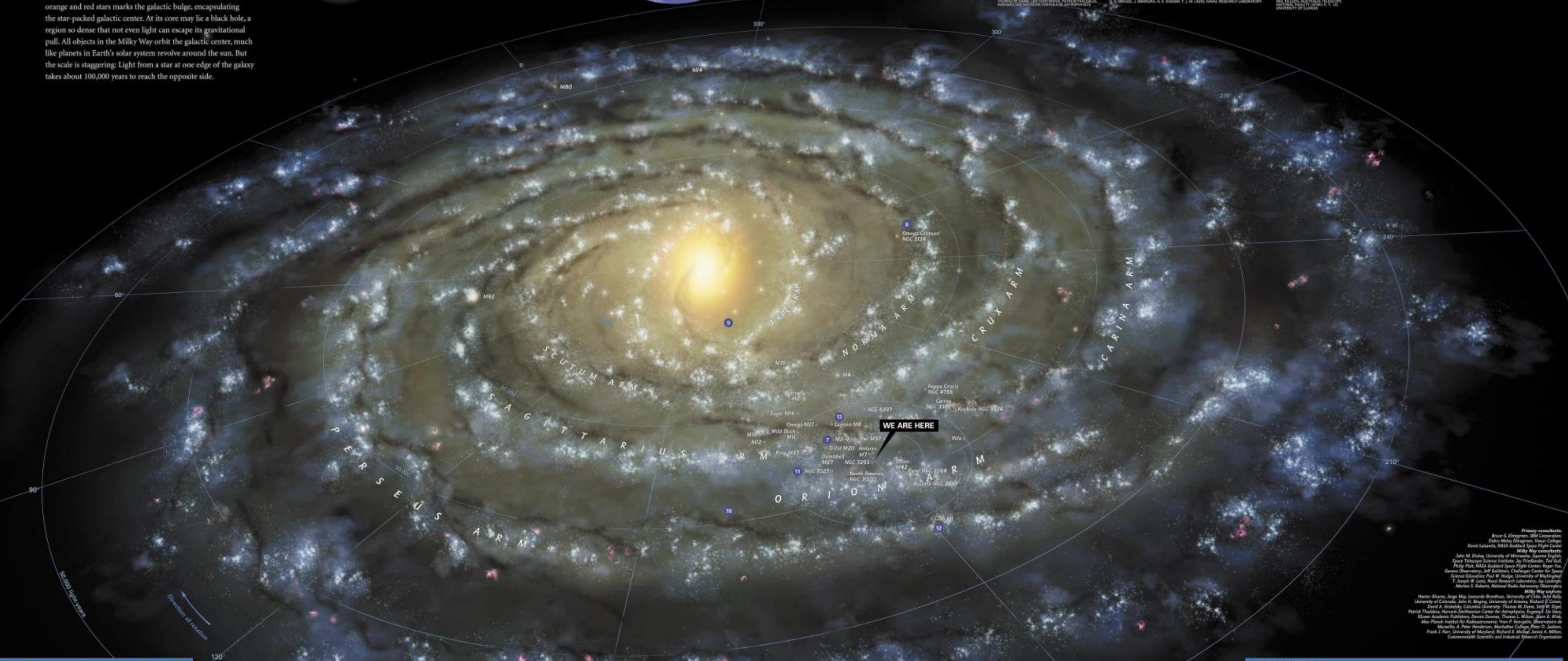


A TURBULENT HEART

4 A graph based on a radio survey reveals the whirlpool motion of molecular gas in the inner part of our galaxy: gas moving away from Earth (top half) and toward Earth (bottom half). The densest gas appears white; least dense, blue.

5 Massive amounts of energy are released near the center of the Milky Way, producing electrons that race along magnetic field lines, illuminating remnants of stellar explosions.

6 Probing even deeper into the core, a radio image details a spiral of hot gas that is falling toward what may be a black hole some 2.6 million times as massive as the sun.



This computer-generated image of the Milky Way—one perspective of a 3-D model newly compiled for NATIONAL GEOGRAPHIC—incorporates the actual positions of hundreds of thousands of stars and nebulae.

- Globular star cluster
- Interstellar gas and dust
- Nebula
- Younger star region (OB stars)
- Molecular cloud
- Galactic bulge or center (older star region)

Reference numbers for galaxies, nebulae, and star clusters
IC (Index Catalog)
M (Messier)
NGC (New General Catalog)

Coordinate system centered on galactic center

Primary consultants:
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Milky Way consultants:
John M. Dickey, University of Minnesota; Jayanne English, Space Telescope Science Institute; Jay Friedlander; Ted Gull, Philip Plait, NASA Goddard Space Flight Center; Roger Fux, Geneva Observatory; Jeff Goldstein, Challenger Center for Space Science Education; Paul W. Hodge, University of Washington; T. Joseph W. Lazio, Naval Research Laboratory; Jay Lockman, Morton S. Roberts, National Radio Astronomy Observatory
Milky Way sources:
Hector Alvarez, Jorge May, Leonardo Bronfman, University of Chile; John Bally, University of Colorado; John H. Bieging, University of Arizona; Richard S. Cohen, David A. Grabelsky, Columbia University; Thomas M. Dame, Seth W. Digel, Patrick Thaddeus, Harvard-Smithsonian Center for Astrophysics; Eugene J. De Geus, Kluwer Academic Publishers; Dennis Downes; Thomas L. Wilson; Jan E. Wink, Max-Planck-Institut für Radioastronomie; Yvon P. Georgelin, Observatoire de Marseille; A. Peter Henderson, Manhattan College; Peter D. Jackson, Frank J. Kerr, University of Maryland; Richard X. McGee, Janice A. Milton, Commonwealth Scientific and Industrial Research Organisation

PLANETARY NEBULA M2-9

BRUCE BALICK, UNIVERSITY OF WASHINGTON; VINCENT ICKE, LEIDEN UNIVERSITY; GARRELT MELLEMA, STOCKHOLM UNIVERSITY; NASA

Exotic kaleidoscopes of the Milky Way, colorful nebulae and star clusters are found throughout Earth's galaxy. Even a run-of-the-mill star may eventually produce a nebula of surpassing beauty.

7 Just as our sun will do in its death throes some five billion years from now, a dying star expanded into a red giant and was transformed into the nebula M2-9 (above). At its center shines a small, hot core, which will cool and fade over eons to come. Its stellar wind, streams of charged particles, rushes outward in opposite directions, like exhaust from back-to-back jet engines. This bipolarism, revealed by the Hubble Space Telescope, is common among planetary nebulae. Ultraviolet light from the star heats M2-9's gases and makes them glow.

Other types of nebulae exist in our galaxy, including dark nebulae rich in microscopic dust that blocks our view of stars beyond. When a star adjoins a dark nebula, the dust particles reflect starlight and the black cloud seems to have a silver lining.

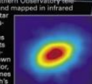
8 The million-plus stars packed into a globular cluster such as Omega Centauri (right) are senior citizens of the Milky Way. Unlike human retirees, however, every star in the cluster is about the same age, billions of years older than our 4.6-billion-year-old sun.

PATRICK SEITZER, UNIVERSITY OF MICHIGAN

HUBBLE HERITAGE TEAM

9 Peering between dust clouds toward the central bulge of the Milky Way, the Hubble Space Telescope focused on a rare clear region in the Sagittarius star cloud (above right). These Sagittarius stars formed at different times; most are older than the sun. They sparkle like an assortment of gems on a jeweler's velvet pad.

10 In some dark clouds lurk strange objects like G339.88-1.26, detected by a European Southern Observatory telescope in Chile and mapped in infrared light (right). A star 20 times as massive as the sun and 10,000 times brighter, it sports a disk of circumstellar dust, shown here in false color, about 20,000 times wider than Earth's orbit. Light from the hot star is absorbed by and warms the dust, making it glow.

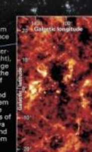


EUROPEAN SOUTHERN OBSERVATORY

11 As stars like the sun die, they become factories for interstellar dust. Celestial soot—the remnants of its red giant stage—surrounds the tiny hot central star of NGC 7027 (above right). Blown outward, the soot would obscure our view of the center of NGC 7027 were it not for this remarkable composite image in infrared and visible light from the Hubble Space Telescope.

WILLIAM B. LATTER, CALIFORNIA INSTITUTE OF TECHNOLOGY; NASA

Clouds of interstellar dust (right), strewn over huge regions along the central plane of the Milky Way, are not thick and smooth but seem as frothy as the head on a glass of beer. Supernova shock waves and stellar wind from evolving stars may have shaped this surprising pattern.



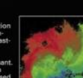
FRANK VAROSI, WILLIAM H. WALLER, NASA; INFRARED ASTRONOMICAL SATELLITE; SKYVIEW

When a massive star comes to the end of its nuclear fuel supply, it collapses and then rebounds in a brief, powerful explosion, or supernova. The Chinese called these celestial fireworks guest stars and recorded one such event in the constellation Taurus in July 1054 that was visible in broad daylight.

JEFF HESTER, PAUL SCOWEN, ARIZONA STATE UNIVERSITY; NASA

12 In that location today astronomers find the fast-expanding Crab Nebula (left), a supernova remnant. At its heart lies a pulsar—a collapsed star—whirling 30 times a second.

Satellite galaxies of the Milky Way host equally remarkable celestial phenomena. In the Large Magellanic Cloud (above right), 180,000 light-years from Earth, clumpy, filamentary clouds of hydrogen gas reveal their stately march in a radio map from the Australia Telescope Compact Array. The lower half of the cloud (blue) is rotating toward the Earth while the topside (red) turns away.



SUNGEUN KIM, UNIVERSITY OF ILLINOIS; LISTER STAVELEY-SMITH, ATNF

LAGOON NEBULA

ADELINE CAULET, EUROPEAN SPACE AGENCY; NASA

13 Glistening along the spiral arms of the galaxy, bright emission nebulae mark regions where new stars are forming. The Lagoon Nebula (above), about 5,000 light-years distant, is easily detected with the naked eye as a fuzzy spot in the southern constellation Sagittarius. Wide-field images show that it covers more of the sky than does the full moon. Where there was once only a vast dark cloud, radiation from the brightest and most massive young star in the nebula, Herschel 36, heats and ionizes the gas across a wide region. Despite the brilliance of the Lagoon Nebula and similar objects like the famous Orion Nebula, such areas are usually little more than hot blisters on the flanks of giant interstellar clouds.

With new tools, astronomers are unraveling the nature of the Milky Way and measuring distances to stars and nebulae with greater accuracy. Still, they ask, how did the Milky Way form in the first place? How and when did the arms form? How many more planets circle nearby stars besides the 102 already discovered? And the biggest question of all: Do any of them harbor life?

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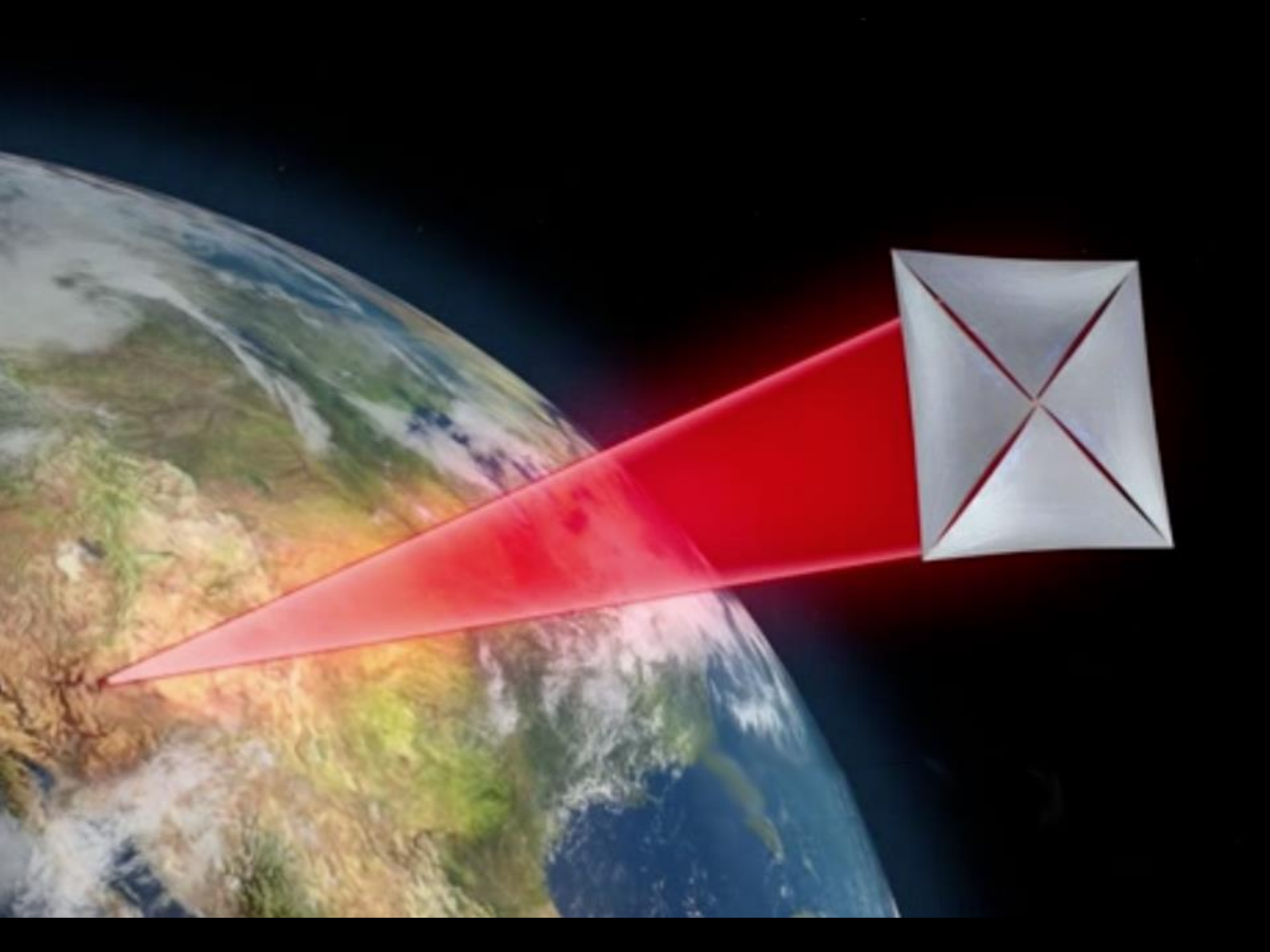
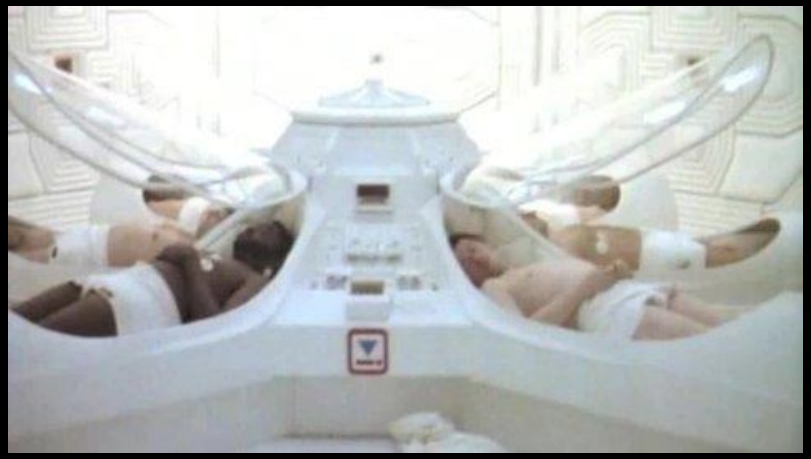
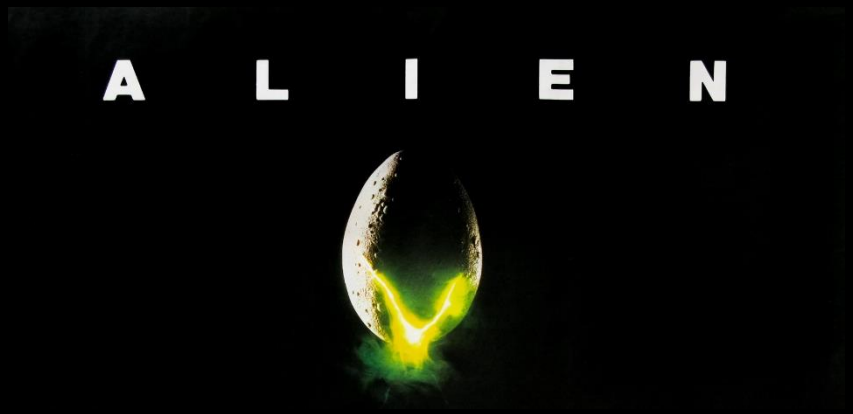
BREAKTHROUGH
Starshot



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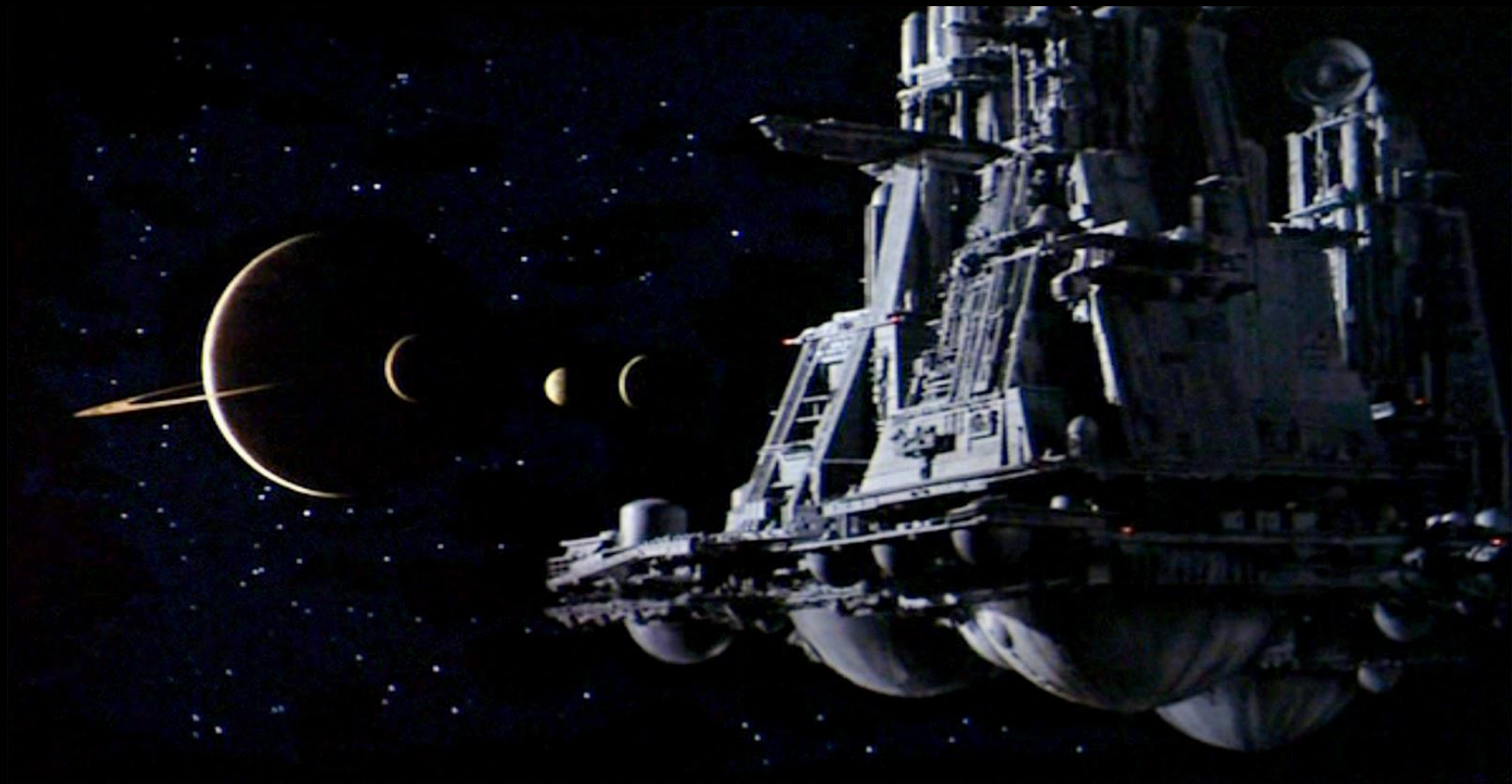
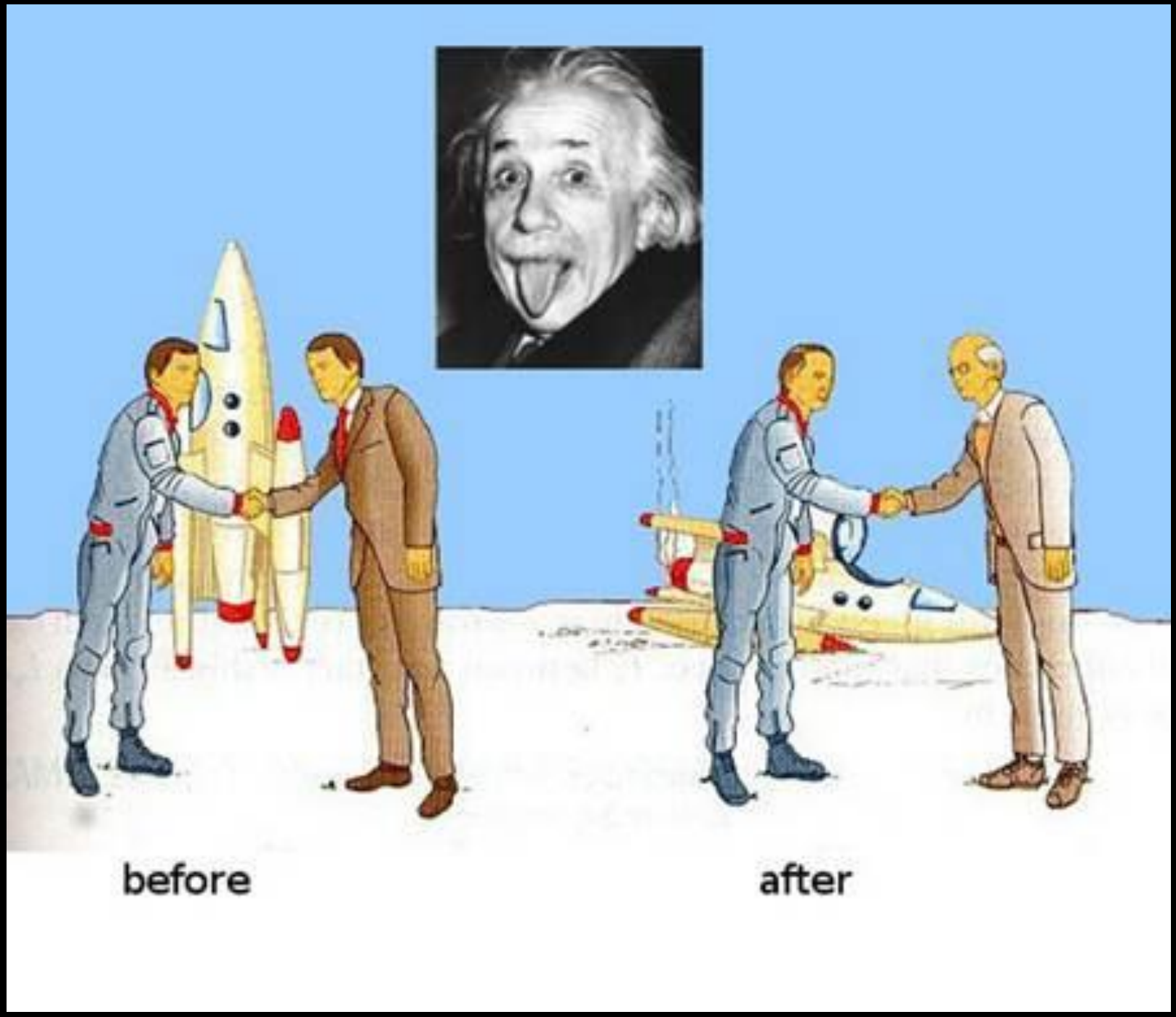



PASSENGERS


AVATAR


before
after

Origin of *Homo* pushed back 400,000 years *p. 1056*

Countering antibiotic resistance *pp. 1082 & 1064*

Democratic capital in the 21st century *p. 1143*

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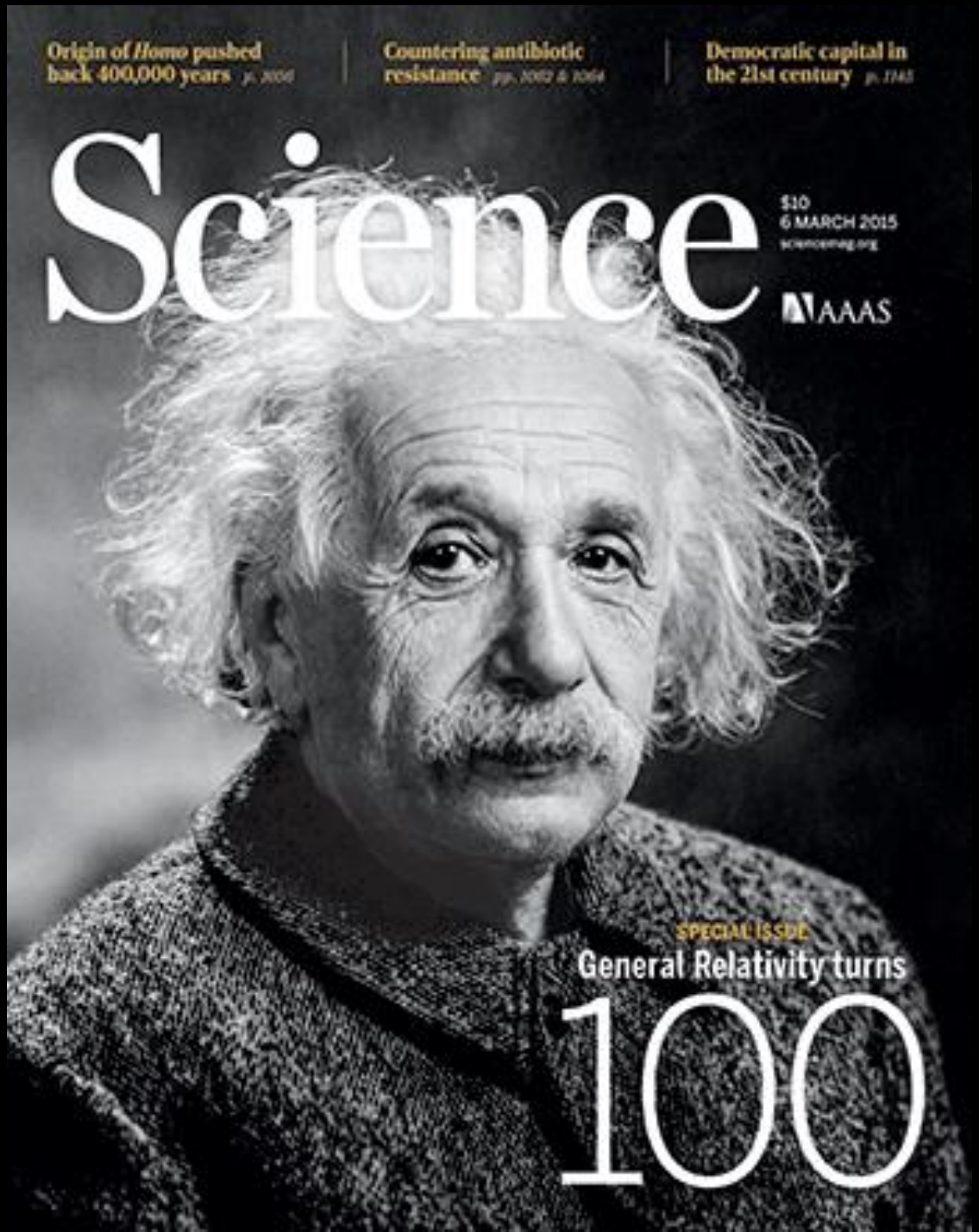
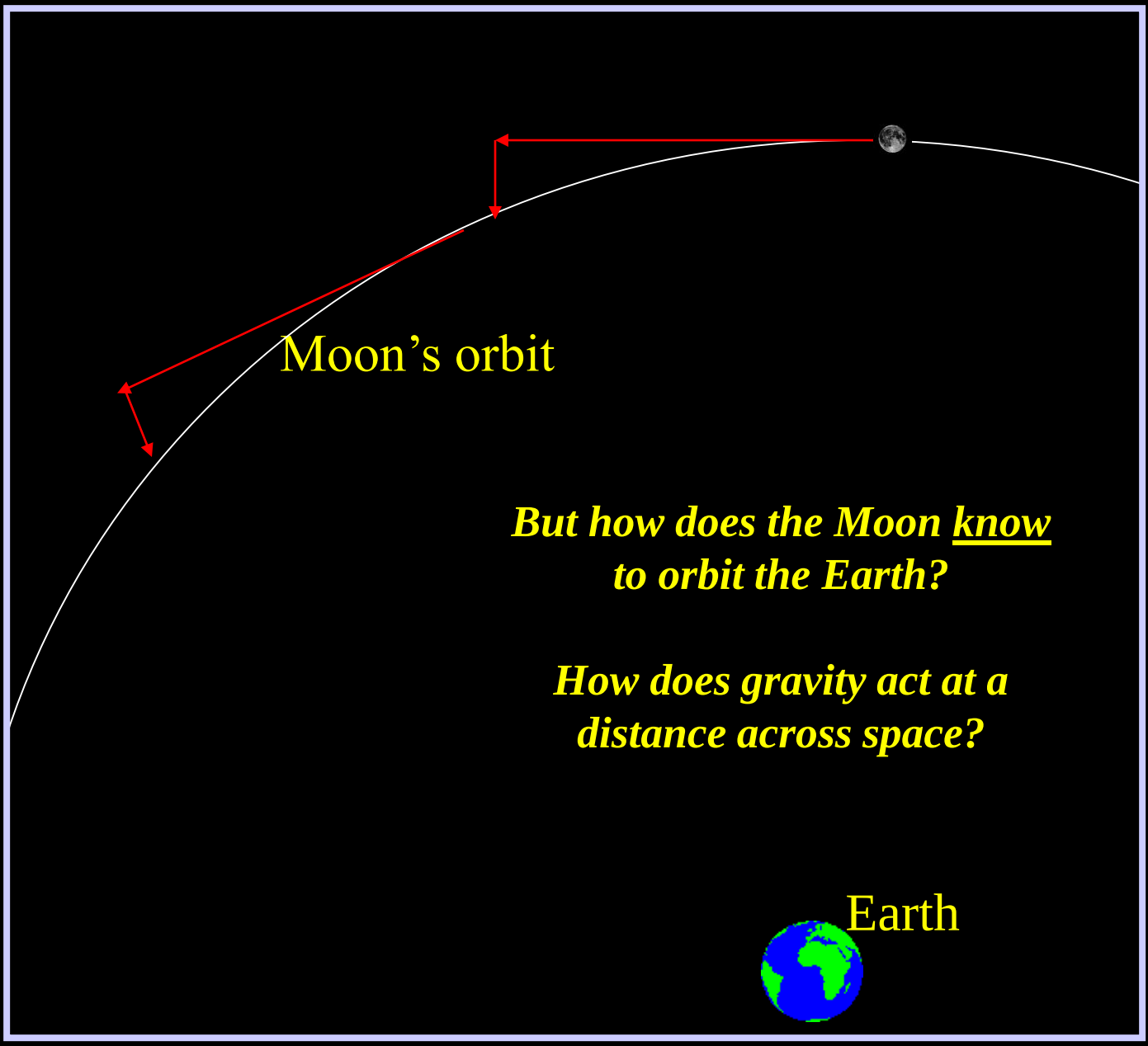


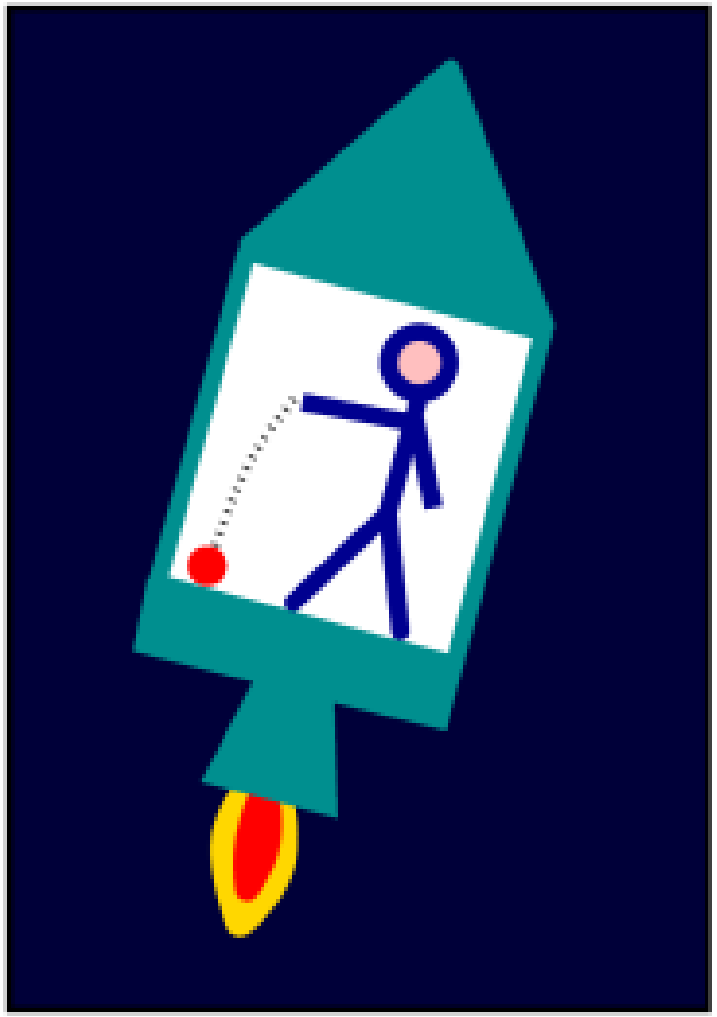
SPECIAL ISSUE

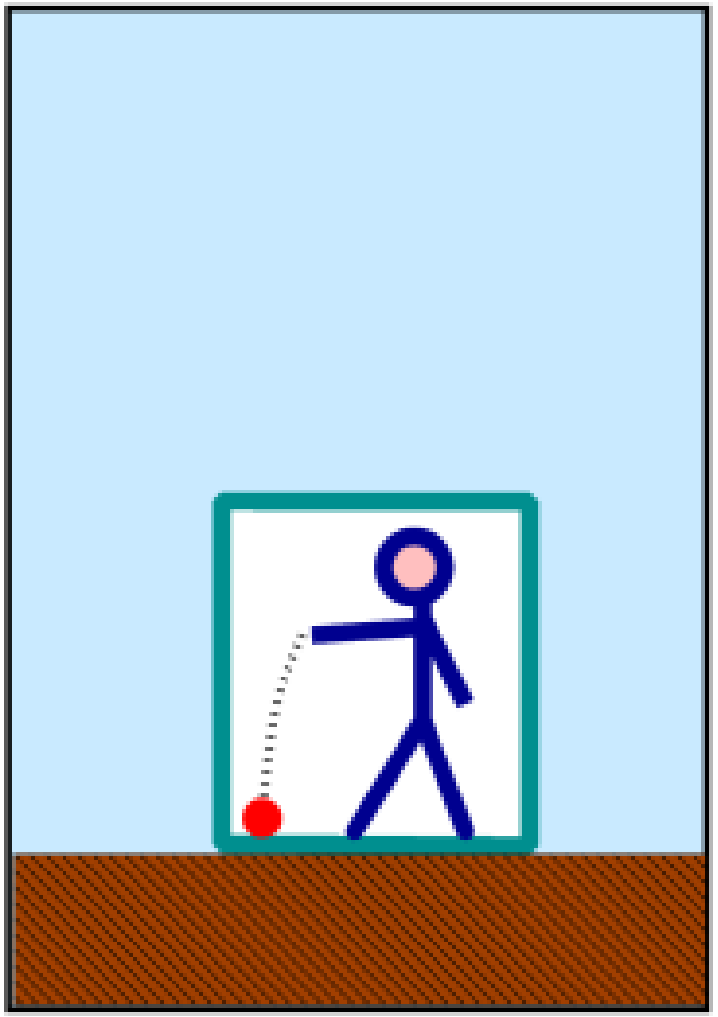
General Relativity turns 100


Moon's orbit
But how does the Moon know to orbit the Earth?
How does gravity act at a distance across space?
Earth

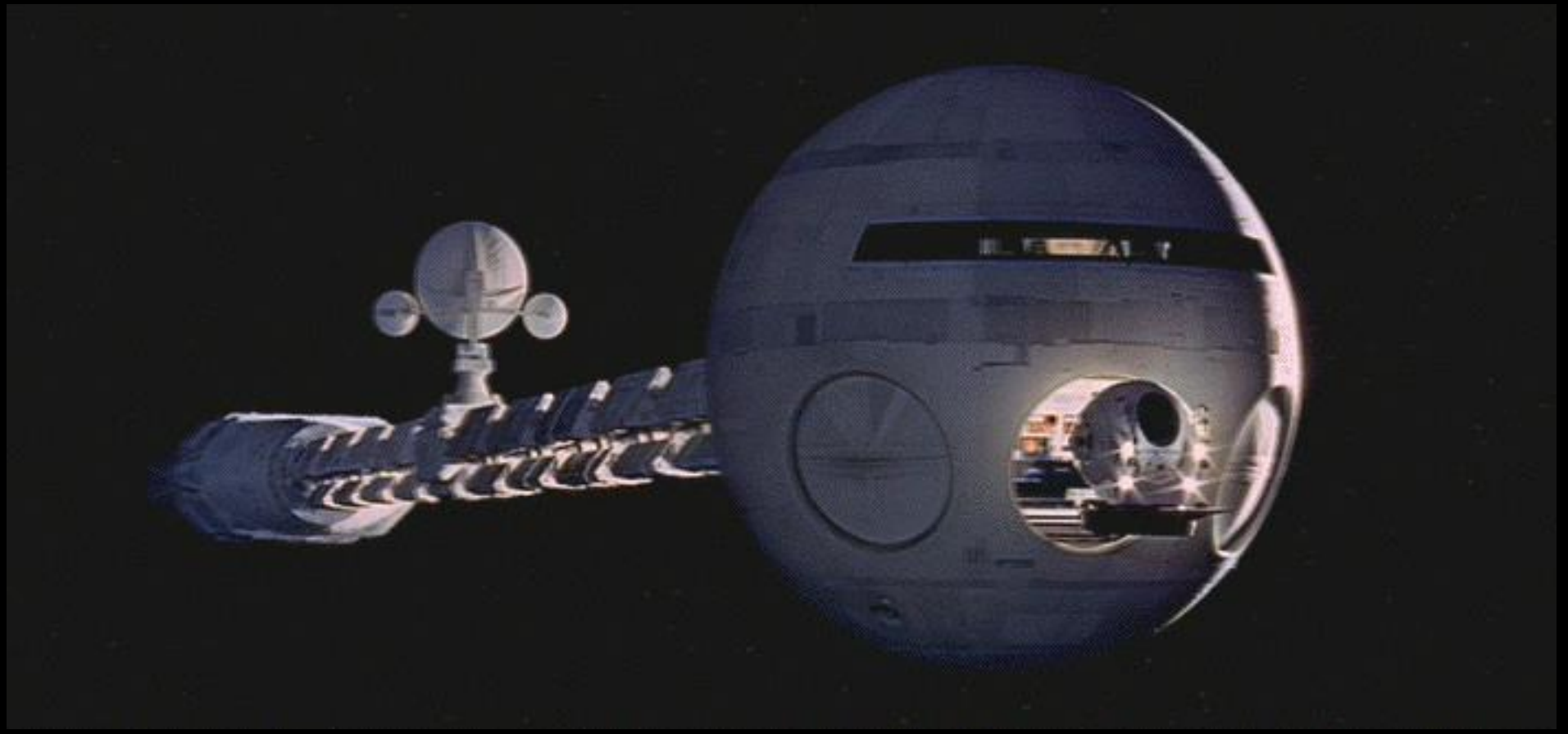
The Equivalence Principle

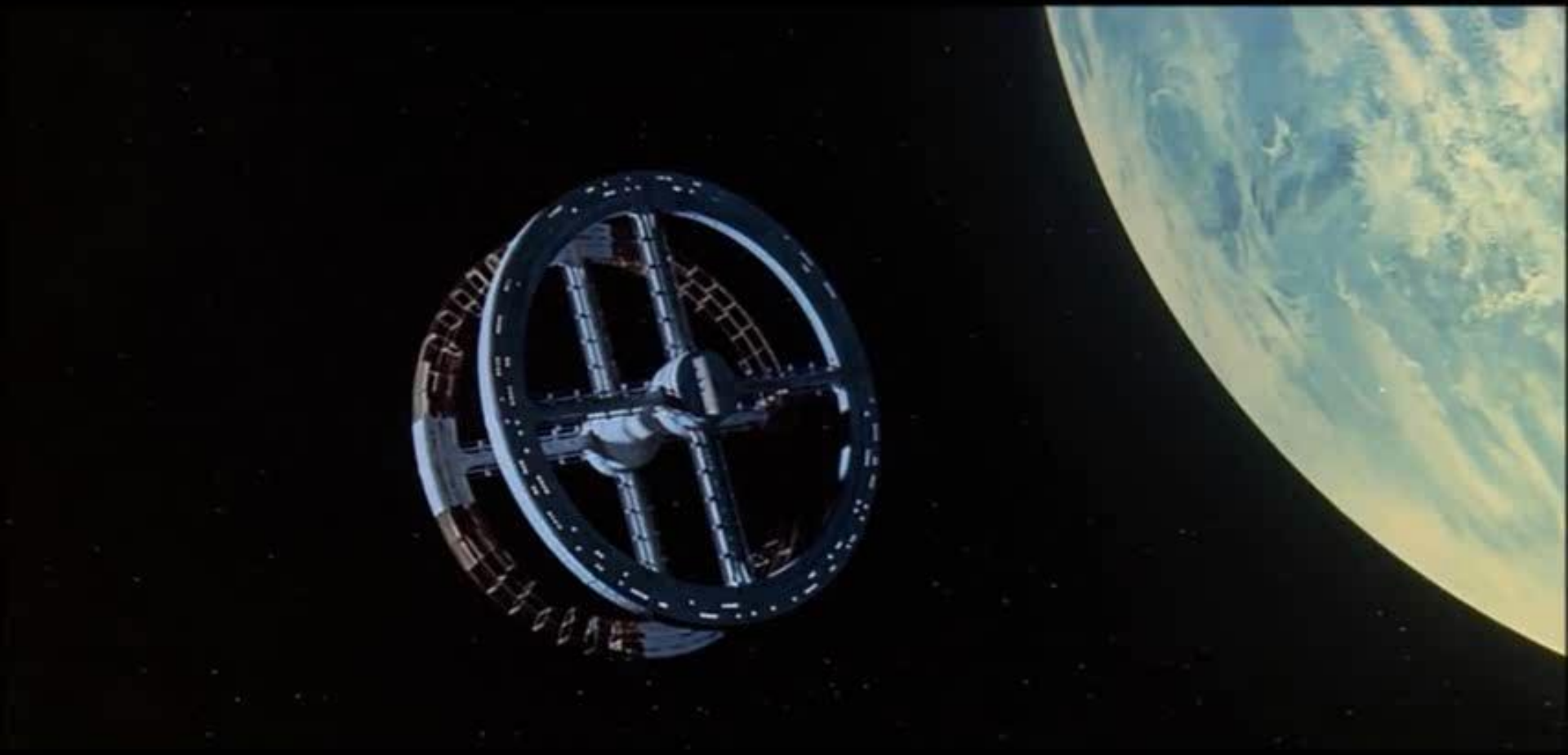
Einstein (1907)

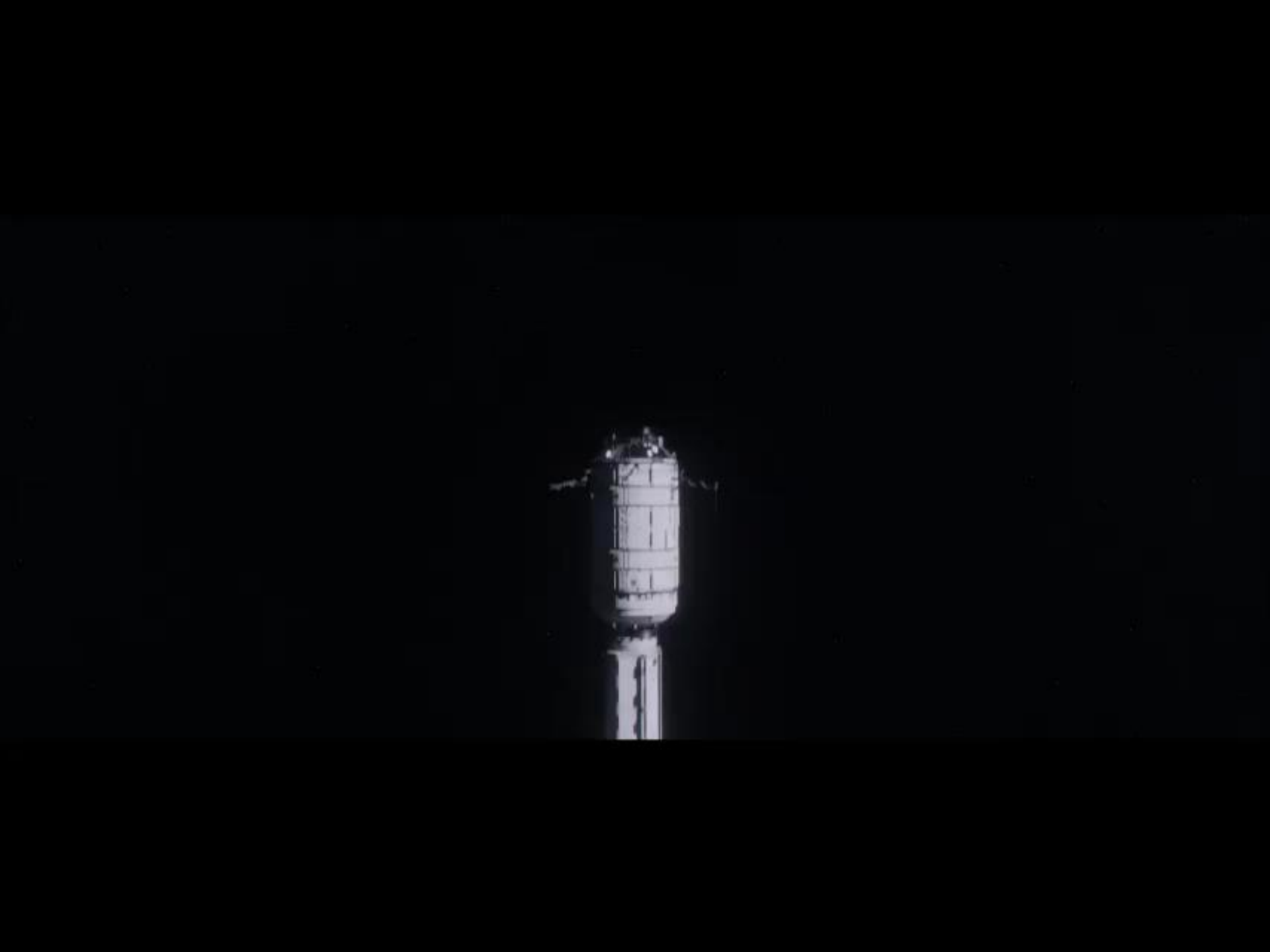




Acceleration due to **motion** and due to **gravity** are equivalent








A FILM BY CHRISTOPHER NOLAN
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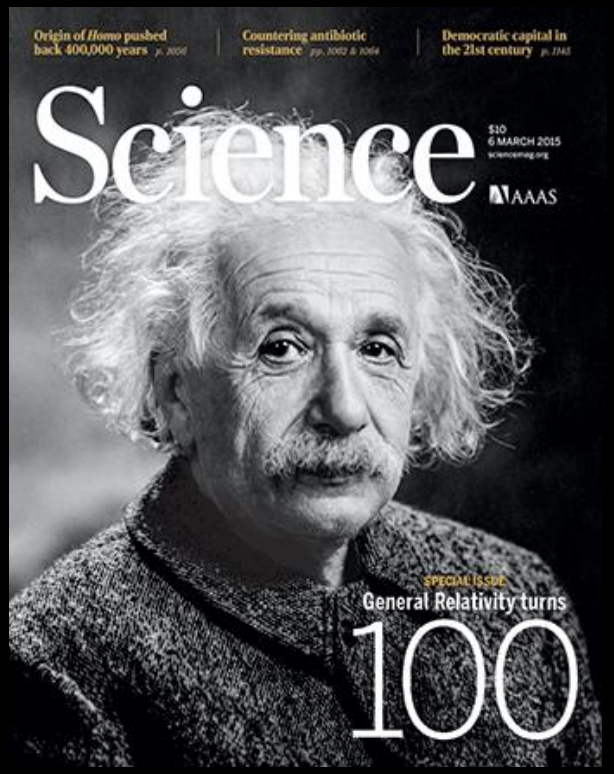
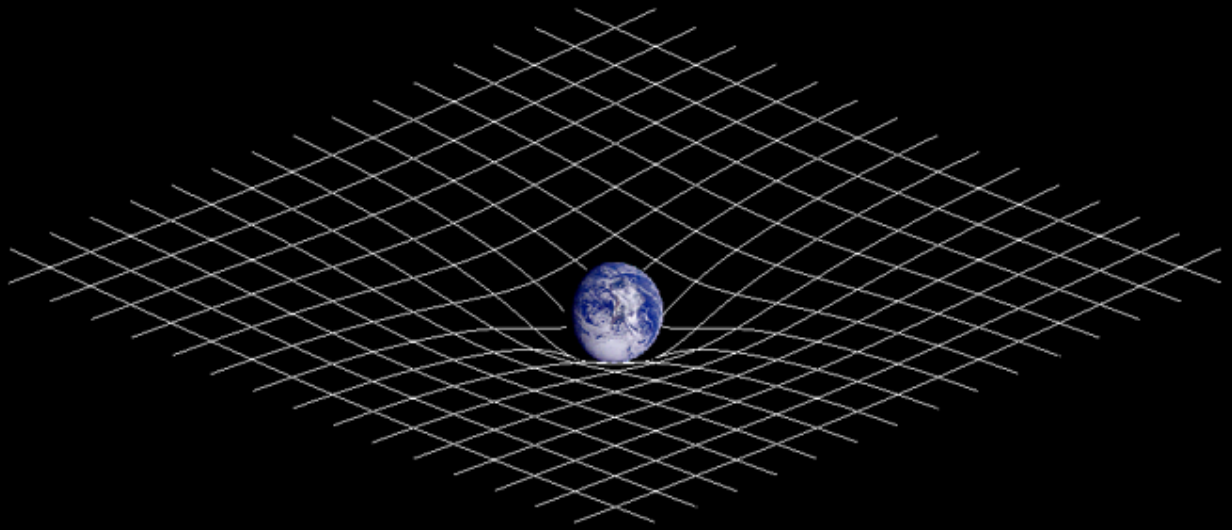
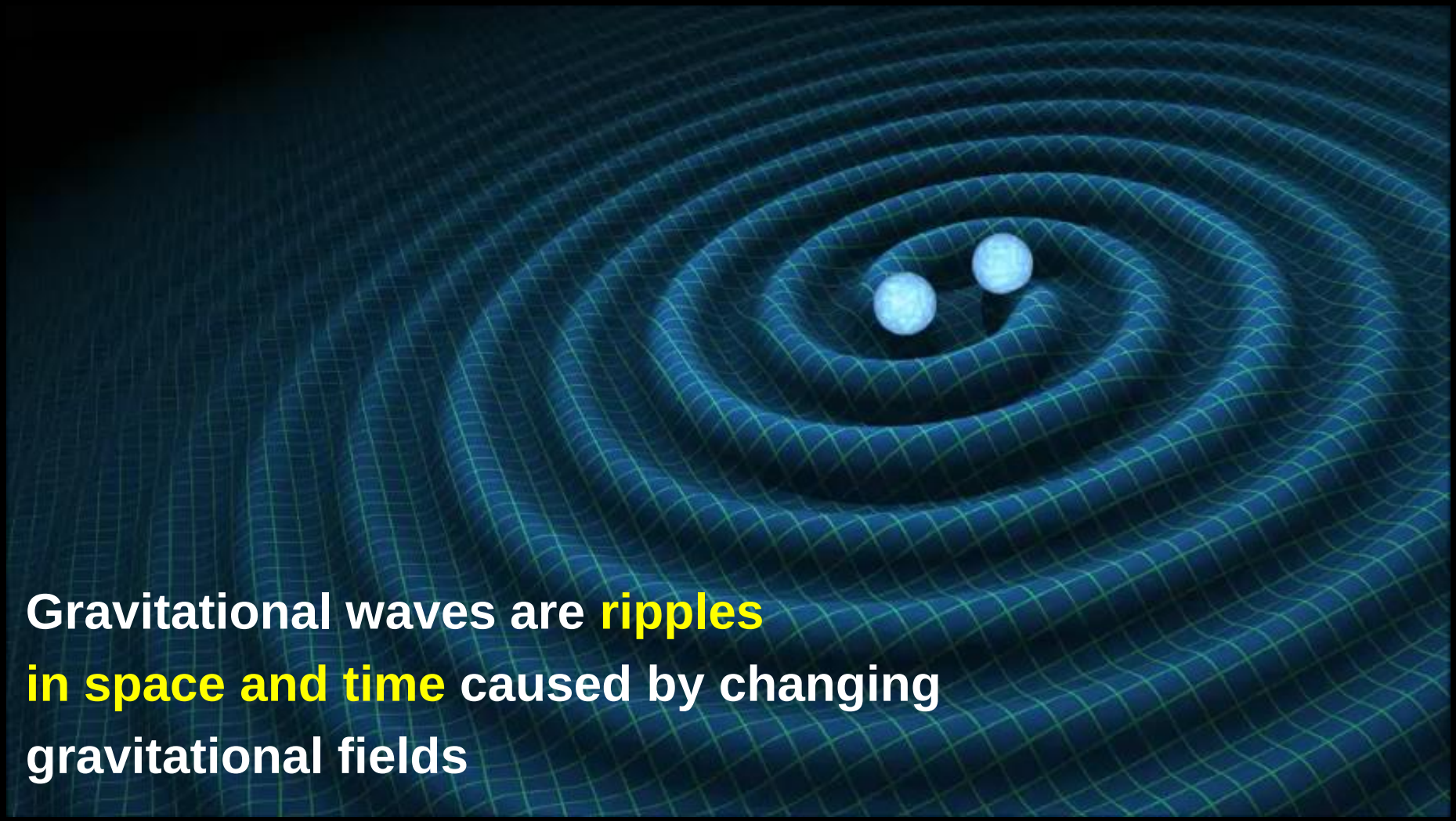


"Spacetime tells matter how to move, and matter tells spacetime how to curve"




Gravitational waves are ripples
in space and time caused by changing
gravitational fields

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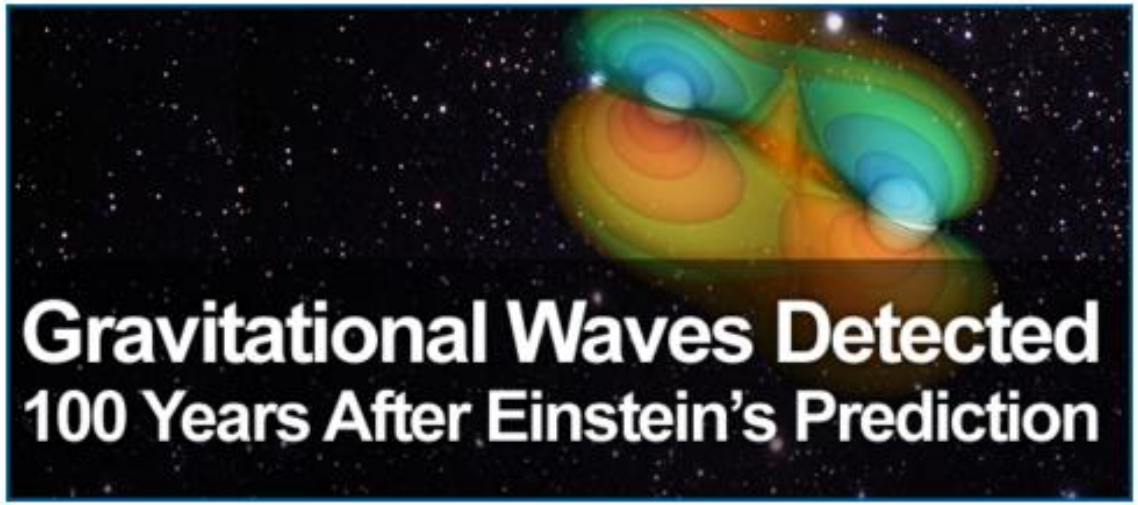


Gravitational Waves Detected
100 Years After Einstein's Prediction

"LIGO, the Path to Detection": Watch the trailer for this new film.

NEWS

Feb 24, 2016 LIGO members to testify on the discovery at US Congress

Feb 17, 2016 LIGO-India approved

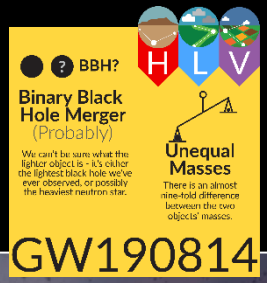
Feb 12, 2016 White House Congratulates the LIGO Team

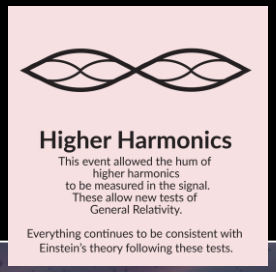
PRESS RELEASE

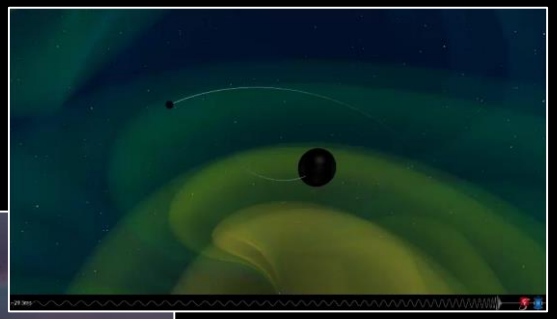
Feb 11, 2016
Gravitational Waves Detected 100 Years After Einstein's Prediction

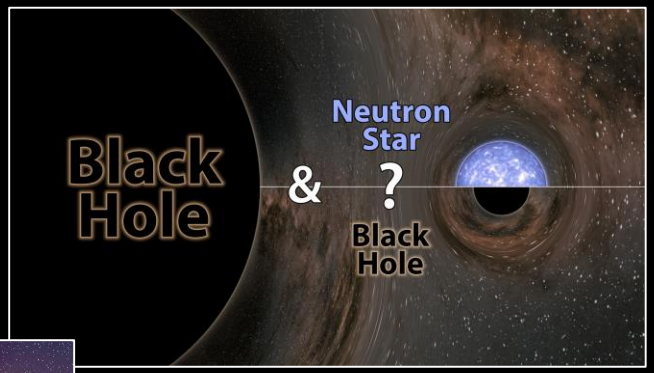
More at the LIGO Lab website

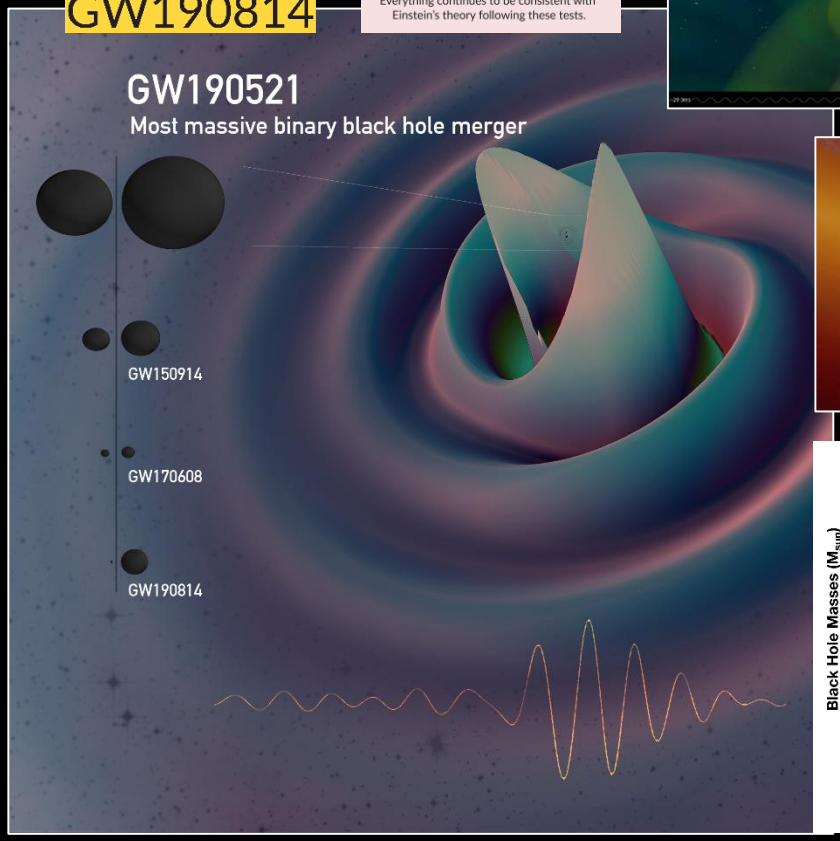
"LIGO Generations": Four generations of scientists working toward one goal. Watch

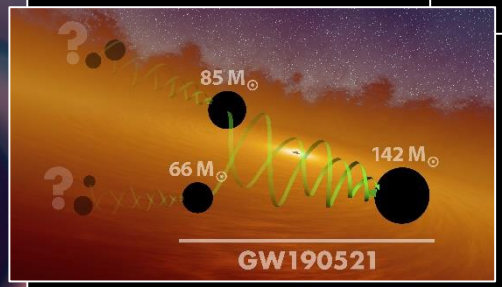

BBH?
Binary Black Hole Merger
(Probably)
We can't be sure what the lighter object is - it's either the lightest black hole we've ever observed, or possibly the heaviest neutron star.
Unequal Masses
There is an almost nine-fold difference between the two objects' masses.
GW190814

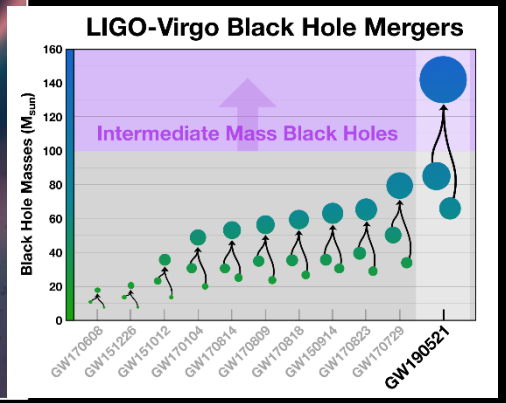

Higher Harmonics
This event allowed the hum of higher harmonics to be measured in the signal. These allow new tests of General Relativity.
Everything continues to be consistent with Einstein's theory following these tests.

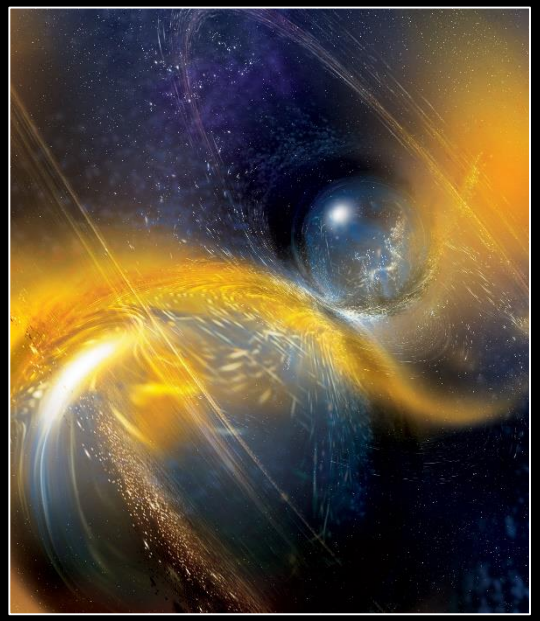



Black Hole
&
Neutron Star
?
Black Hole


GW190521
Most massive binary black hole merger
GW150914
GW170608
GW190814

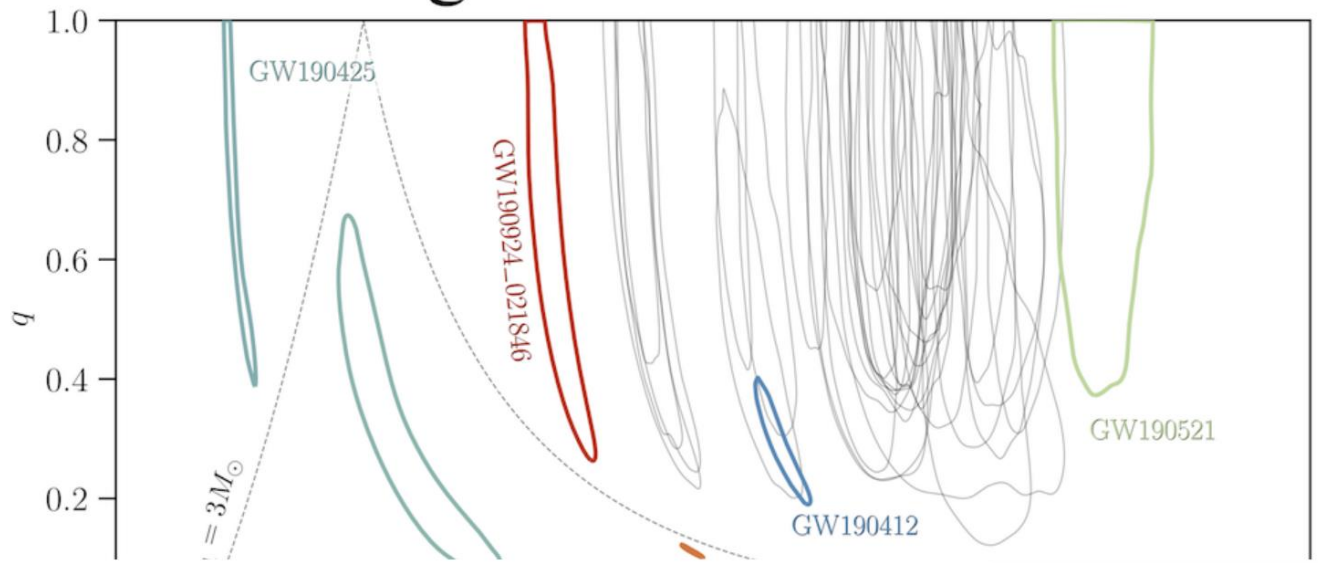

85 M⊙
66 M⊙
142 M⊙
GW190521

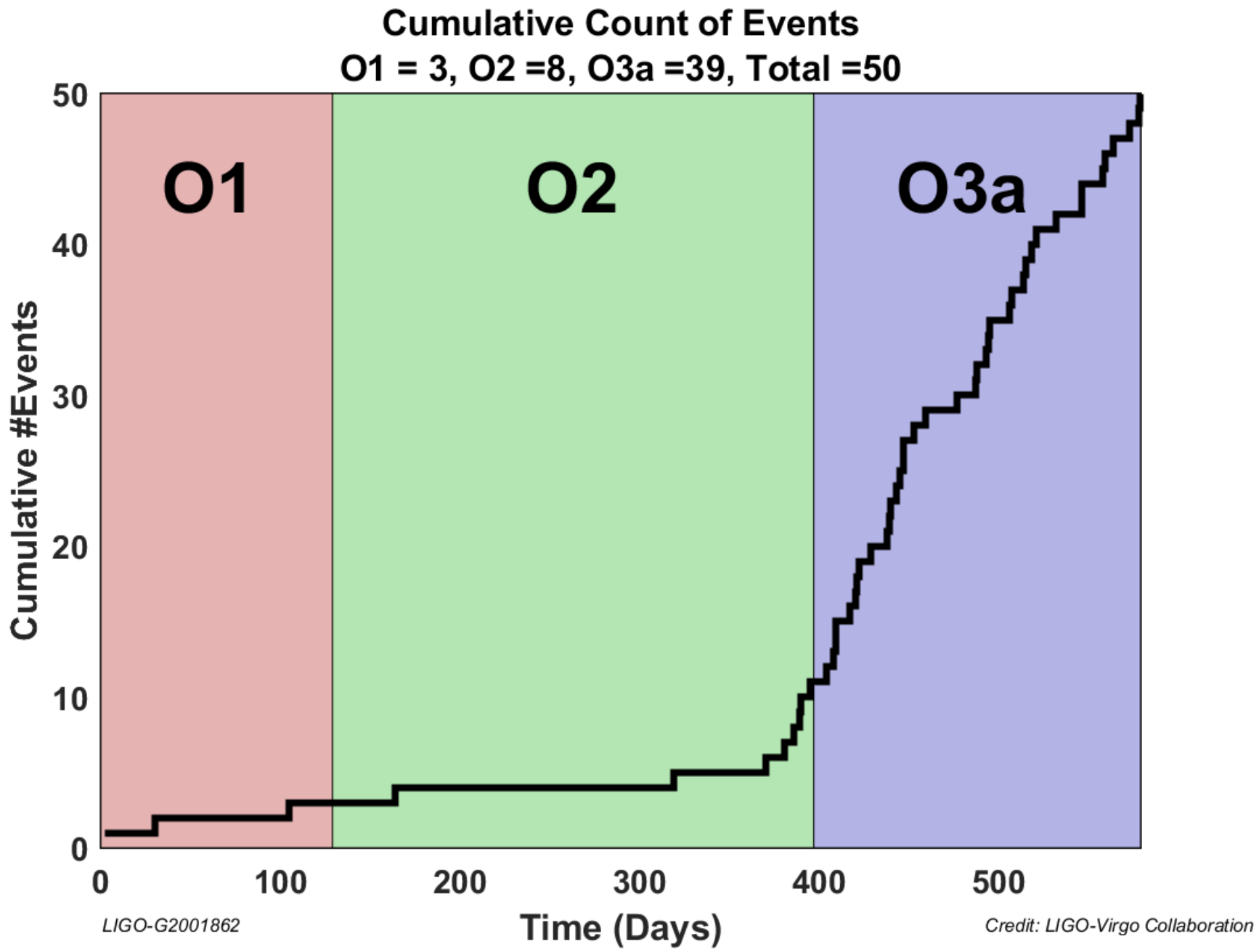

LIGO-Virgo Black Hole Mergers
Black Hole Masses (M_sun)
Intermediate Mass Black Holes
GW170608
GW151226
GW151012
GW170104
GW170814
GW170809
GW170818
GW150914
GW170823
GW170729
GW190521

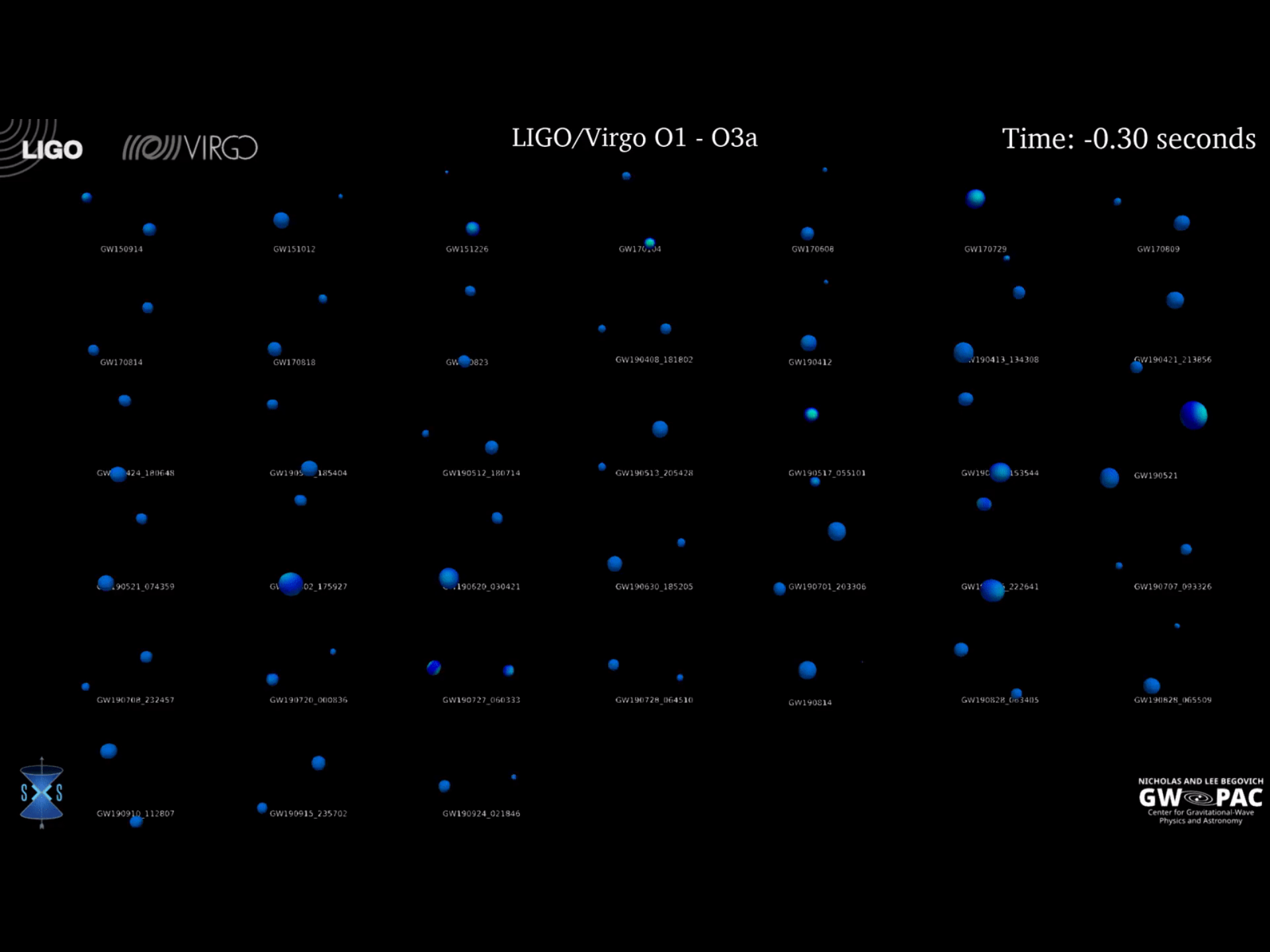


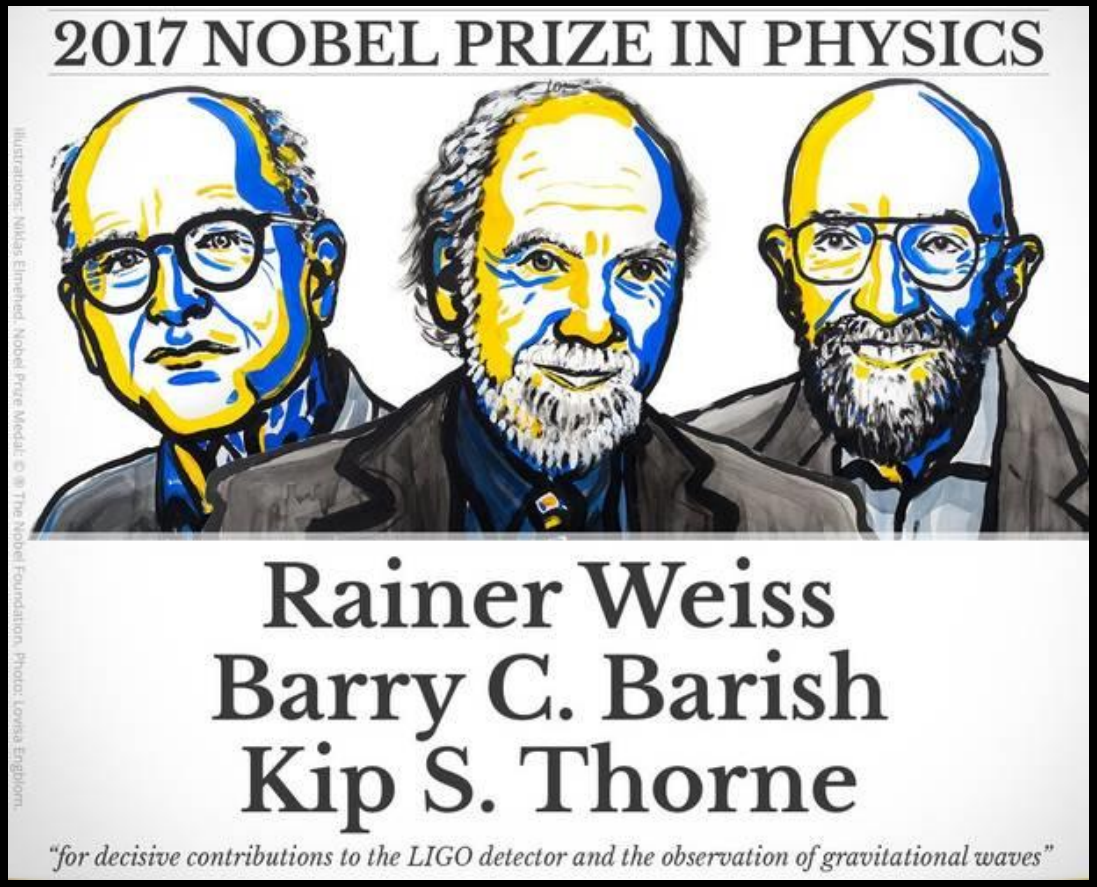
LSC LIGO Scientific Collaboration

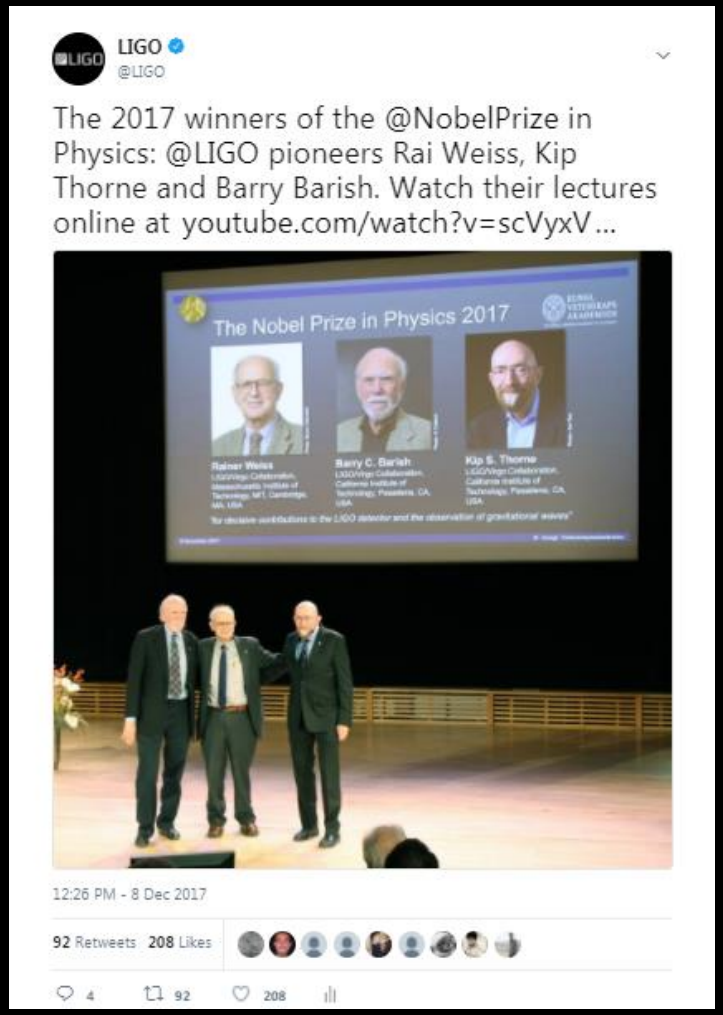
LIGO/Virgo release new catalog of gravitational-wave events



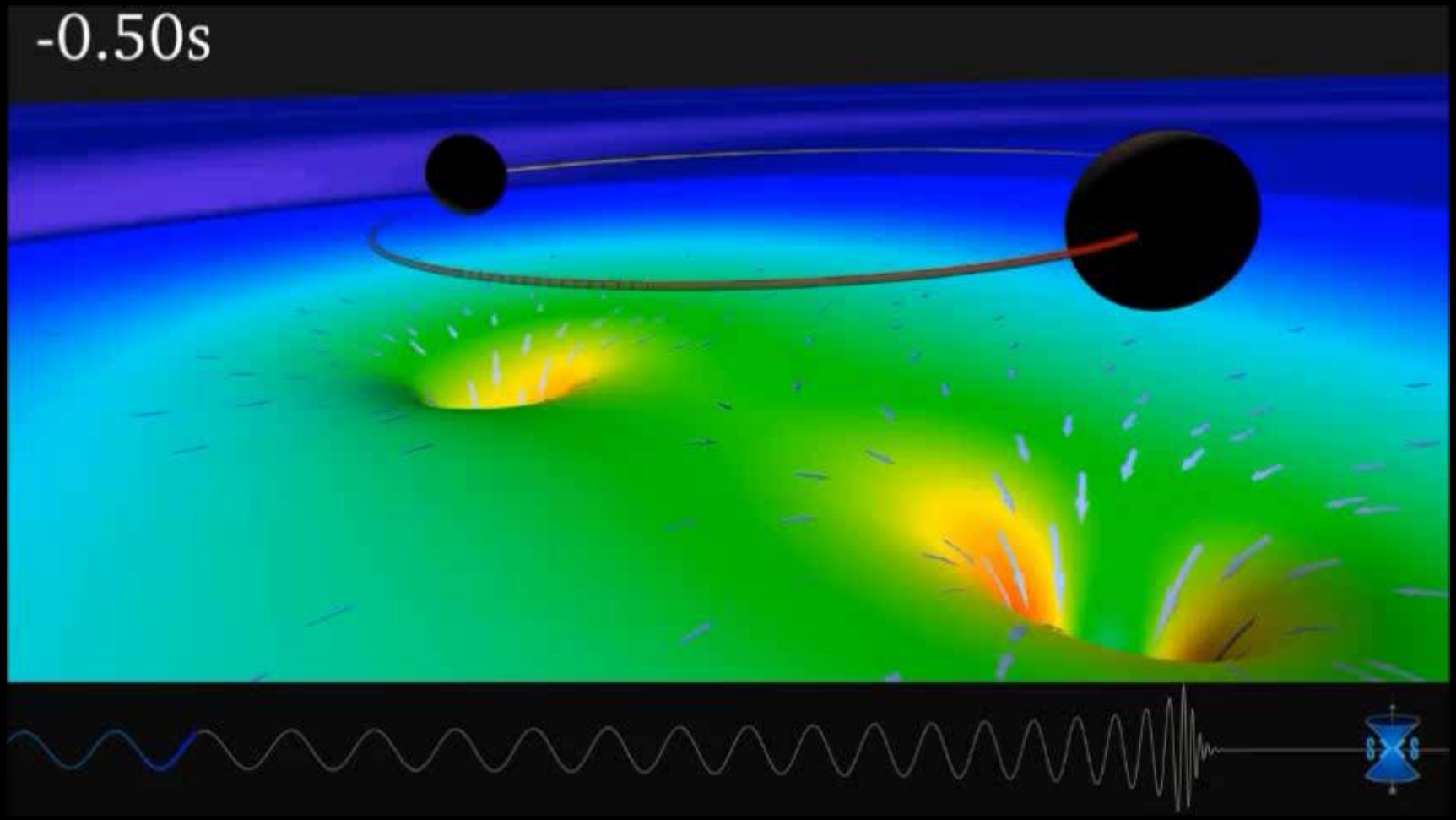

Cumulative Count of Events
O1 = 3, O2 =8, O3a =39, Total =50
O1
O2
O3a
Cumulative #Events
0
10
20
30
40
50
0
100
200
300
400
500
Time (Days)
LIGO-G2001862
Credit: LIGO-Virgo Collaboration

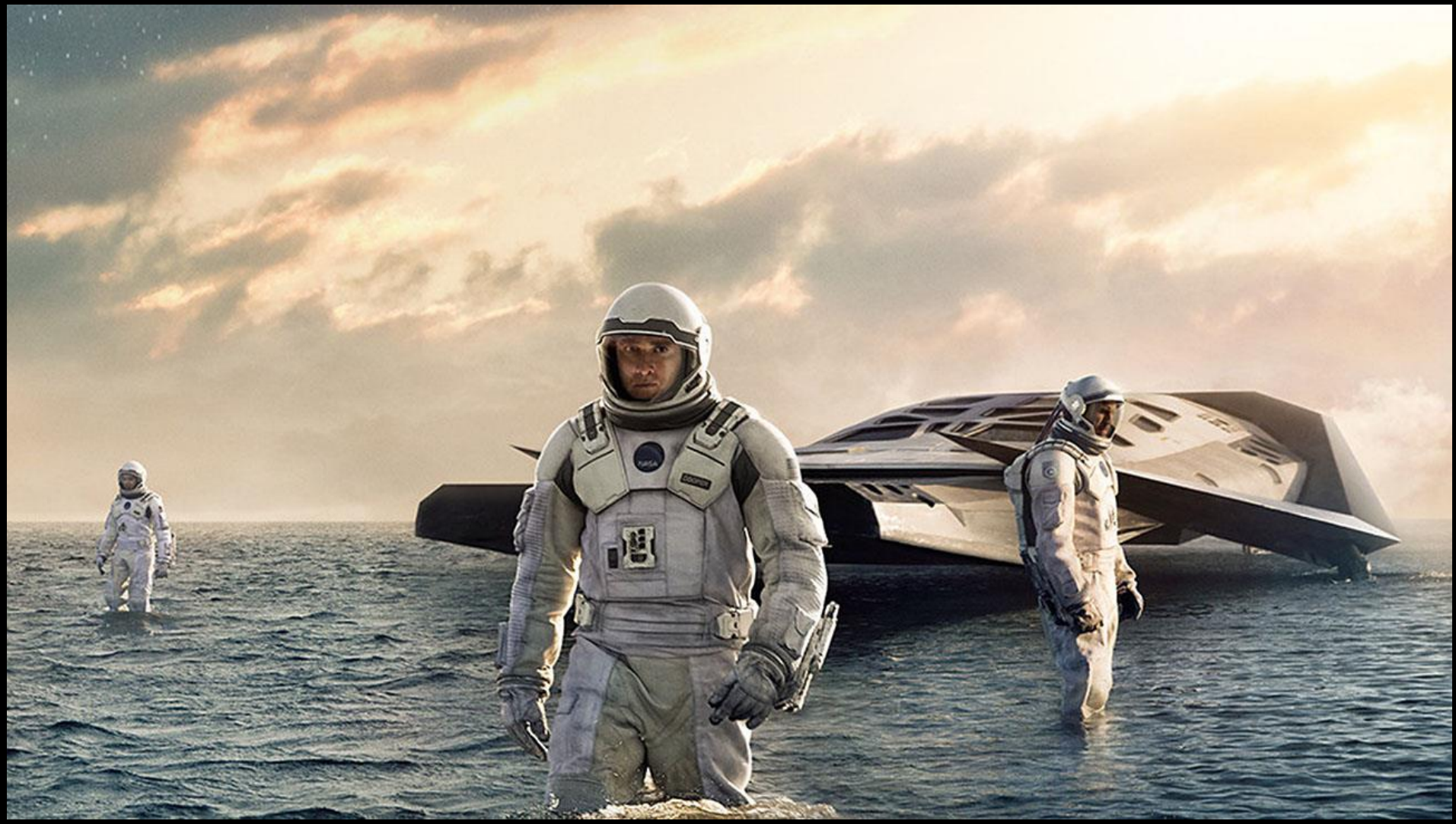

LIGO
VIRGO
LIGO/Virgo O1 - O3a
Time: -0.30 seconds
GW150914
GW151012
GW151226
GW170608
GW170729
GW170809
GW170814
GW170818
GW190408_181802
GW190412
GW190421_213856
GW190512_180714
GW190513_205428
GW190517_055101
GW190521
GW190630_185205
GW190701_203306
GW190707_093326
GW190708_232457
GW190720_000836
GW190727_060333
GW190728_064510
GW190814
GW190828_065509
GW190910_112807
GW190915_235702
GW190924_021846
NICHOLAS AND LEE BEGOVICH
GW PAC
Center for Gravitational-Wave
Physics and Astronomy

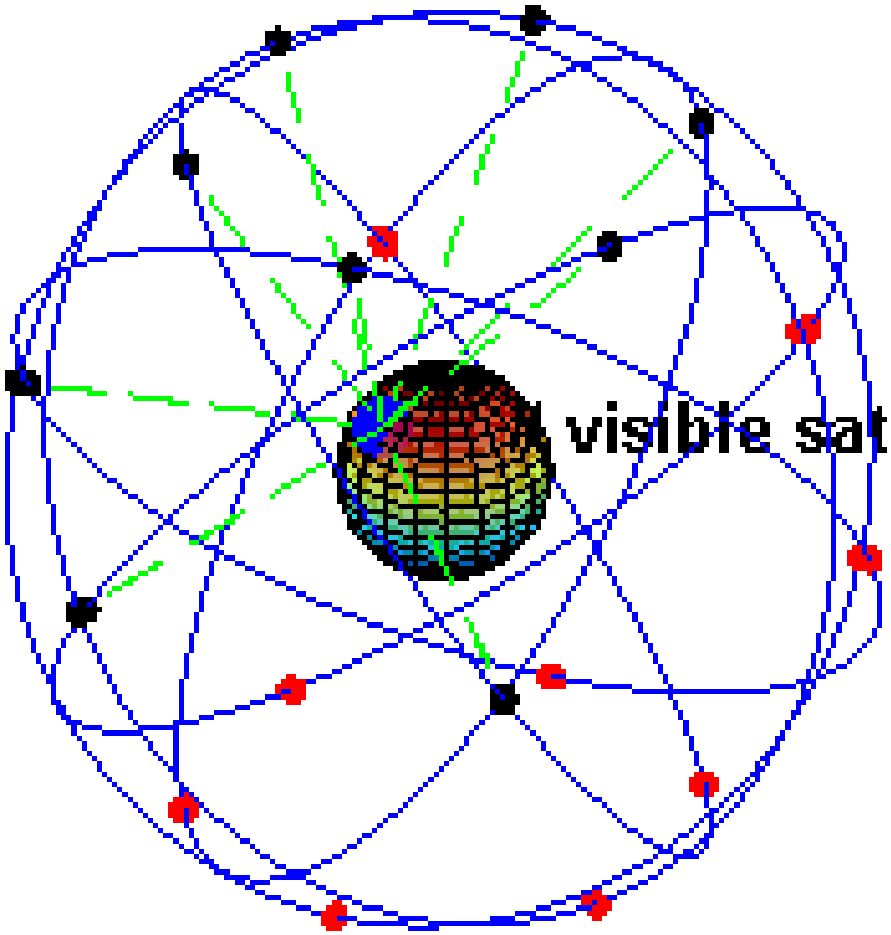

2017 NOBEL PRIZE IN PHYSICS
Rainer Weiss
Barry C. Barish
Kip S. Thorne
"for decisive contributions to the LIGO detector and the observation of gravitational waves"
Illustrations: Niklas Elmehed. Nobel Prize Medal: © The Nobel Foundation. Photo: Lovisa Engblom.


LIGO
@LIGO
The 2017 winners of the @NobelPrize in Physics: @LIGO pioneers Rai Weiss, Kip Thorne and Barry Barish. Watch their lectures online at youtube.com/watch?v=scVyxV...
The Nobel Prize in Physics 2017
Rainer Weiss
Barry C. Barish
Kip S. Thorne
12:26 PM - 8 Dec 2017
92 Retweets 208 Likes
4
92
208

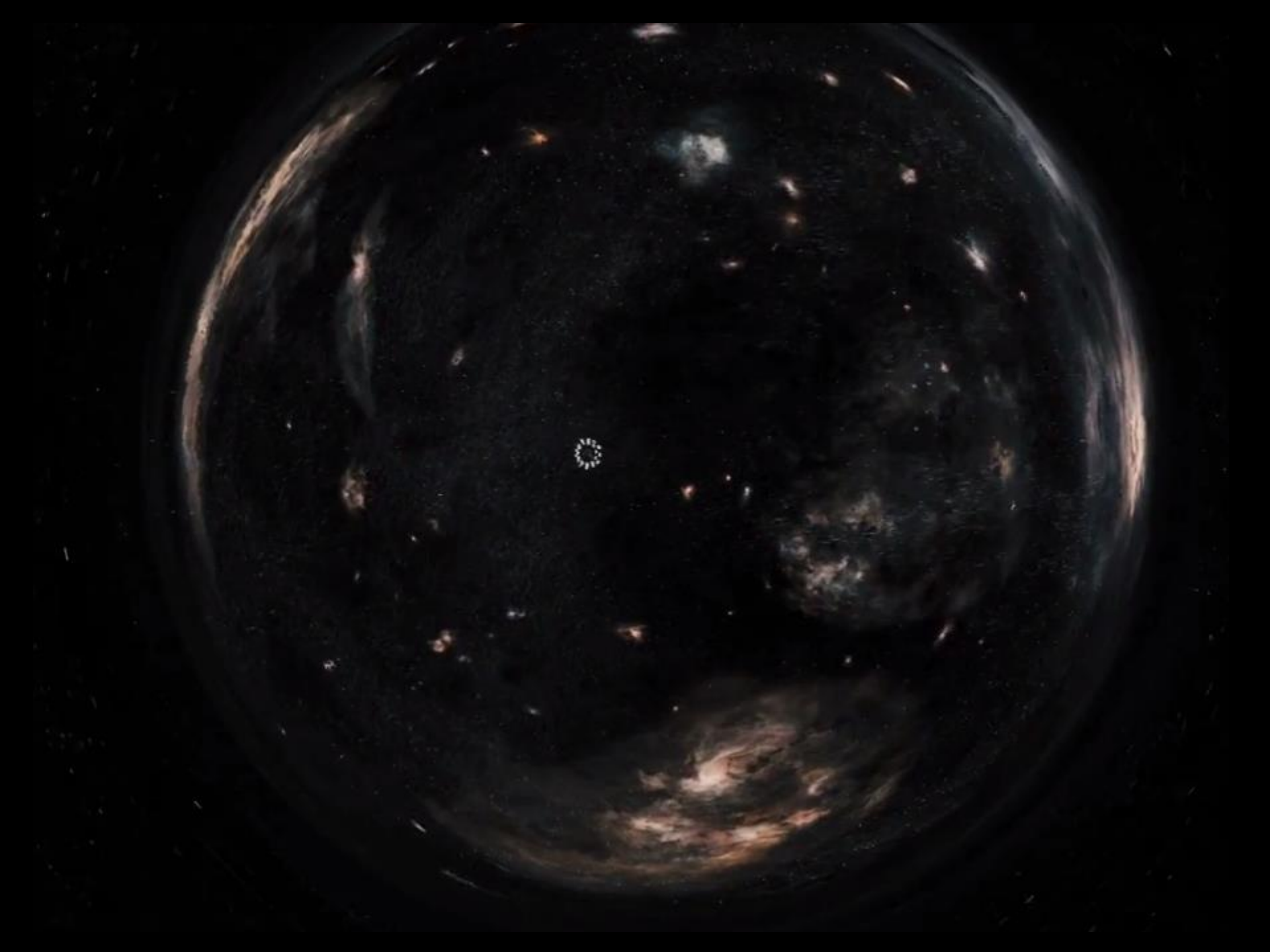
https://www.ligo.caltech.edu/video/ligo20160211v10

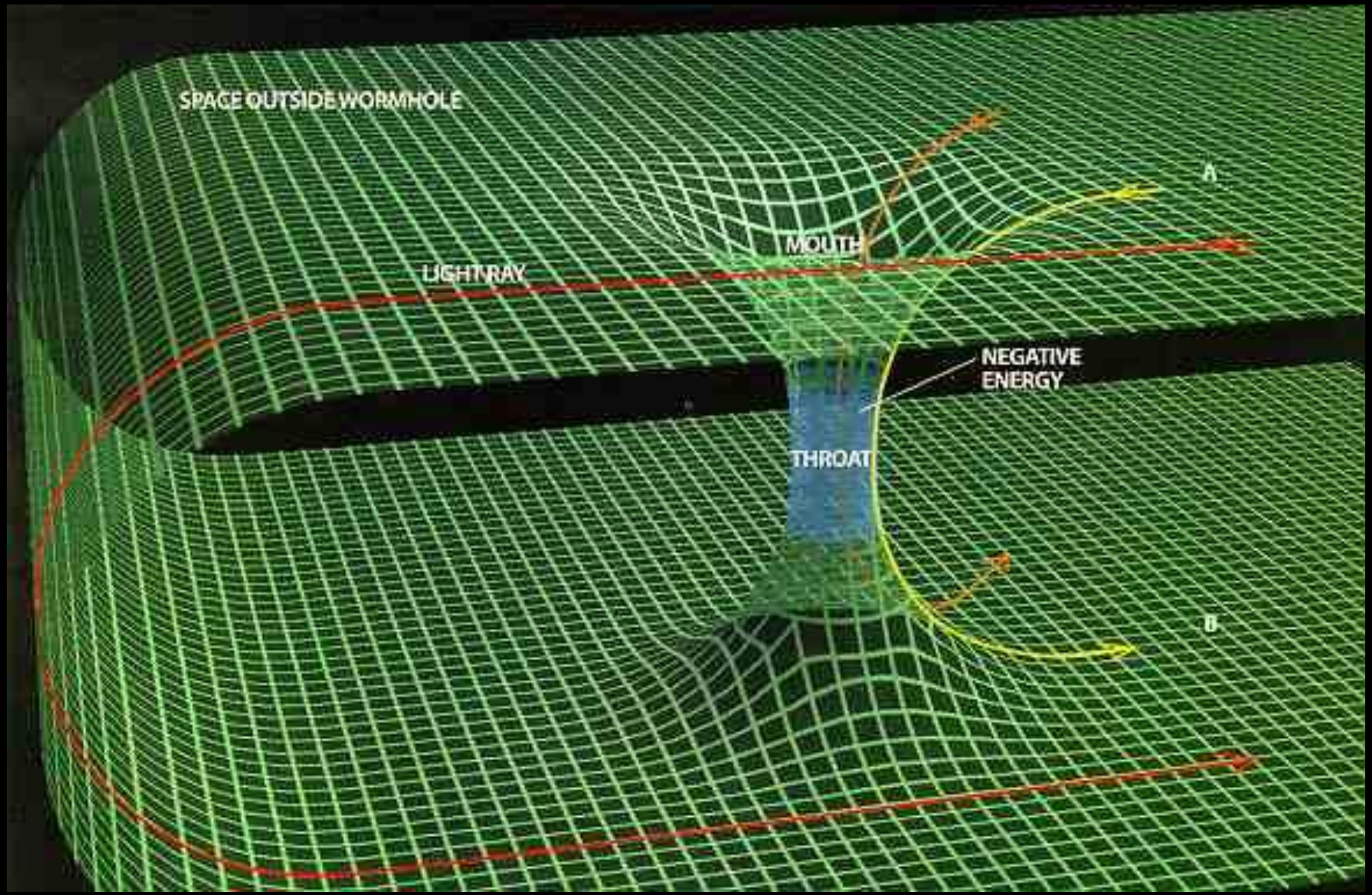


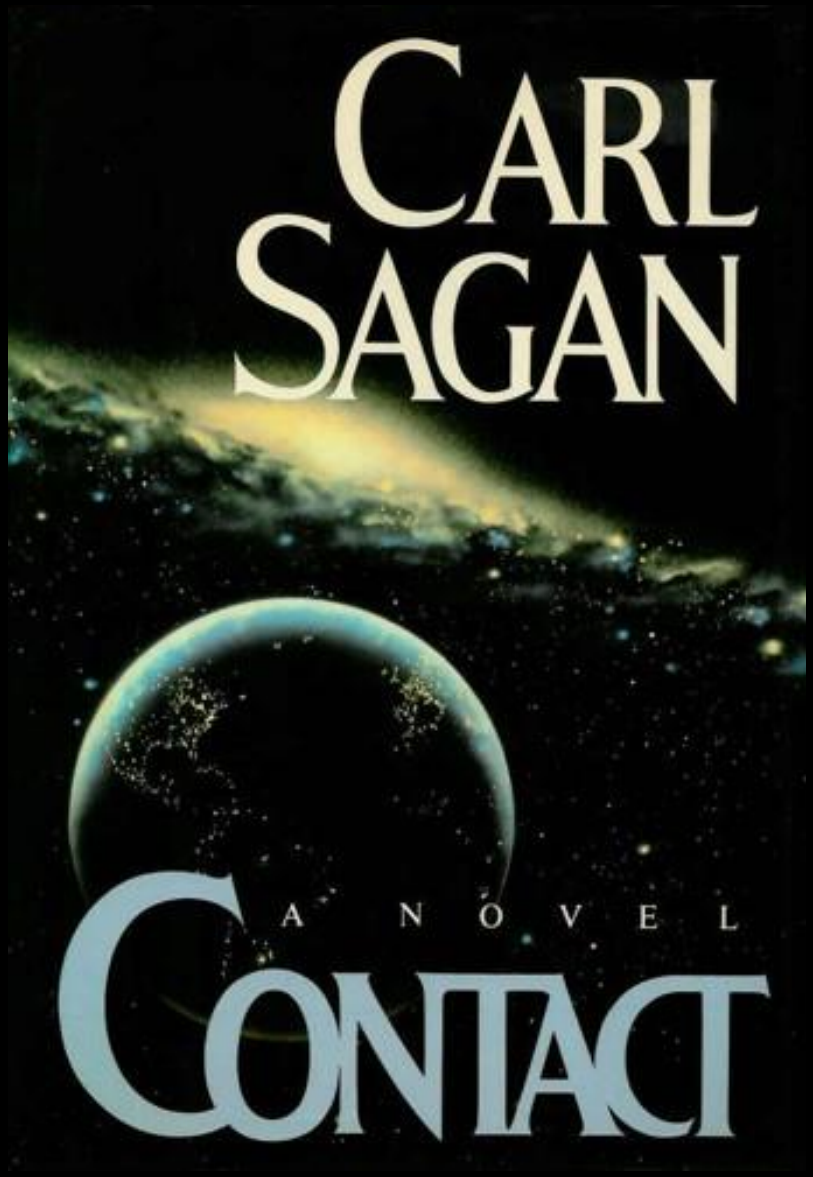


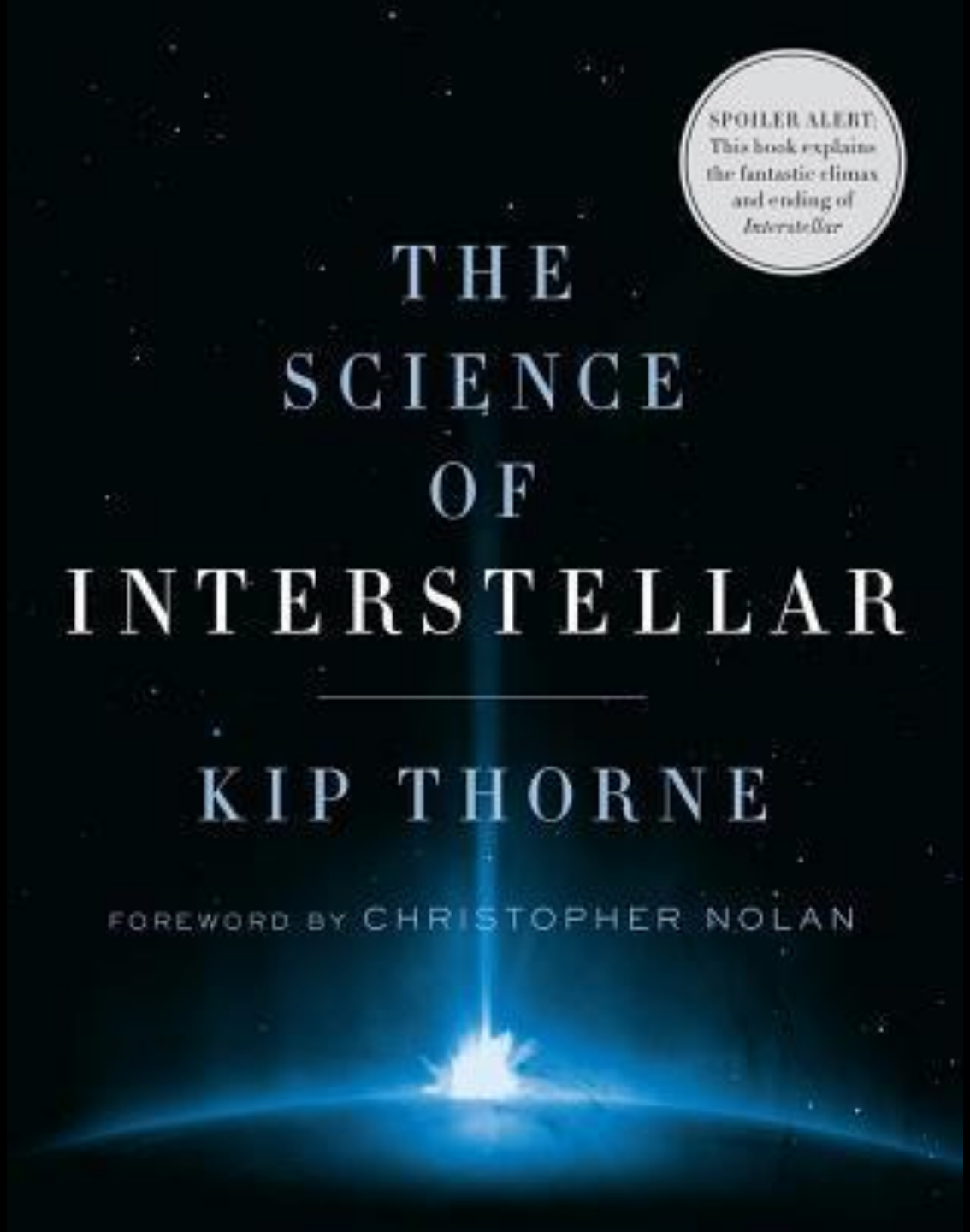

visible sat = 12


GPS



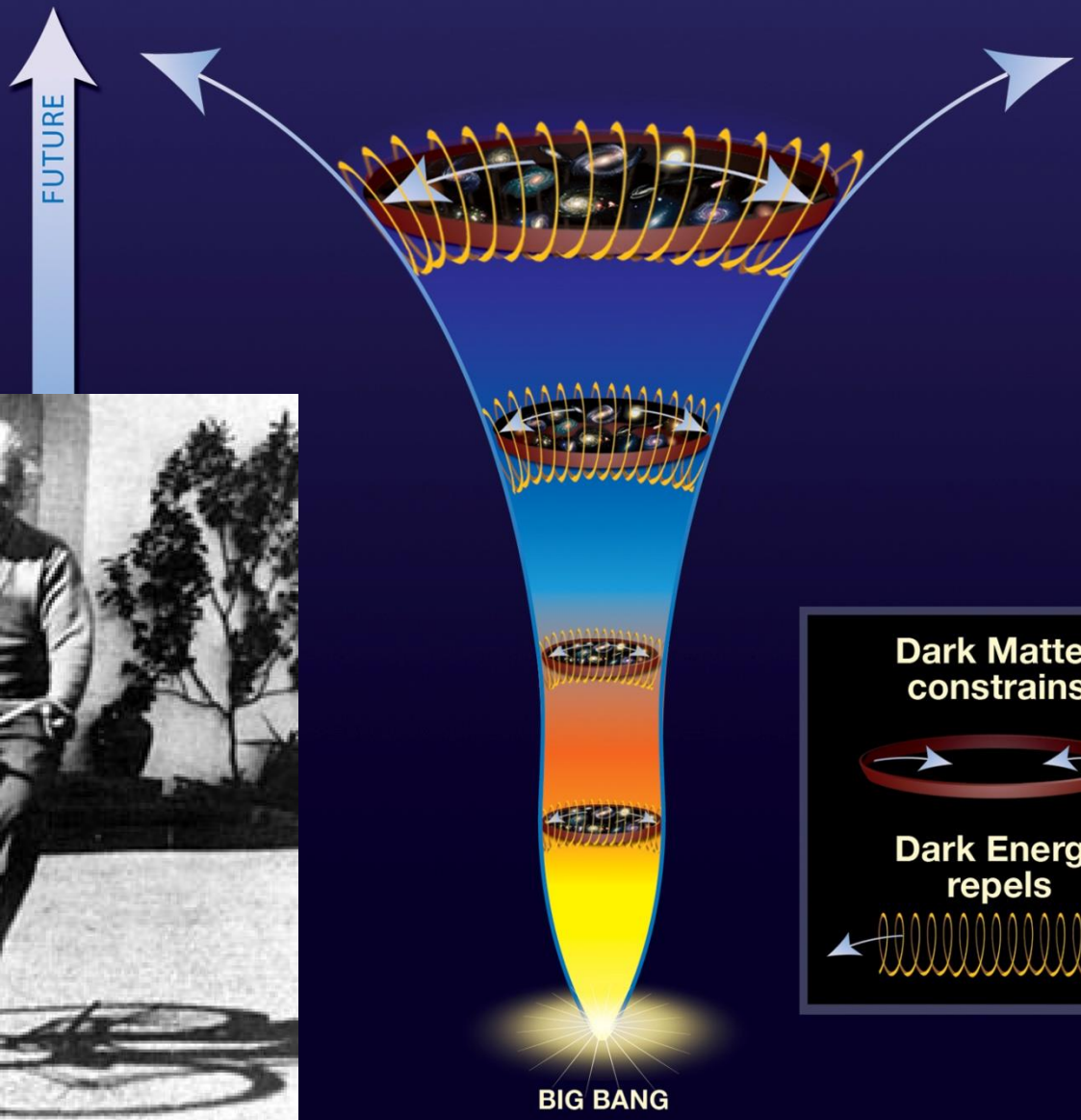

SPACE OUTSIDE WORMHOLE
A
MOUTH
LIGHT RAY
NEGATIVE ENERGY
THROAT
B


CARL
SAGAN
A NOVEL
CONTACT


SPOILER ALERT:
This book explains the fantastic climax and ending of *Interstellar*
THE SCIENCE OF INTERSTELLAR
KIP THORNE
FOREWORD BY CHRISTOPHER NOLAN

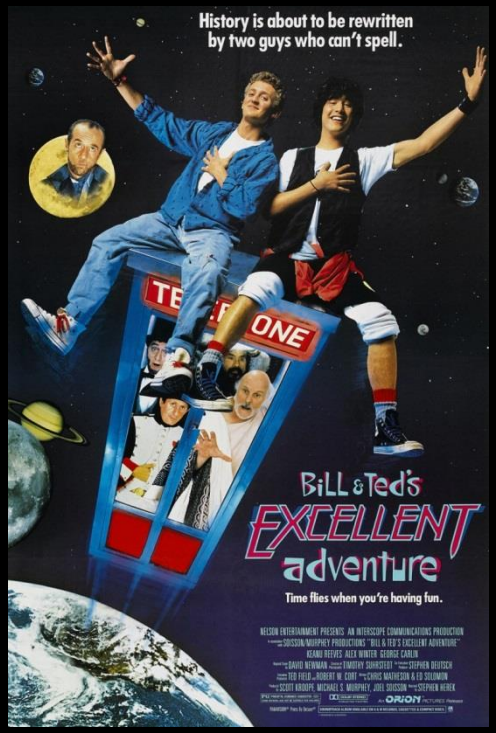
Cosmic tug of war

The force of dark energy surpasses that of dark matter as time progresses.



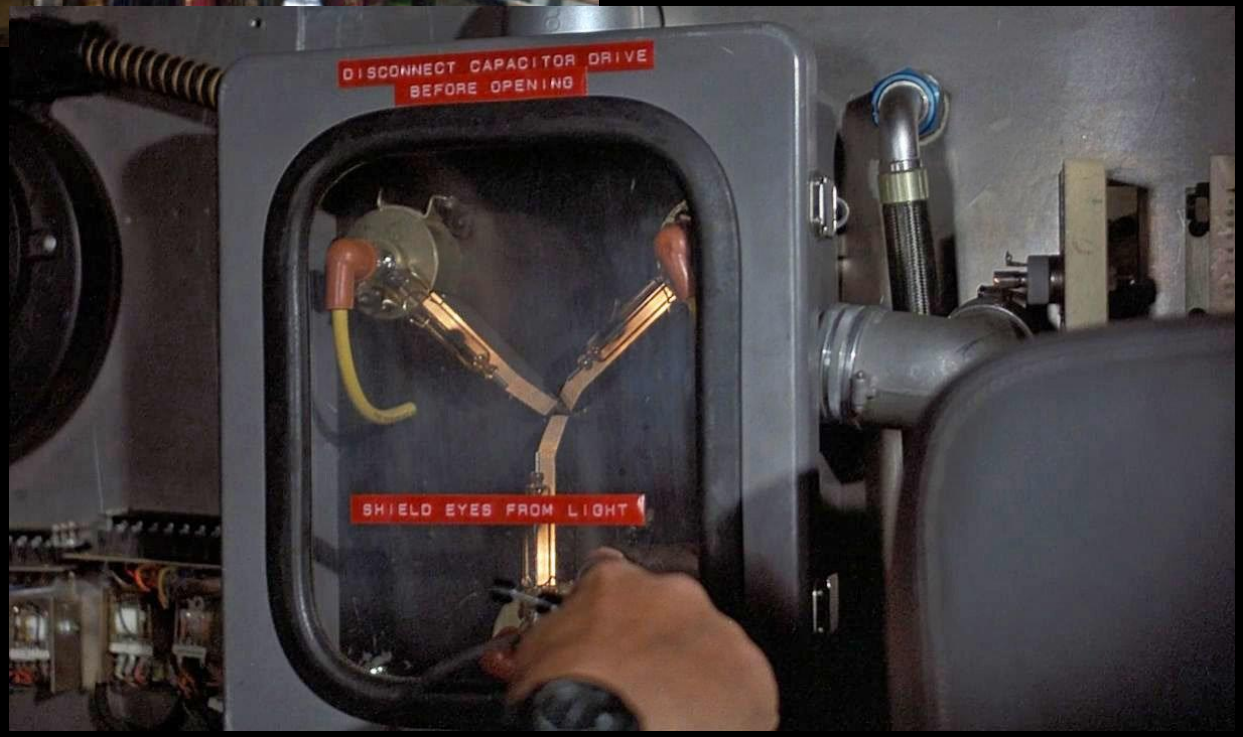

NASA


Eric Bana
Rachel McAdams
The Time Traveler's Wife
From The Acclaimed Bestseller


History is about to be rewritten
by two guys who can't spell.
Bill & Ted's
EXCELLENT
adventure
Time flies when you're having fun.


12 MONKEYS


BRUCE WILLIS
JOSEPH GORDON-LEVITT
EMILY BLUNT
LOOPER

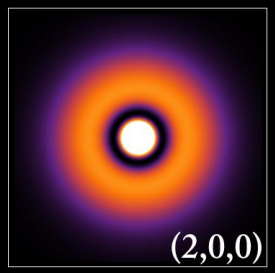

DISCONNECT CAPACITOR DRIVE
BEFORE OPENING
SHIELD EYES FROM LIGHT

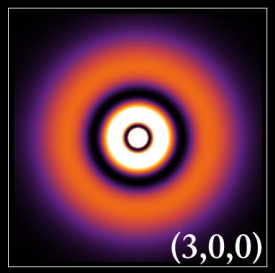

HWV 273X

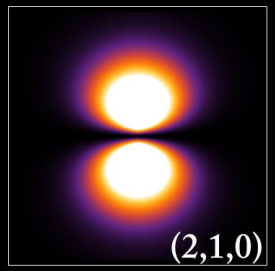
Hydrogen Wave Function

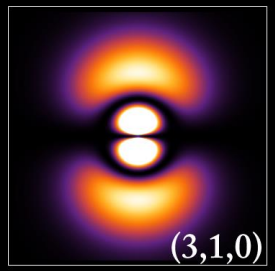
Probability density plots.

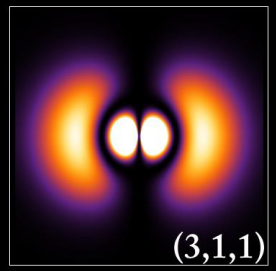
$$\psi_{nlm}(r,\vartheta,\varphi) = \sqrt{\left(\frac{2}{na_0}\right)^3 \frac{(n-l-1)!}{2n[(n+l)!]}} e^{-\rho/2} \rho^l L_{n-l-1}^{2l+1}(\rho) \cdot Y_{lm}(\vartheta,\varphi)$$

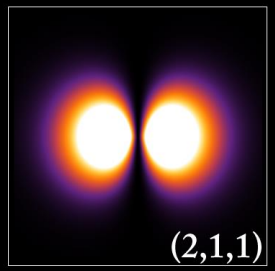


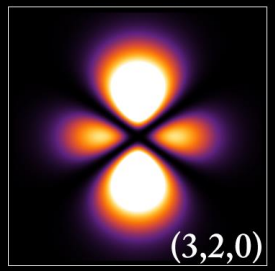


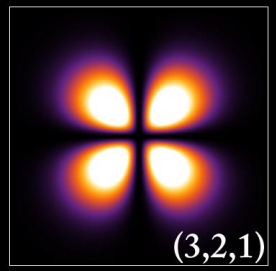


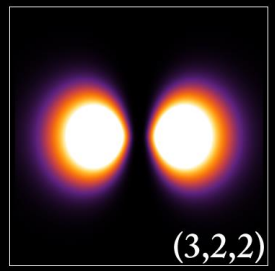


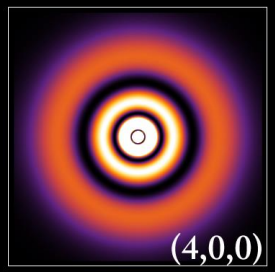


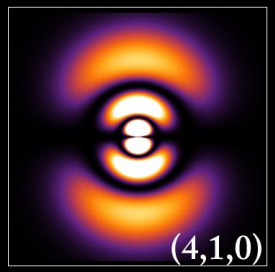


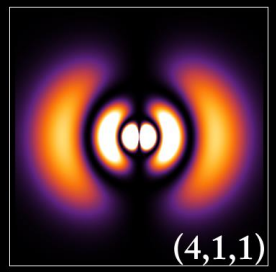


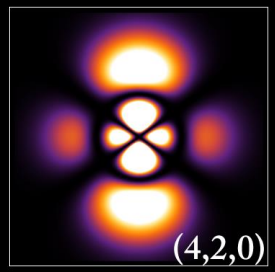


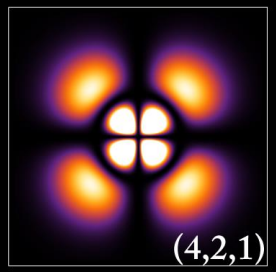


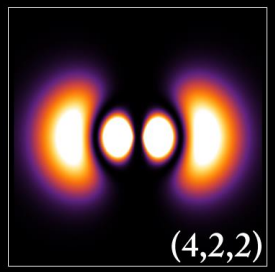


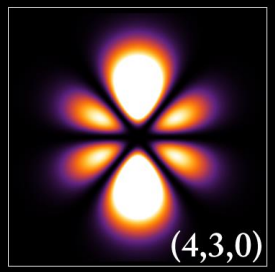


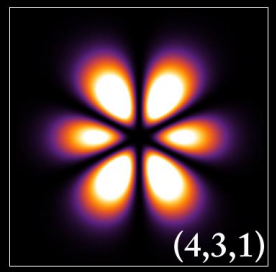


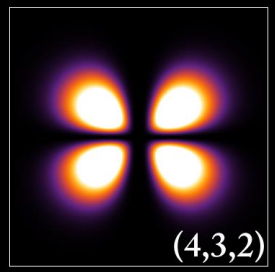


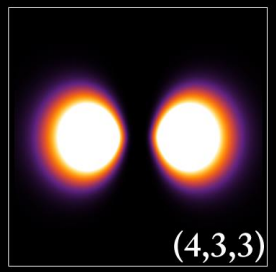












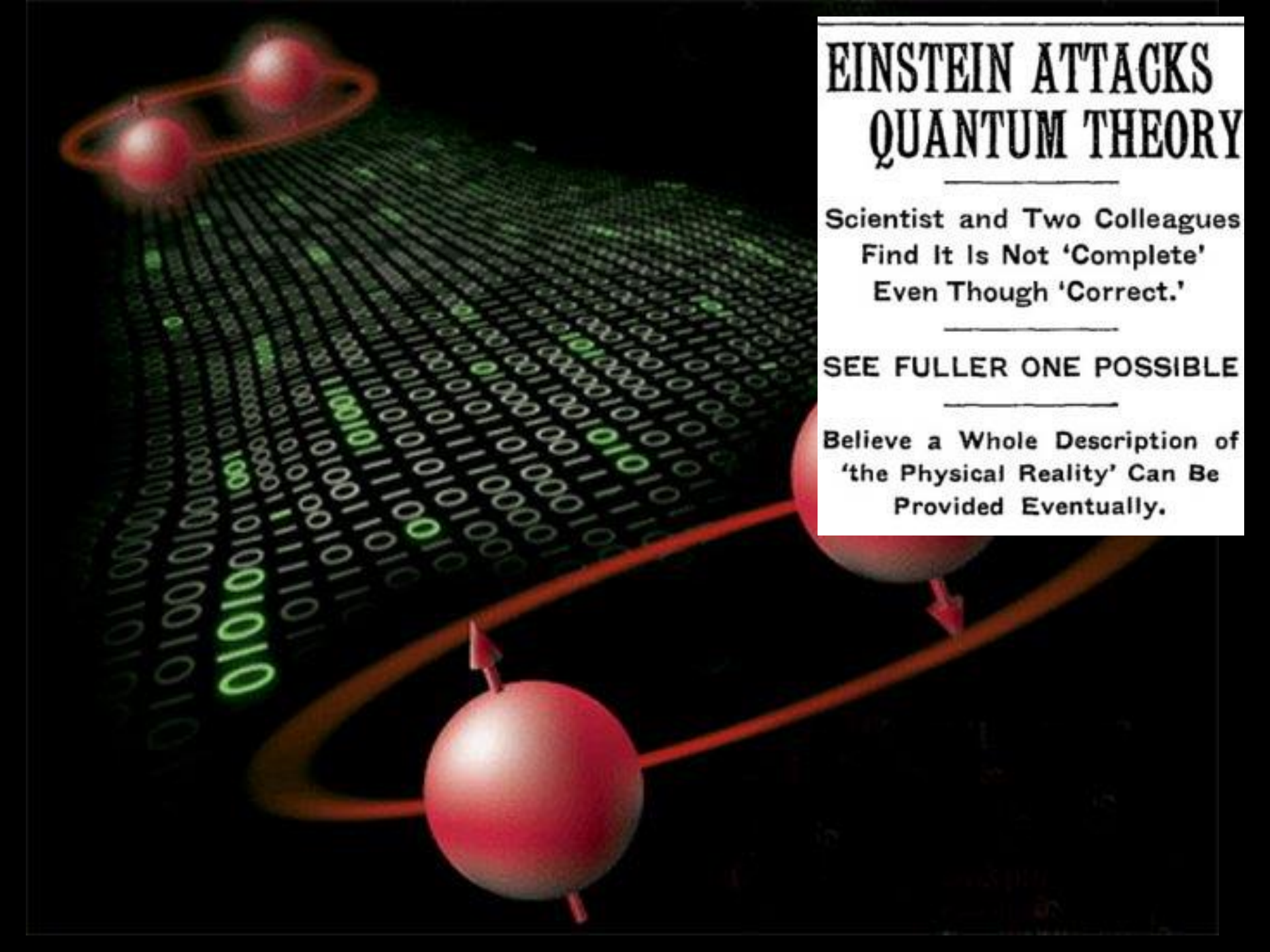

UNCERTAINTY - BY NANSCLARK
Do you know how fast you were going!?
No, but I know where I am.
Heisenberg
WWW.TOONDOO.COM

Heisenberg Uncertainty Principle

The precision of measurements in a quantum system is limited ***in principle***

$$\Delta p \Delta x \sim \hbar$$

Position and momentum are *complementary* properties: the action of measurement determines which of the two properties the quantum system possesses

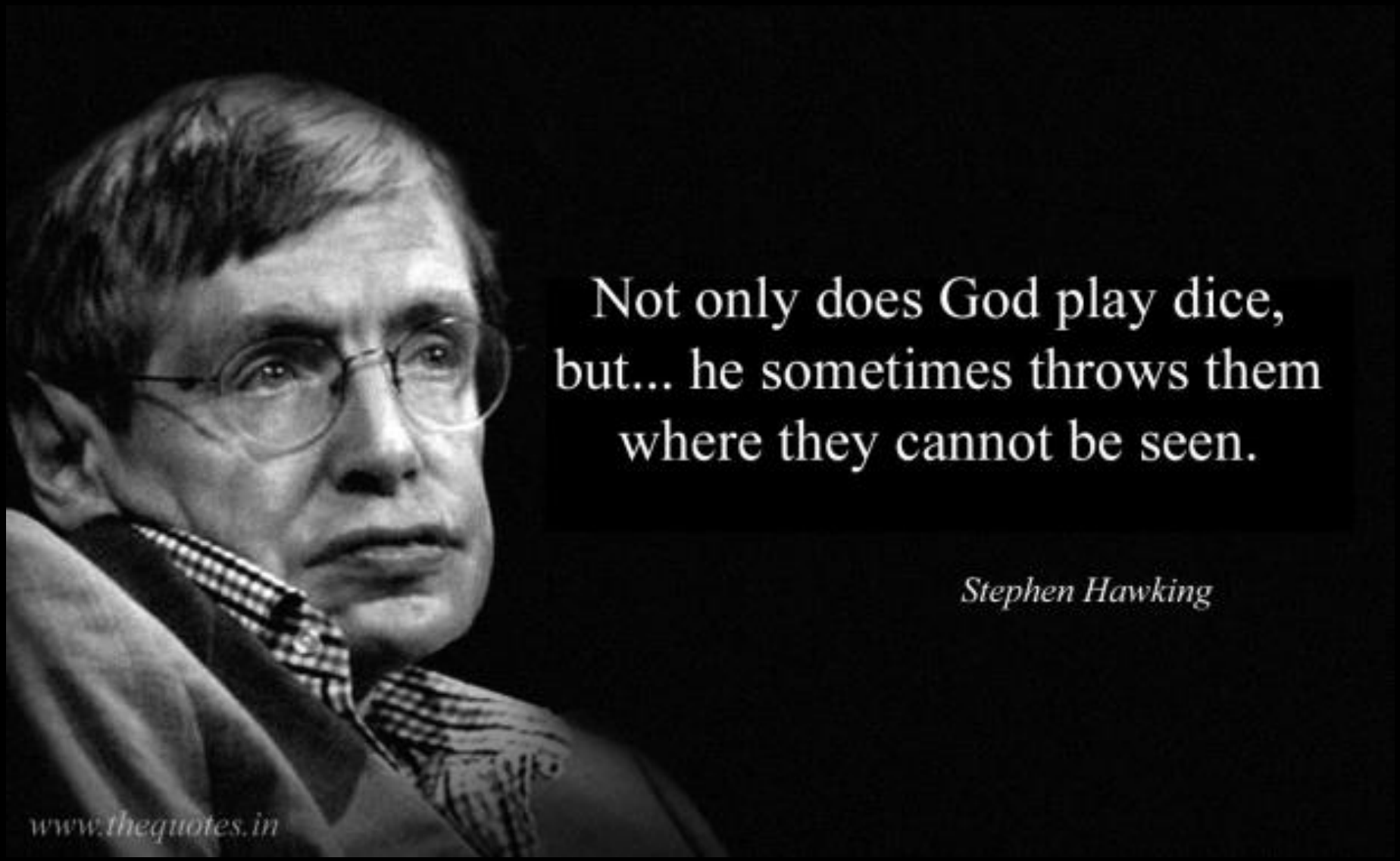


EINSTEIN ATTACKS QUANTUM THEORY

Scientist and Two Colleagues Find It Is Not 'Complete' Even Though 'Correct.'

SEE FULLER ONE POSSIBLE

Believe a Whole Description of 'the Physical Reality' Can Be Provided Eventually.


Not only does God play dice,
but... he sometimes throws them
where they cannot be seen.
Stephen Hawking
www.thequotes.in


TENET