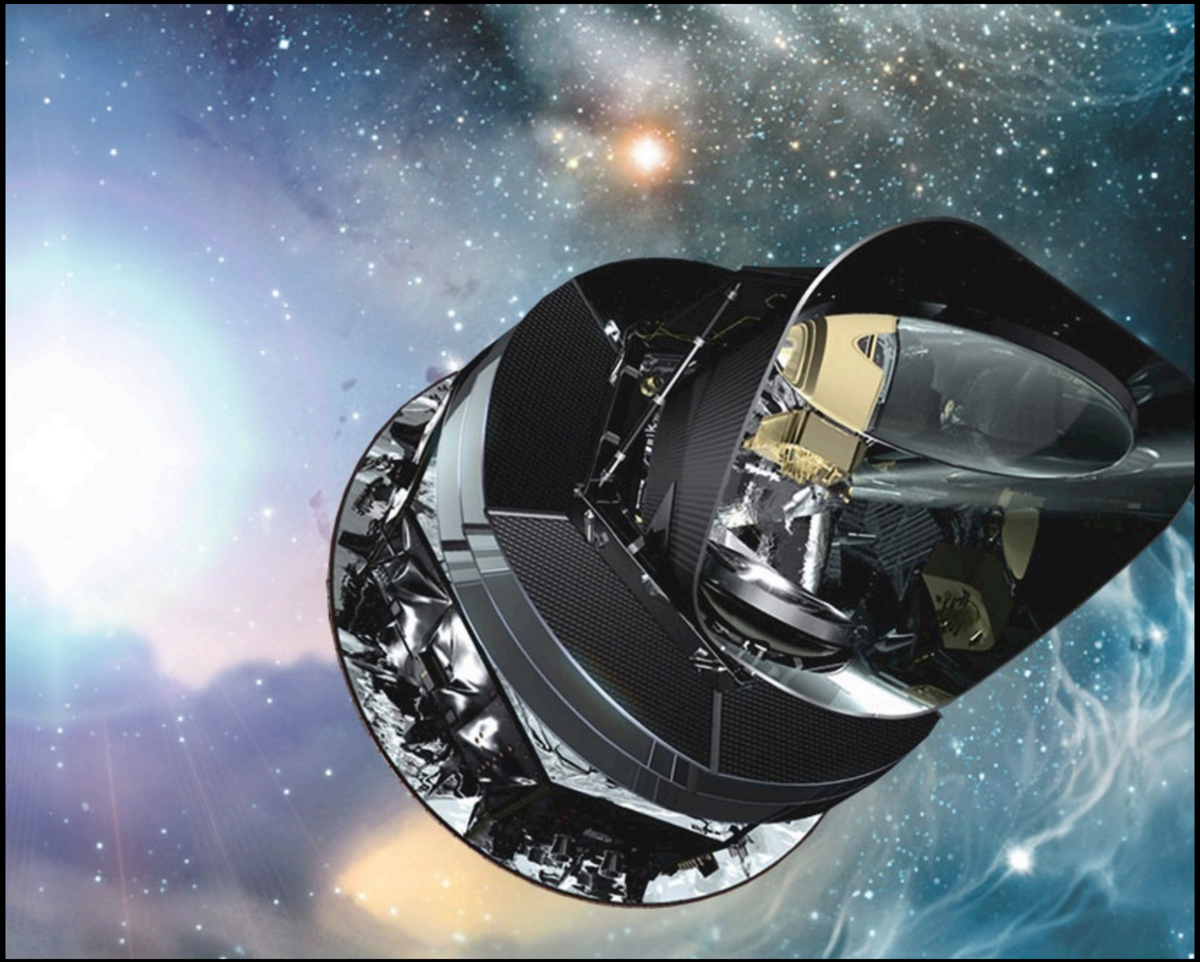
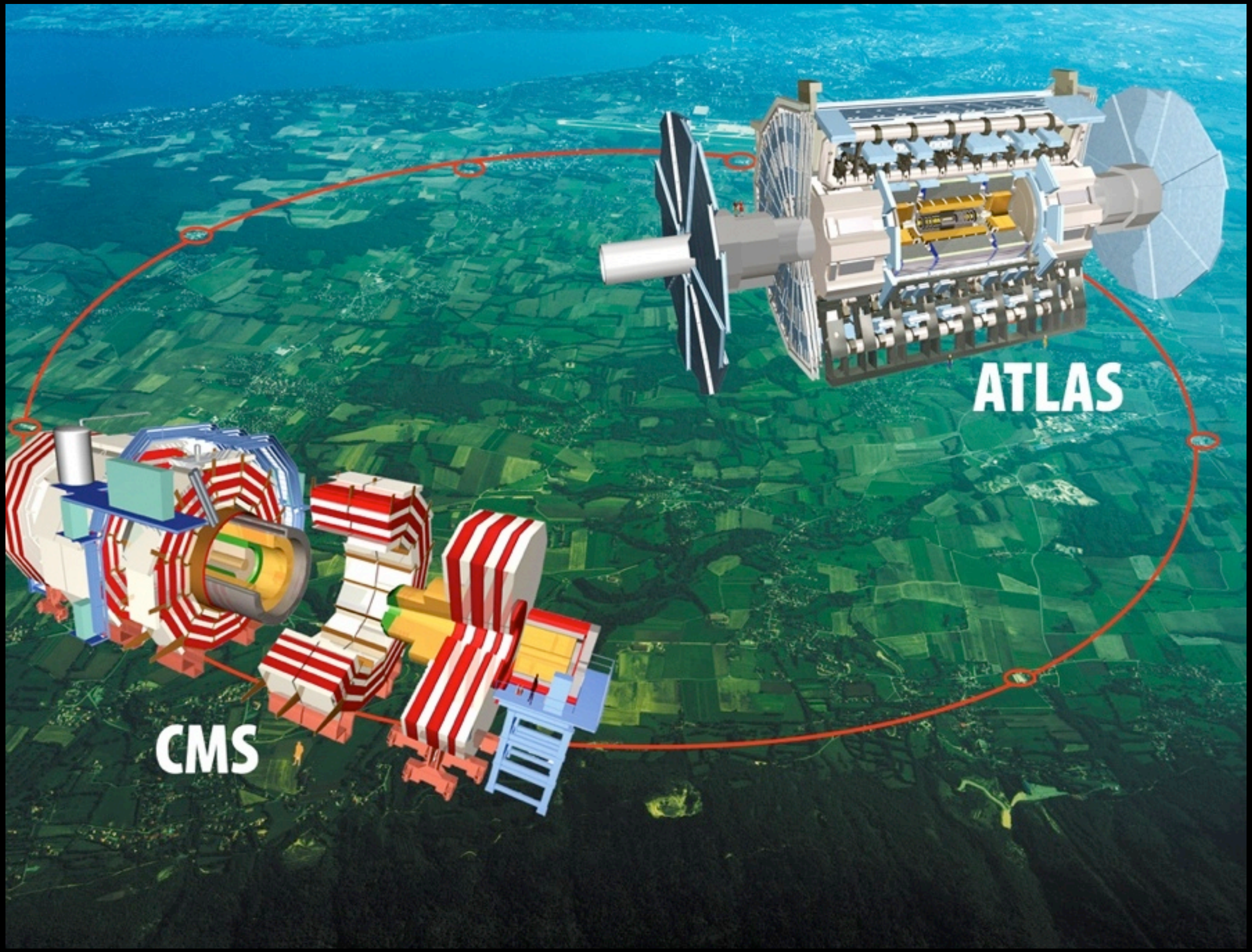

Thank you!

we live at a special moment in human history

most powerful telescope
ESA Planck satellite

most powerful microscope
Large Hadron Collider





most precise measurement of length
Advanced LIGO

LIGO Hanford

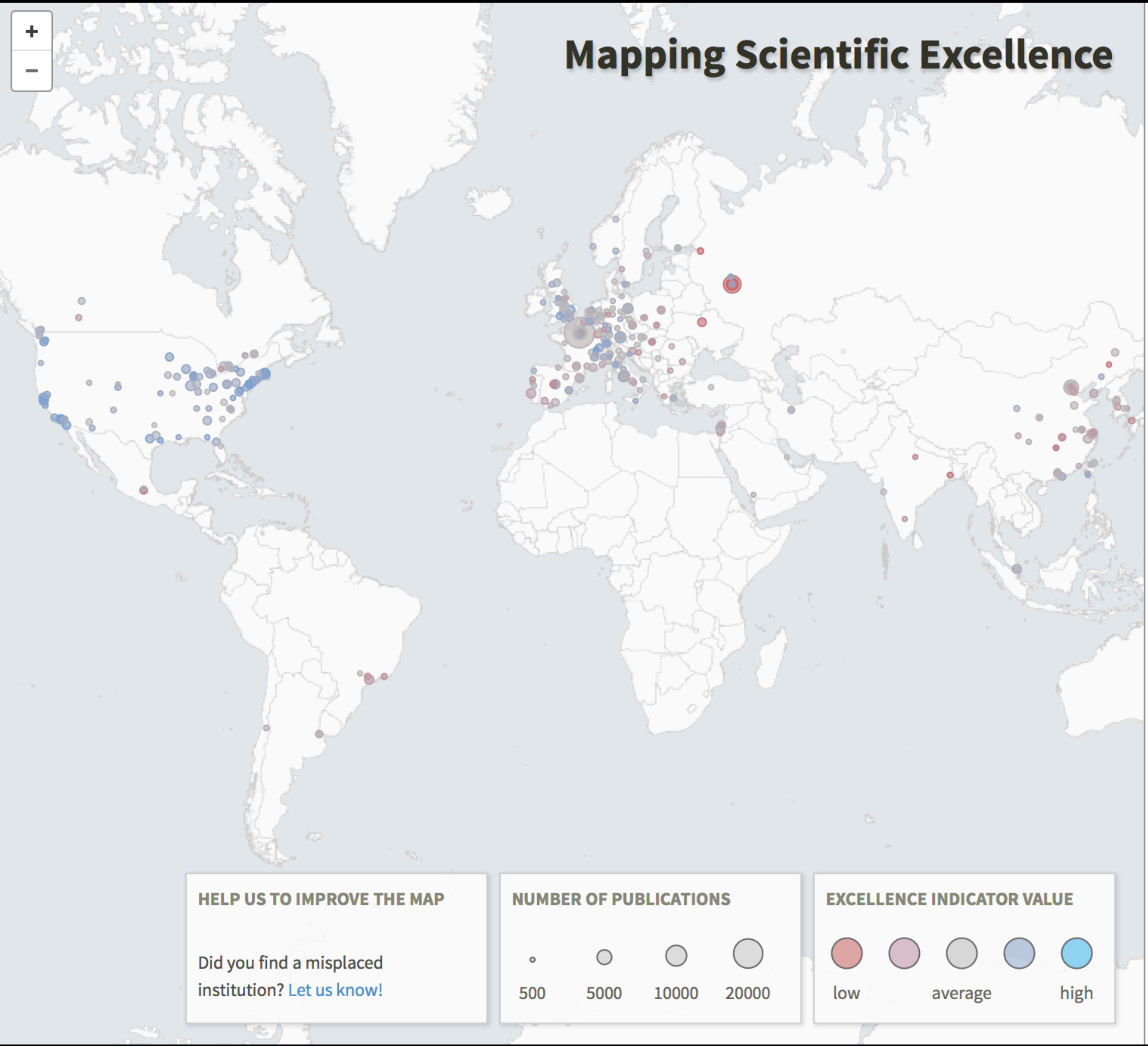
LIGO Livingstone

we need to take care of
our people and our planet


1 NO POVERTY
2 NO HUNGER
3 GOOD HEALTH
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 RENEWABLE ENERGY
8 GOOD JOBS AND ECONOMIC GROWTH
9 INNOVATION AND INFRASTRUCTURE
010
011
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE AND JUSTICE
17 PARTNERSHIPS FOR THE GOALS
THE GLOBAL GOALS
For Sustainable Development

by 2050, 40 % of the world's youth will be African

Mapping Scientific Excellence



This web application visualizes scientific excellence worldwide in 17 subject areas. For each institution (university or research-focused institution), the estimated probabilities of (i) publishing highly cited papers (Best Paper Rate) or (ii) publishing in the most influential journals (Best Journal Rate) are shown. Both probabilities, which can be adjusted by covariates, range from blue (high probability) through grey (average) to red (low probability) at a circle. The circle size corresponds to the institutional number of papers.

→ More information

2005 - 2009 | 2006 - 2010 | **2007 - 2011**

SUBJECT AREA

Mathematics

COVARIATE

- none -

EXCELLENCE INDICATORS

Best Paper Rate | Best Journal Rate

SIGNIFICANCE

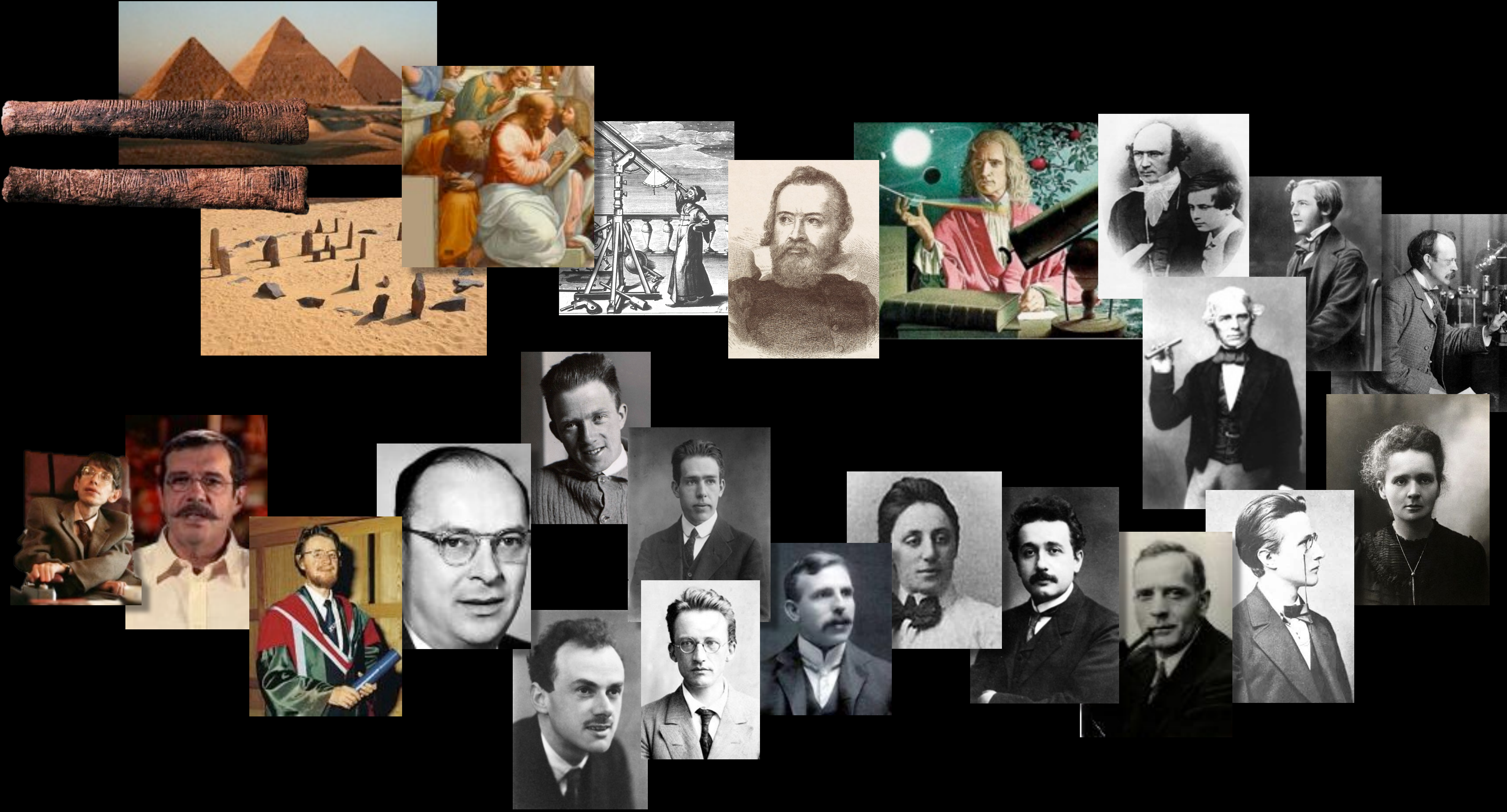
☐ Show statistically significant results only

INSTITUTIONAL SCORES

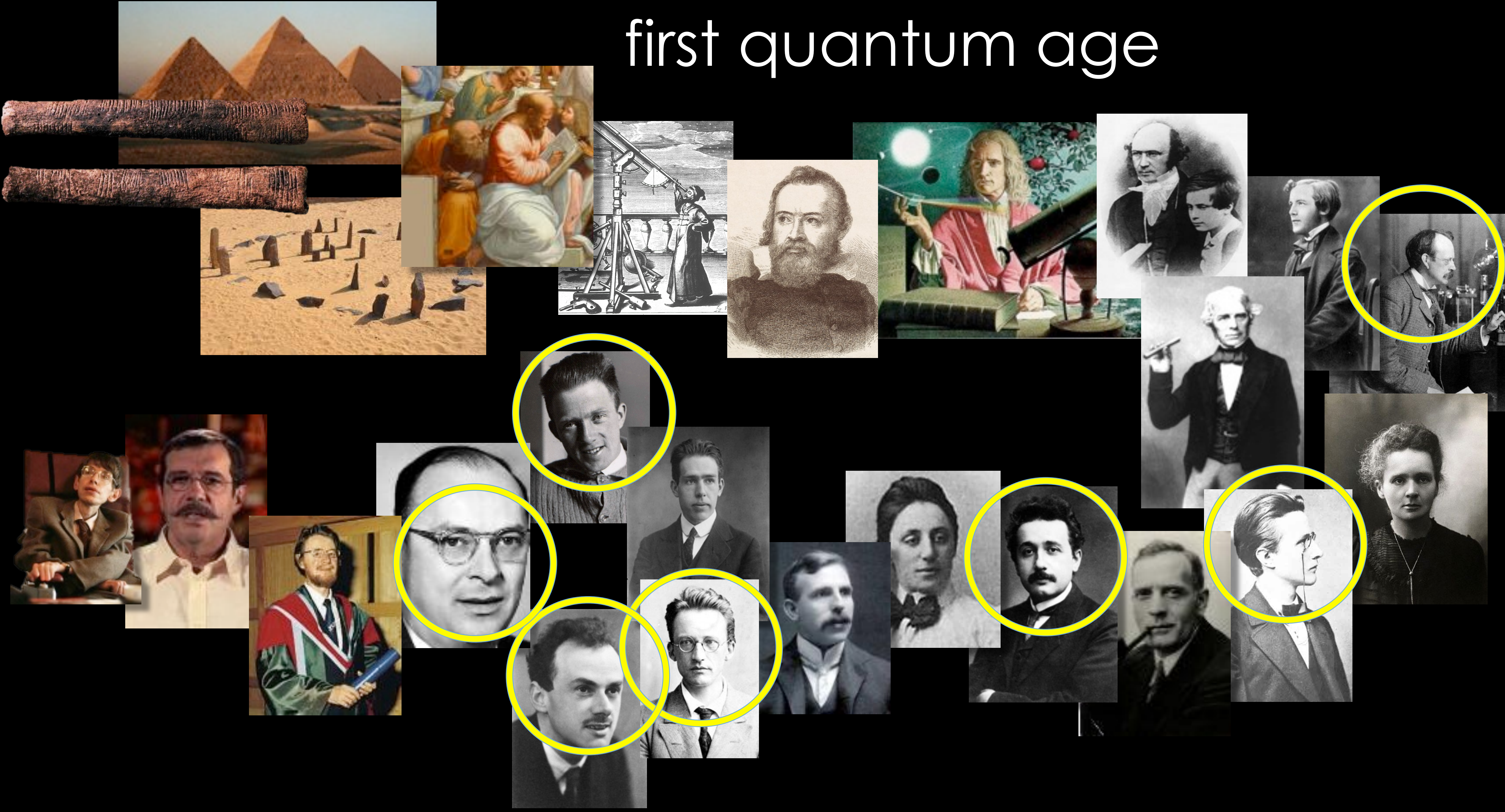
SEARCH:

Institution	Country	Papers	Indicator value
California Institute of Technology	USA	1364	27.4%
Lawrence Berkeley National Laboratory	USA	723	26.9%
Stanford University	USA	1758	25.7%


R I F T
Kasindi
Karambi
Mpondwe
V A L L E Y
Équateur
PARC NATIONAL
DES VIRUNGA
Katojo
OUGANDA
CONGO
Ishango
Lac
Edouard
Kabatoro
Katwe

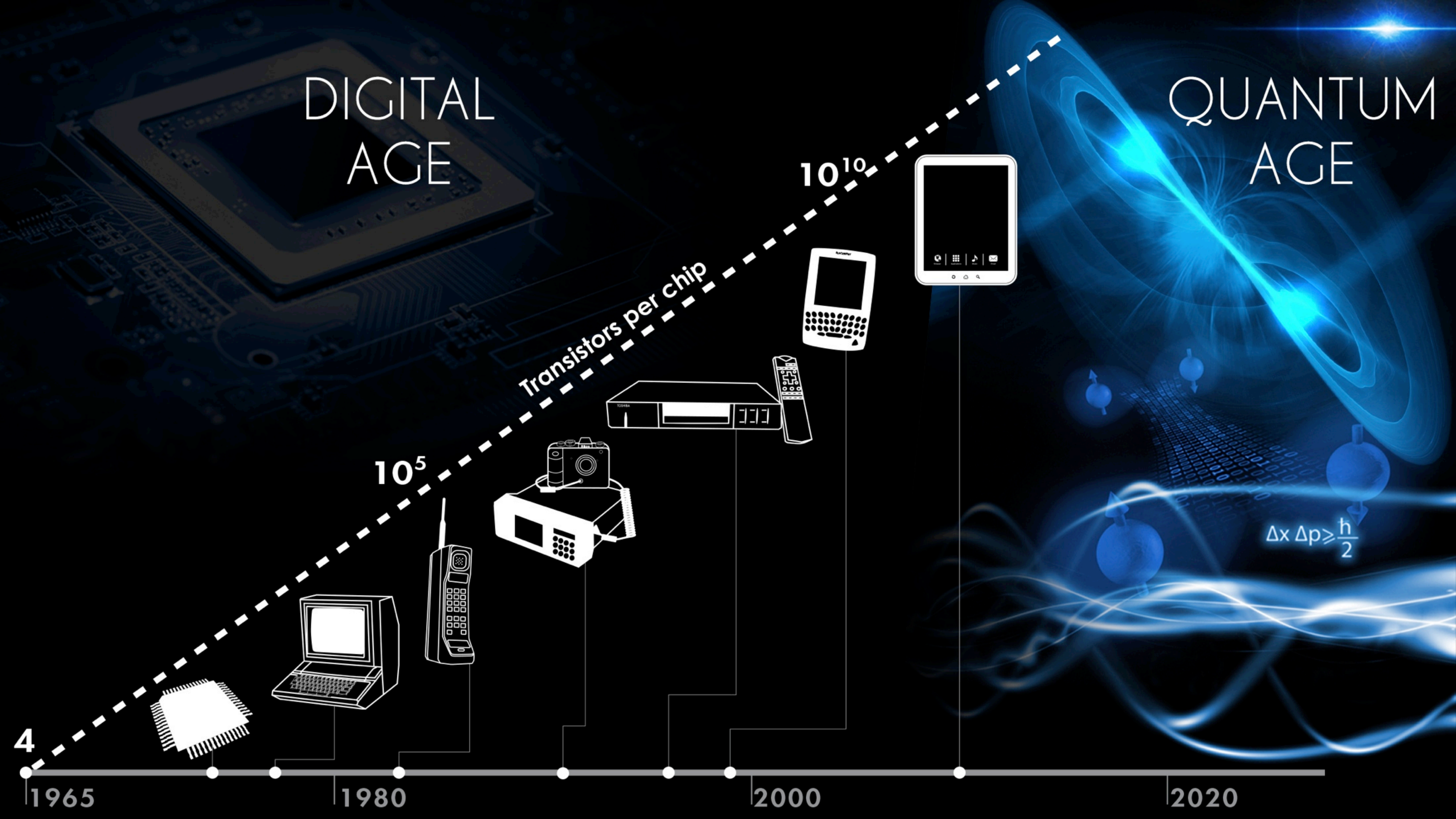


first quantum age



1947: the transistor

John Bardeen,
Walter Brattain,
and William
Shockley



DIGITAL AGE
QUANTUM AGE
Transistors per chip
4
10^5
10^{10}
$\Delta x \Delta p \geq \frac{\hbar}{2}$
1965
1980
2000
2020

Worldwide Electronics industry:

$1.6 trillion

Decision & Etudes Conseil, and Council on Foreign Relations

Worldwide Information industry::

$3.58 trillion

Gartner Worldwide IT Spending Forecast

Worldwide Telecommunications market:

$4.7 trillion USD

Plunkett Research

education, science and technology
hold the keys to our future

but they must change

we must reconnect
our science to our humanity

Africa can set the example

African Institute for
Mathematical Sciences

AIMS-South Africa 2003

an African Institute

* pan-African student body
* outstanding international lecturers
* a 24/7 learning environment

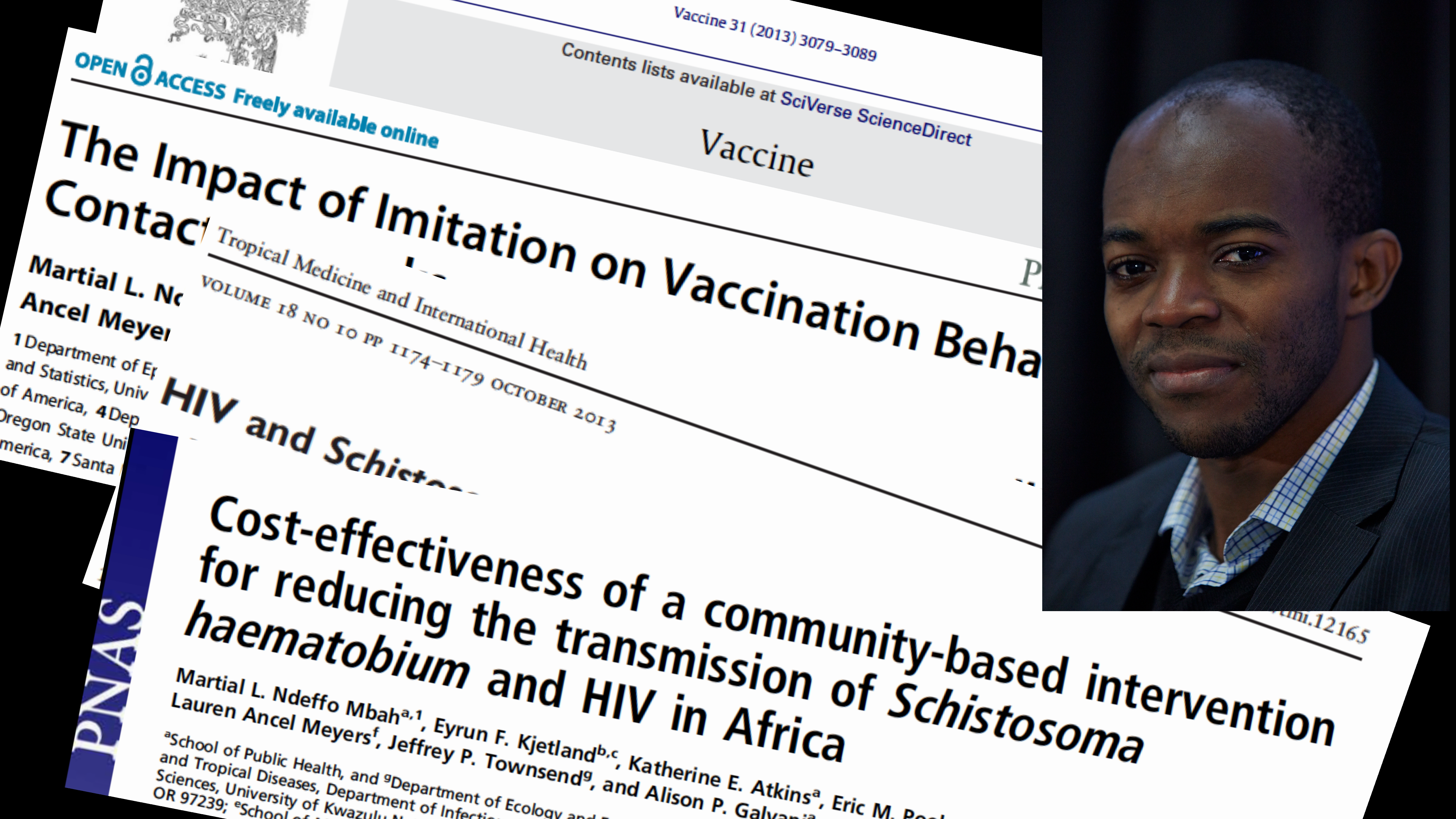
Relevant
Innovative
Cost-Effective
High Quality


Senegal 2011
Cameroon 2013
VENUE AU PALAIS DES CONGRES DE YAOUN
Ghana 2012
Tanzania 2014
South Africa 2003

AIMS-Ghana June 2016

AIMS so far

- 1210 alumni, 250+ entering this month
- 30% women
- almost half continue to PhDs
- 65% currently working in Africa
- 3000 applications this year for
- Six centres so far: South Africa, Senegal, Ghana, Cameroon, Tanzania, Rwanda

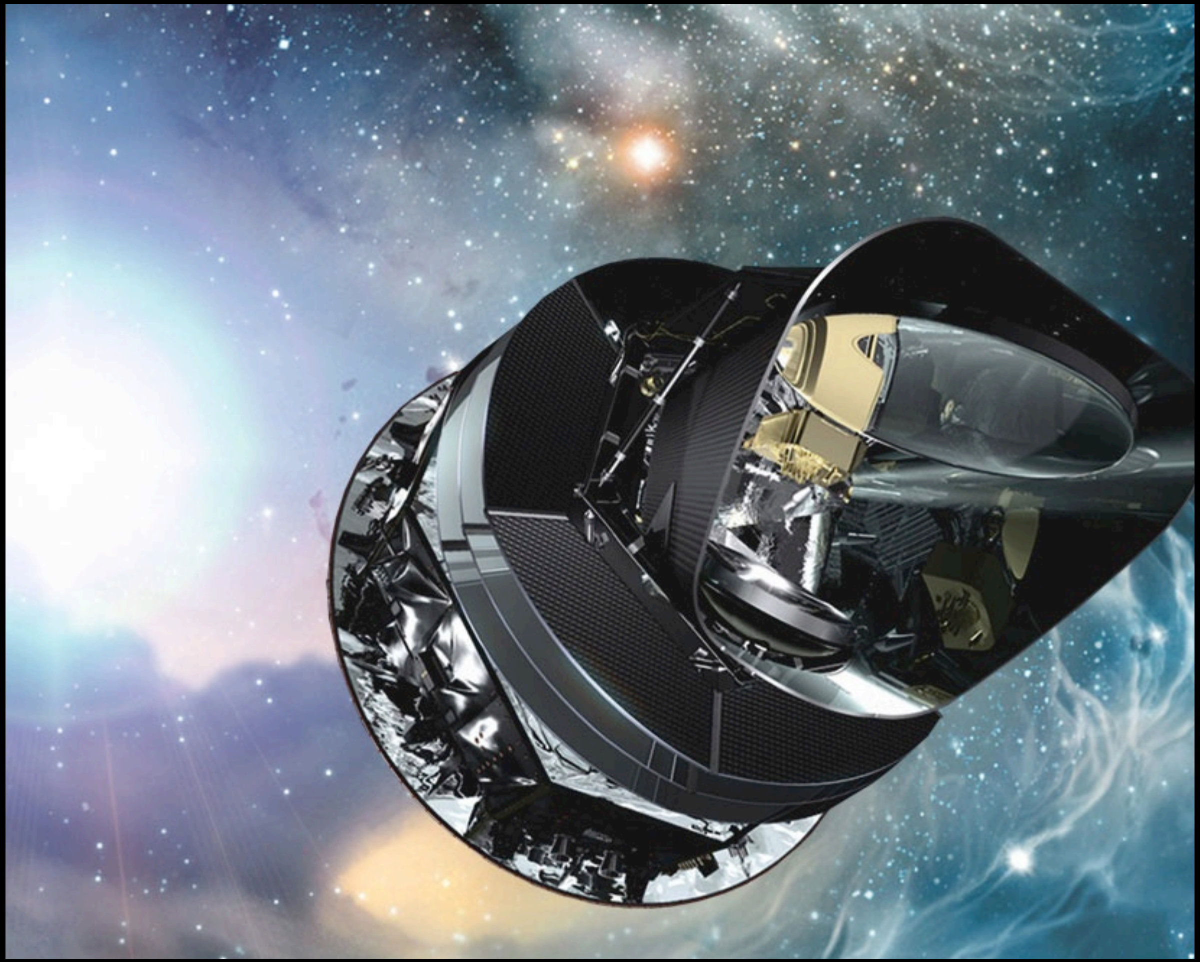

Vaccine 31 (2013) 3079–3089
Contents lists available at SciVerse ScienceDirect
Vaccine
OPEN ACCESS Freely available online
The Impact of Imitation on Vaccination Beha
Contac
Martial L. Nd
Ancel Meyer
1 Department of Ep
and Statistics, Univ
of America, 4 Dep
Oregon State Uni
merica, 7 Santa
Tropical Medicine and International Health
VOLUME 18 NO 10 PP 1174–1179 OCTOBER 2013
HIV and Schisto
PNAS
Cost-effectiveness of a community-based intervention
for reducing the transmission of Schistosoma
haematobium and HIV in Africa
Martial L. Ndeffo Mbah[a,1], Eyrun F. Kjetland[b,c], Katherine E. Atkins[a], Eric M. Poo
Lauren Ancel Meyers[f], Jeffrey P. Townsend[g], and Alison P. Galvani[a]
[a]School of Public Health, and [g]Department of Ecology and
and Tropical Diseases, Department of Infecti
Sciences, University of Kwazulu N
OR 97239; [e]School
tmi.12165

Introducing

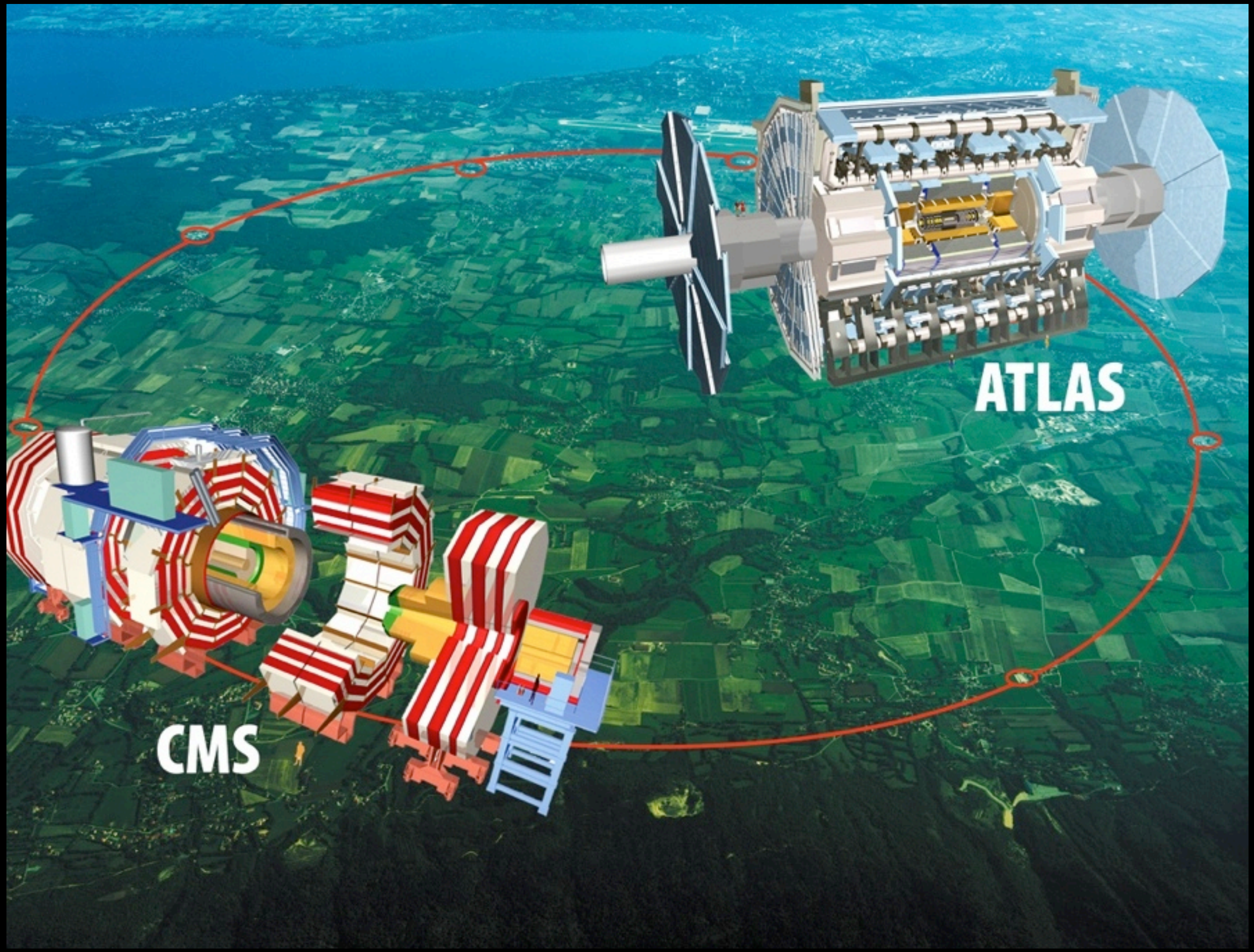
Thierry Zomahoun

President and CEO of AIMS

most powerful telescope
ESA Planck satellite



most powerful microscope
Large Hadron Collider



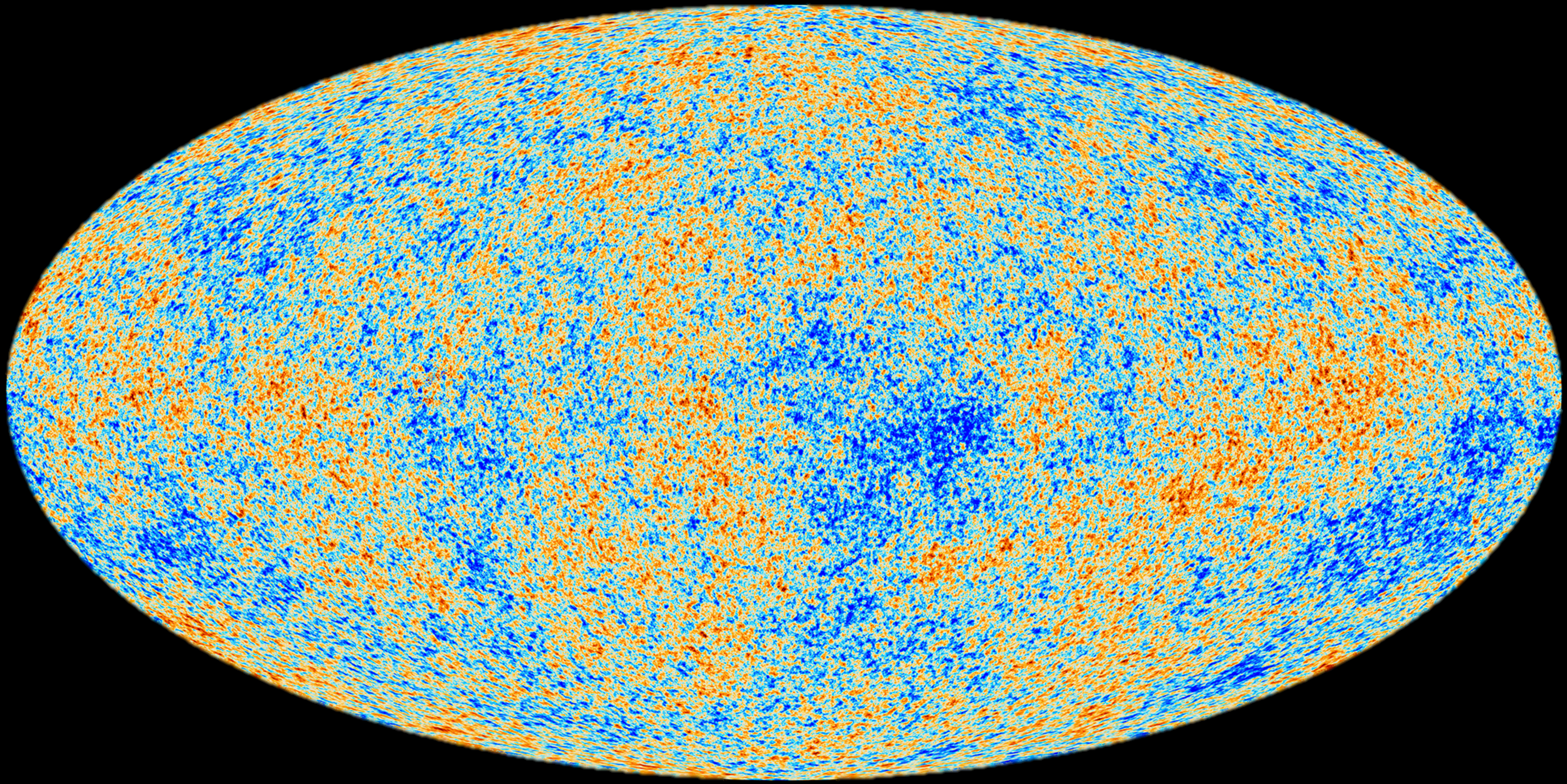
most precise measurement of length
Advanced LIGO

LIGO Hanford

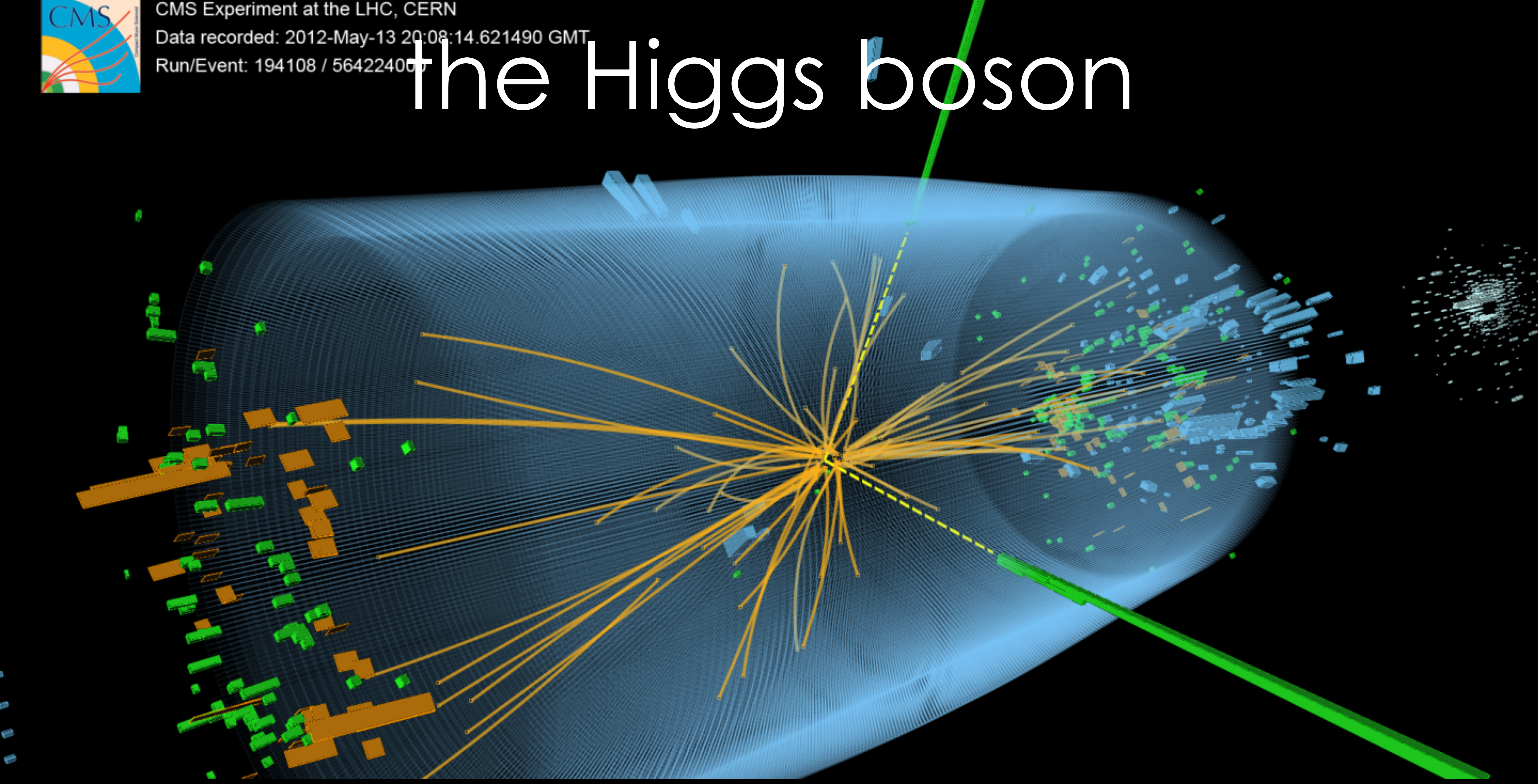
LIGO Livingstone


square kilometer array

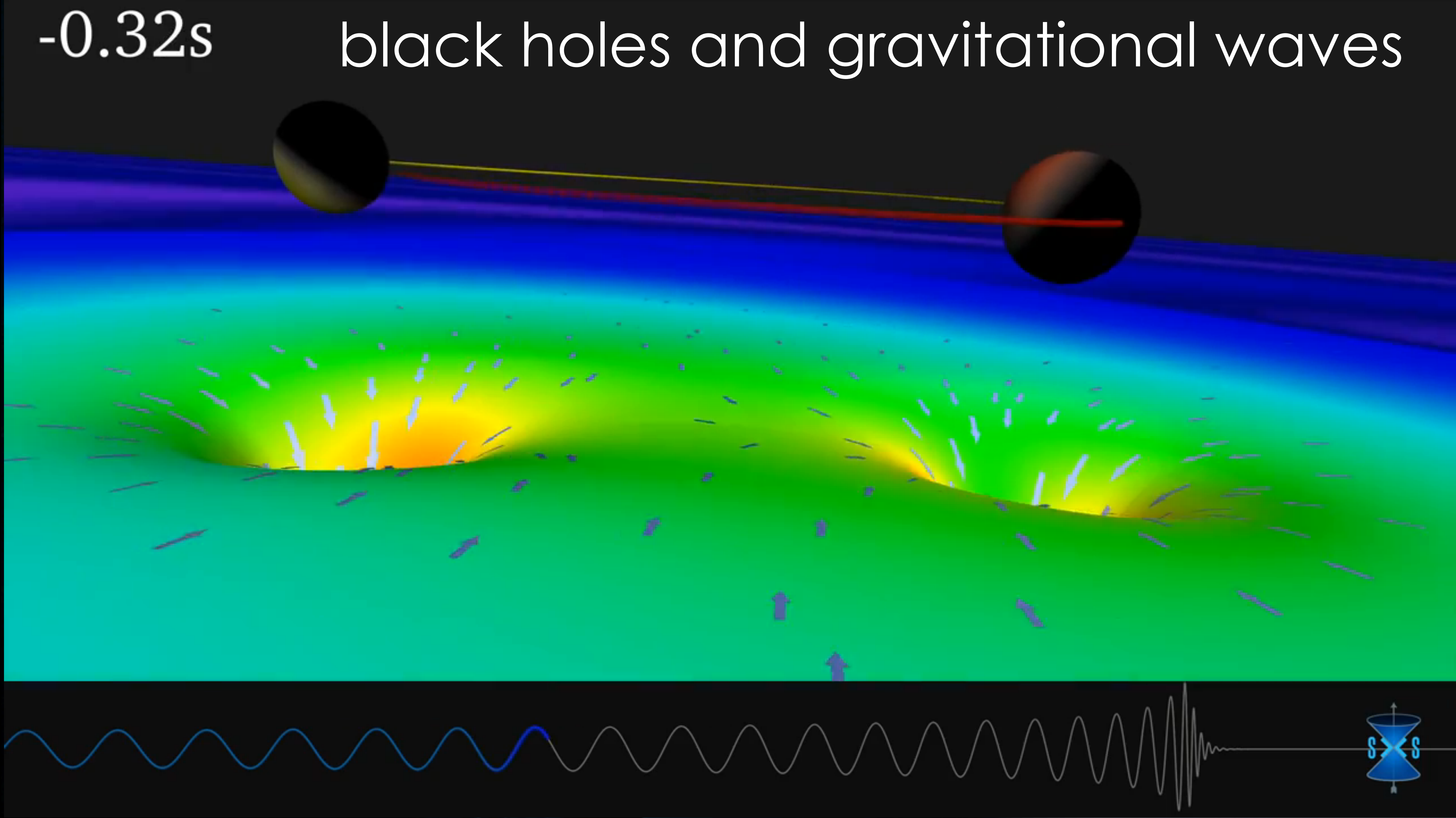
the entire visible universe



the Higgs boson



black holes and gravitational waves



quantum Nature of Reality

0

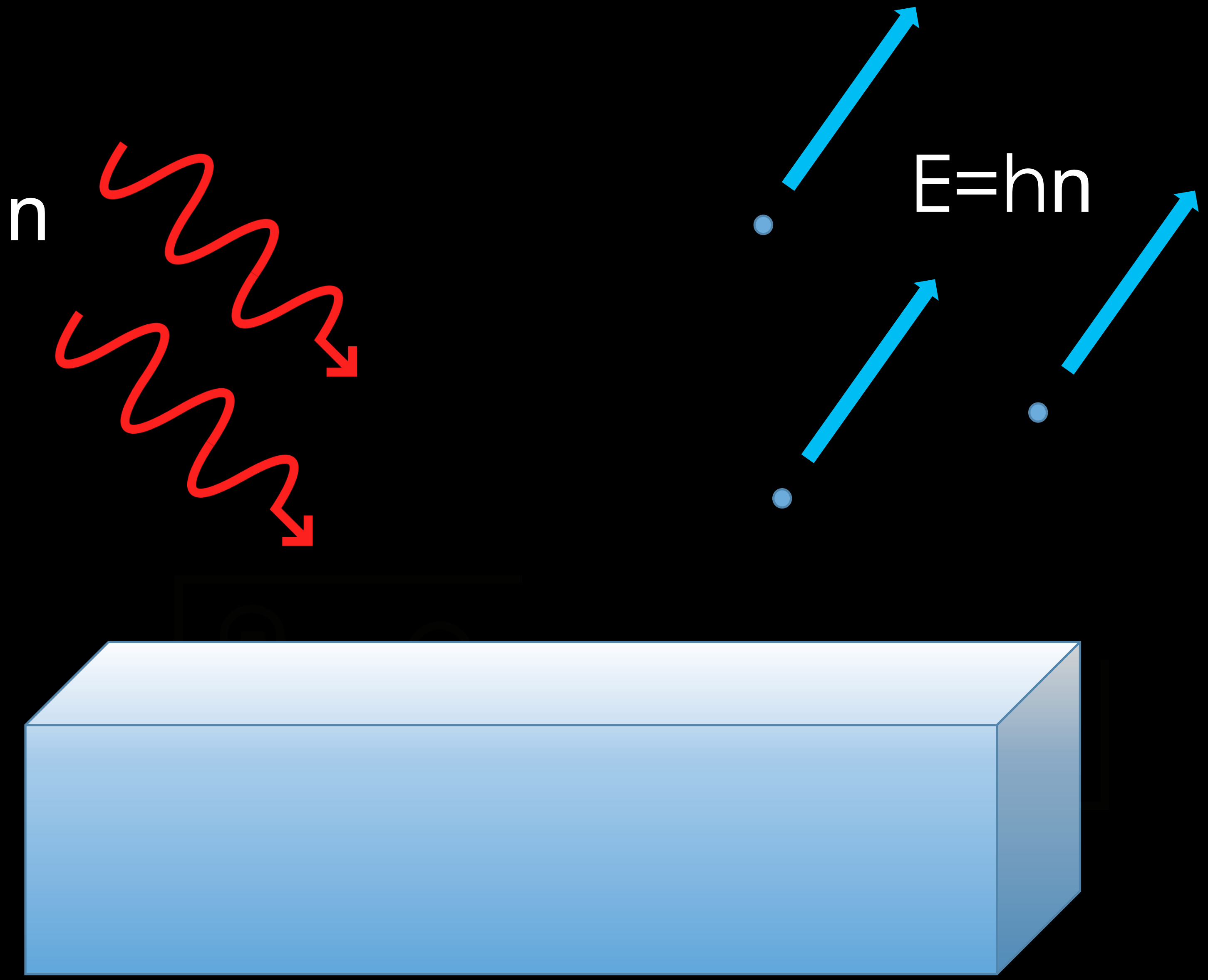
bit versus qubit

1

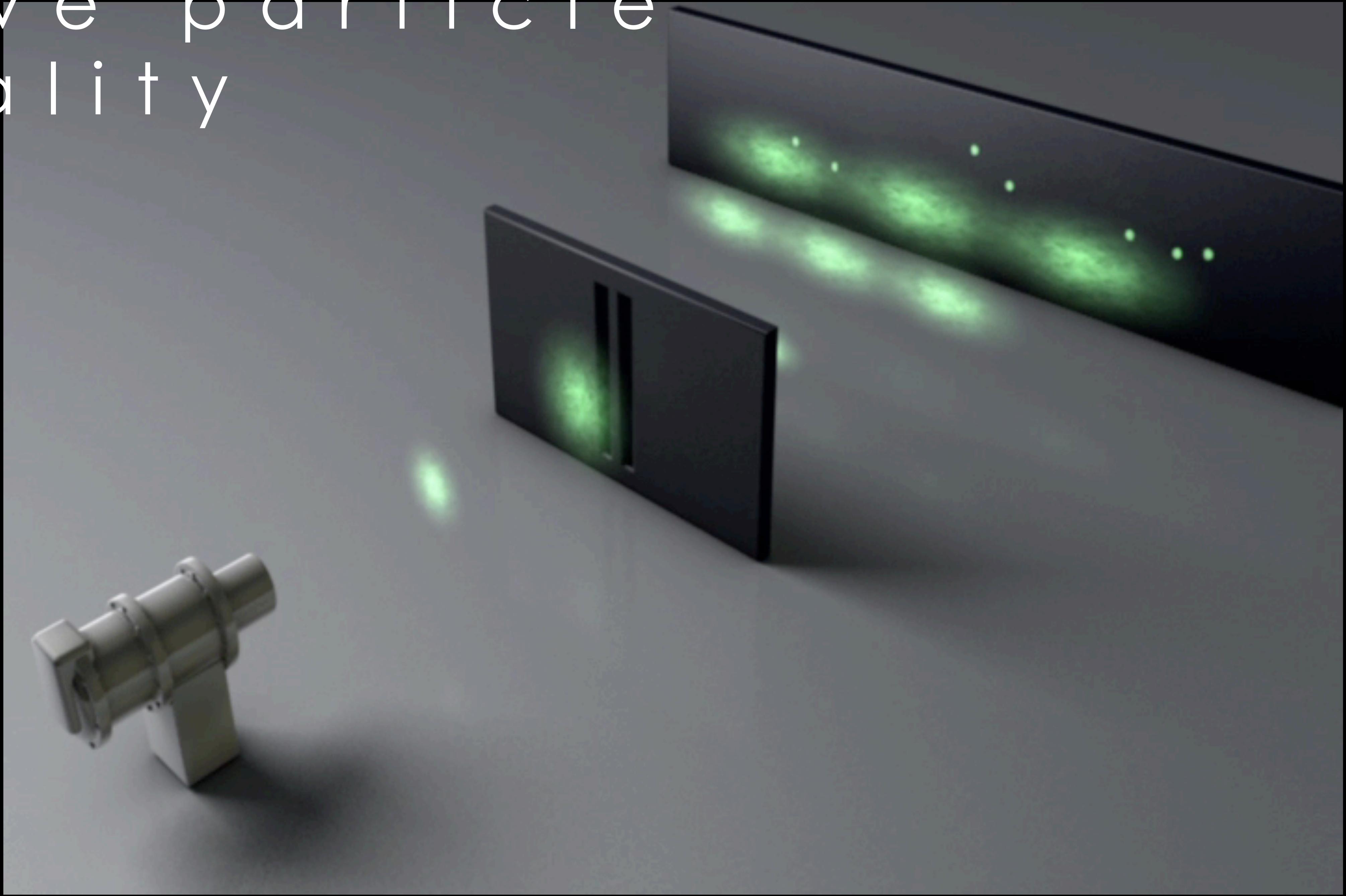
h e a t   a n d   t h e   q u a n t u m

Planck

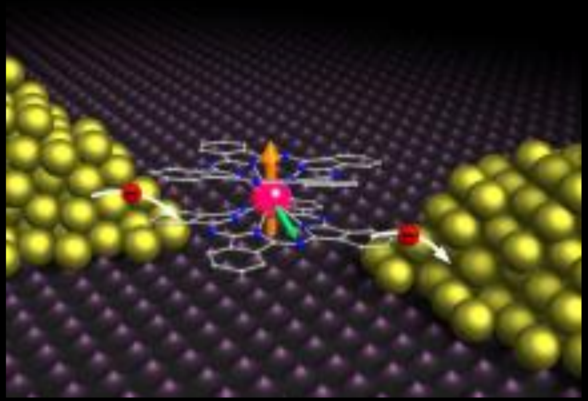
quantum

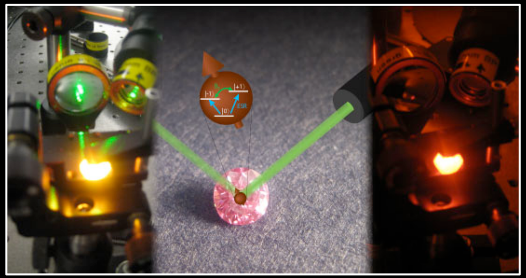


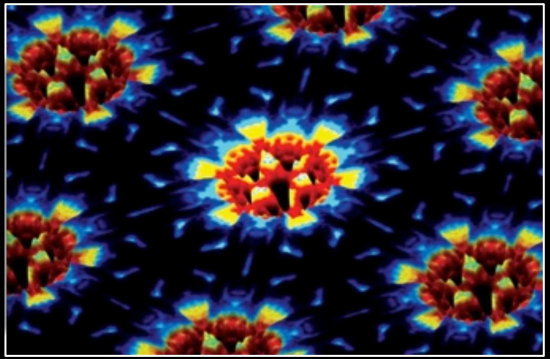
w a v e p a r t i c l e d u a l i t y

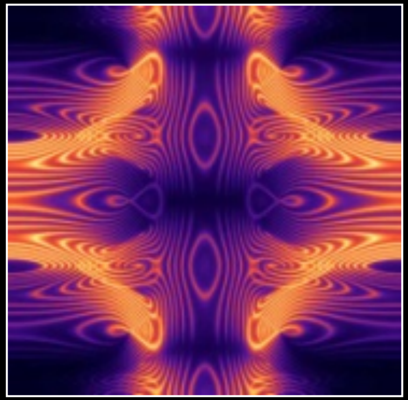


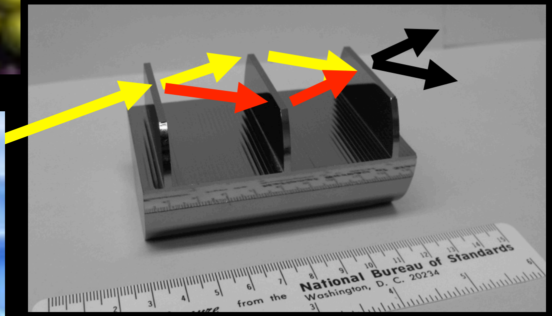
learning to understand and manipulate quantum reality

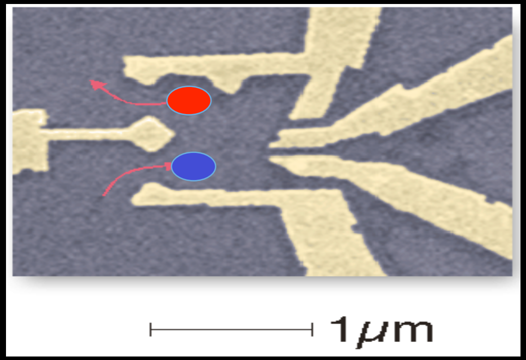




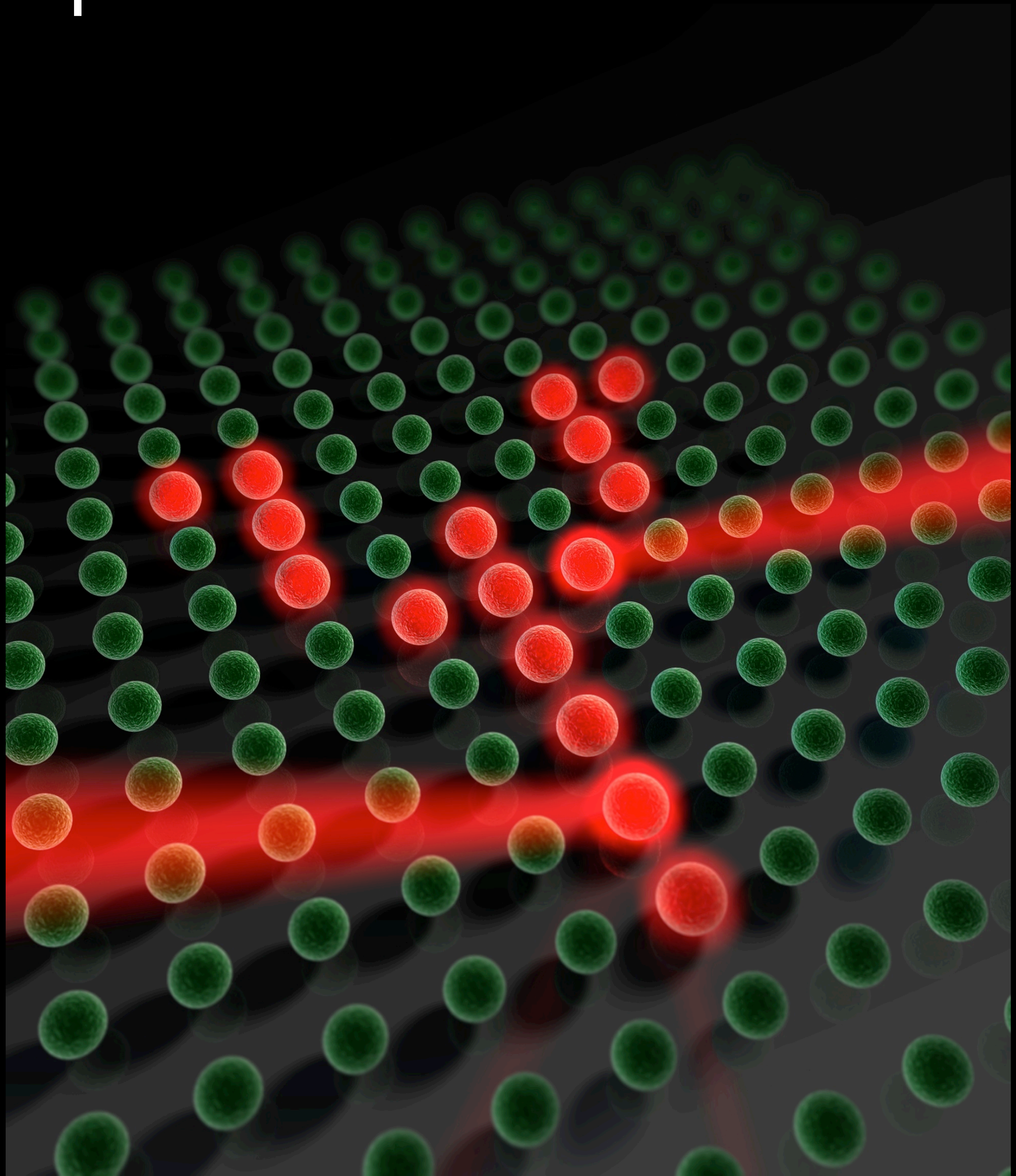




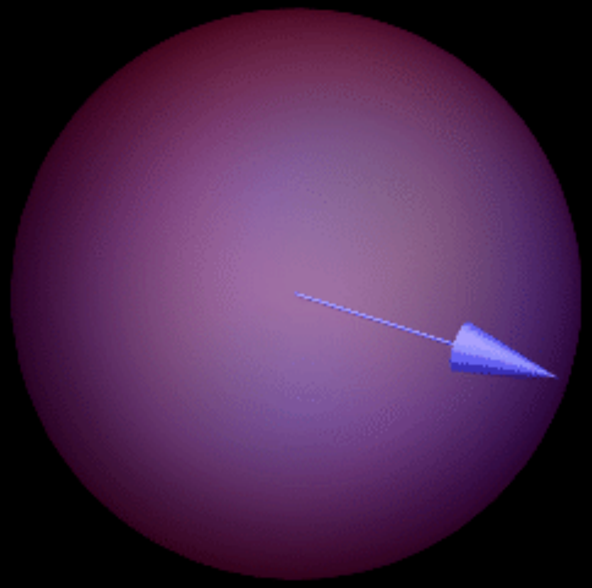




u s i n g   q u a n t u m   a t o m s



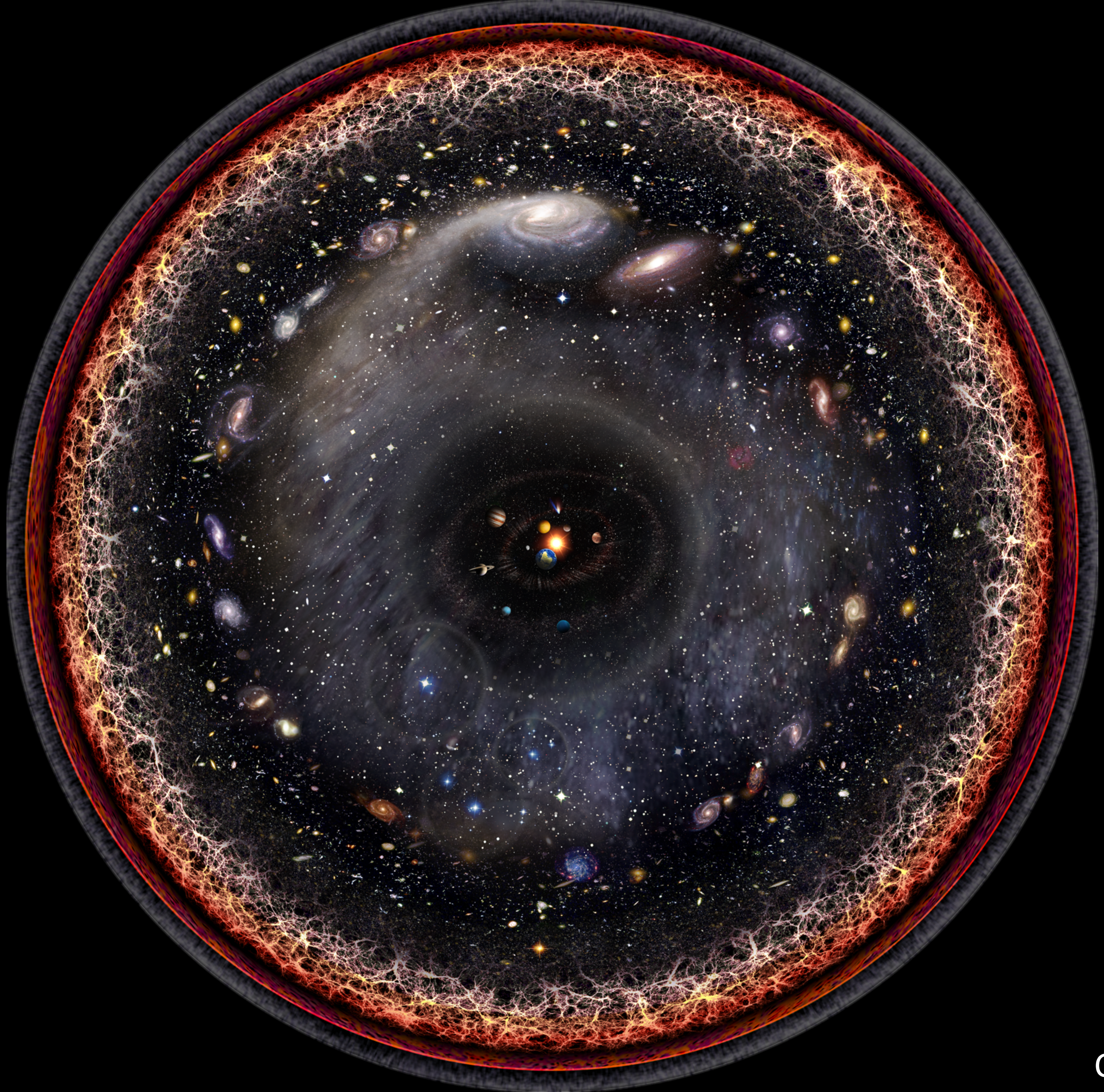
manipulating qubits



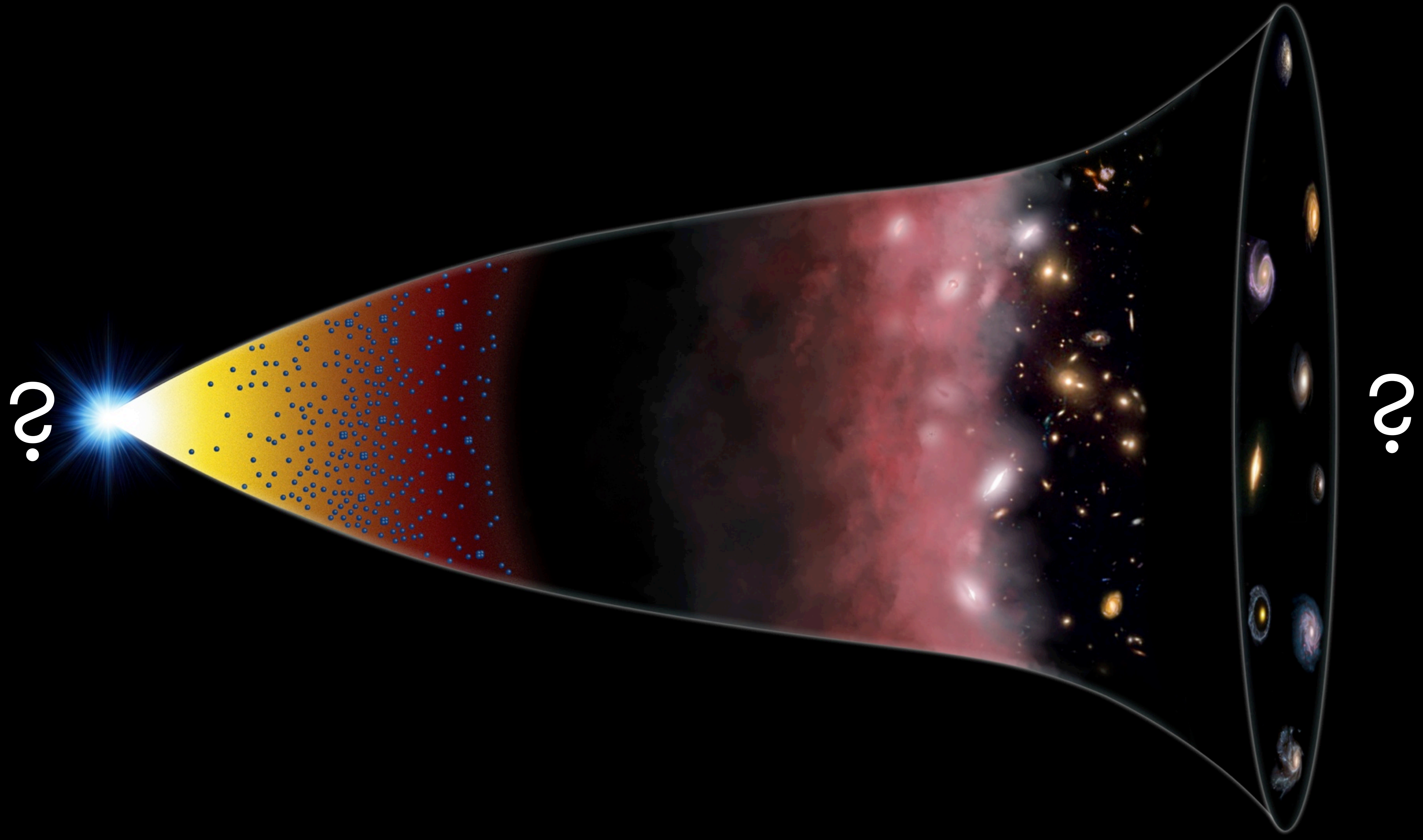
What is coming:

Quantum Materials, Quantum electronics

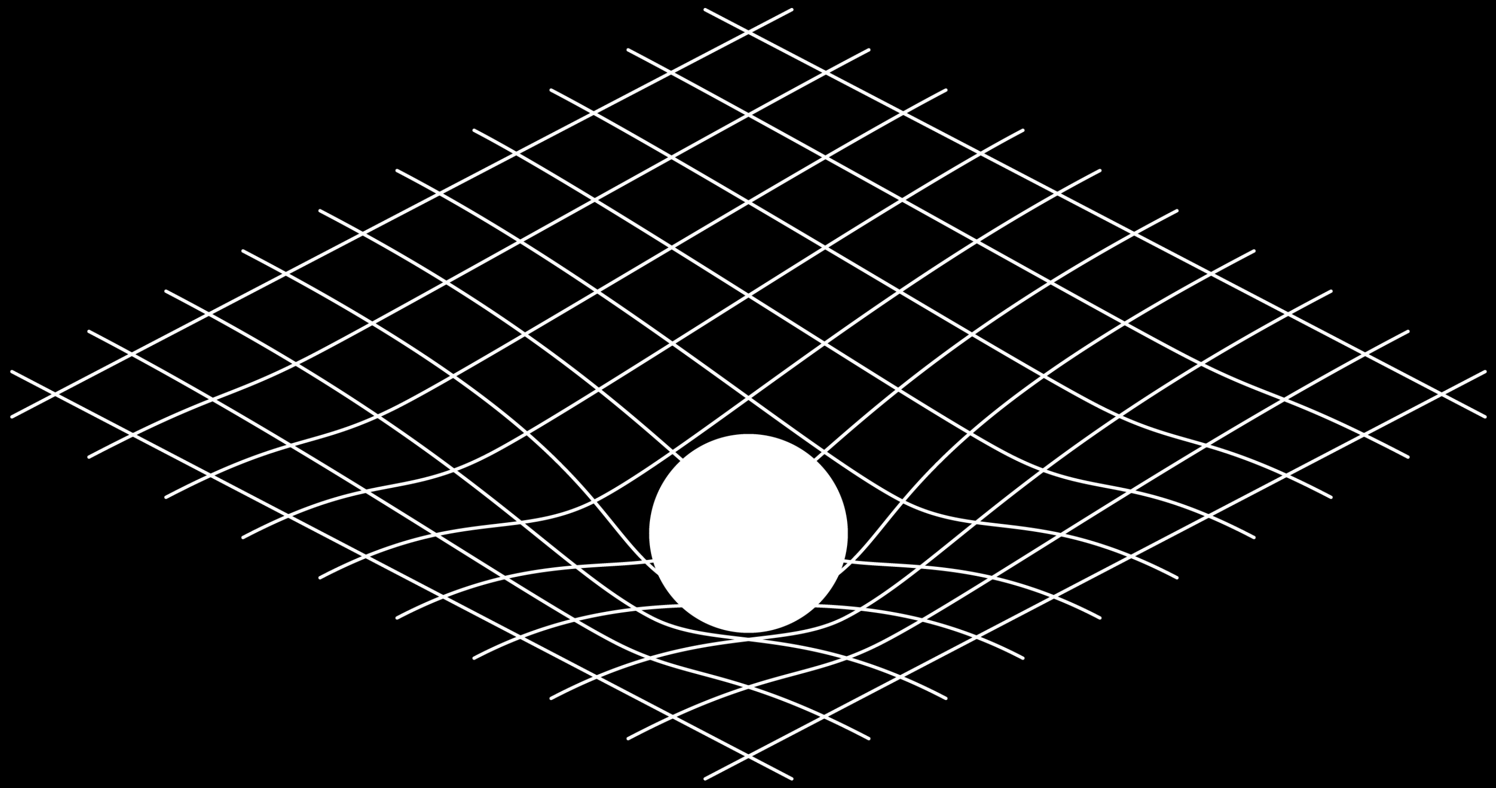
Quantum Computers, Sensors, Communications



Credit: Pablo Carlos Budassi



g r a v i t y



expanding universe

what we have learned:

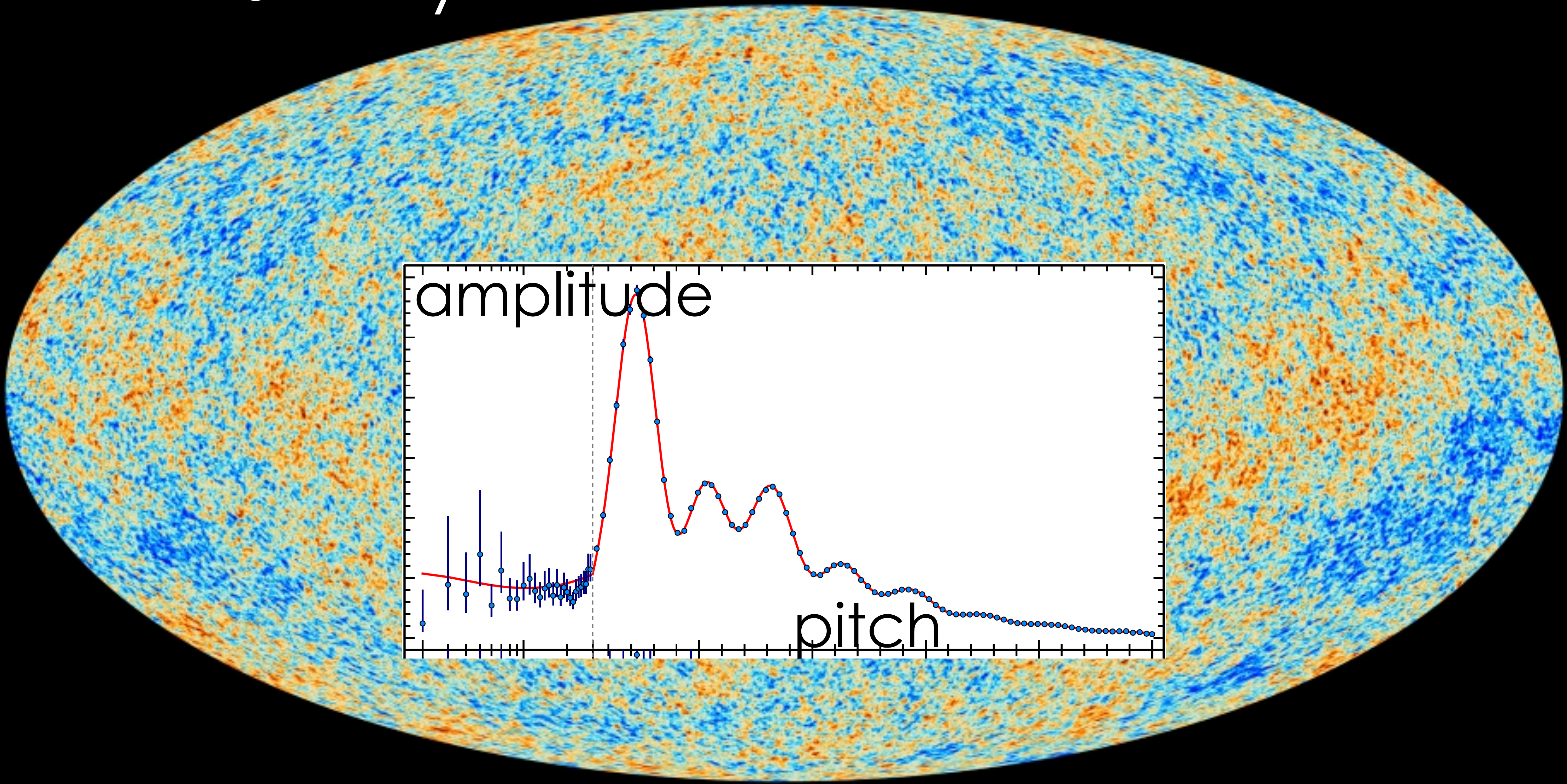
simplicity

Just five numbers describe the cosmos

			Measurement Error
today	Expansion rate:	67.8±0.9 km s^{-1} Mpc^{-1}	1%
	(Temperature)	2.728 ± 0.004 K	.1%
	(Age)	13.799 ±0.038 bn yrs	.3%
	Baryon-entropy ratio	6±.1x10^{-10}	1%
critical density	Baryon density	0.048±0.0005 x critical	1%
	Dark matter density	0.26±0.005 x critical	2%
	Dark energy density	0.69±0.006 x critical	1%
	Scalar amplitude A_s	4.6±0.006 x 10^{-5}	1%
	Scalar spectral index n_s (scale invariant = 0)	-.033±0.004	12%

$$+m_\nu\text{'s}; \quad \text{but } \Omega_k,\ 1+w_{DE},\ \frac{dn_s}{d\ln k},\ \langle\delta^3\rangle,\langle\delta^4\rangle..,r=\frac{A_{gw}}{A_s}$$ consistent with zero

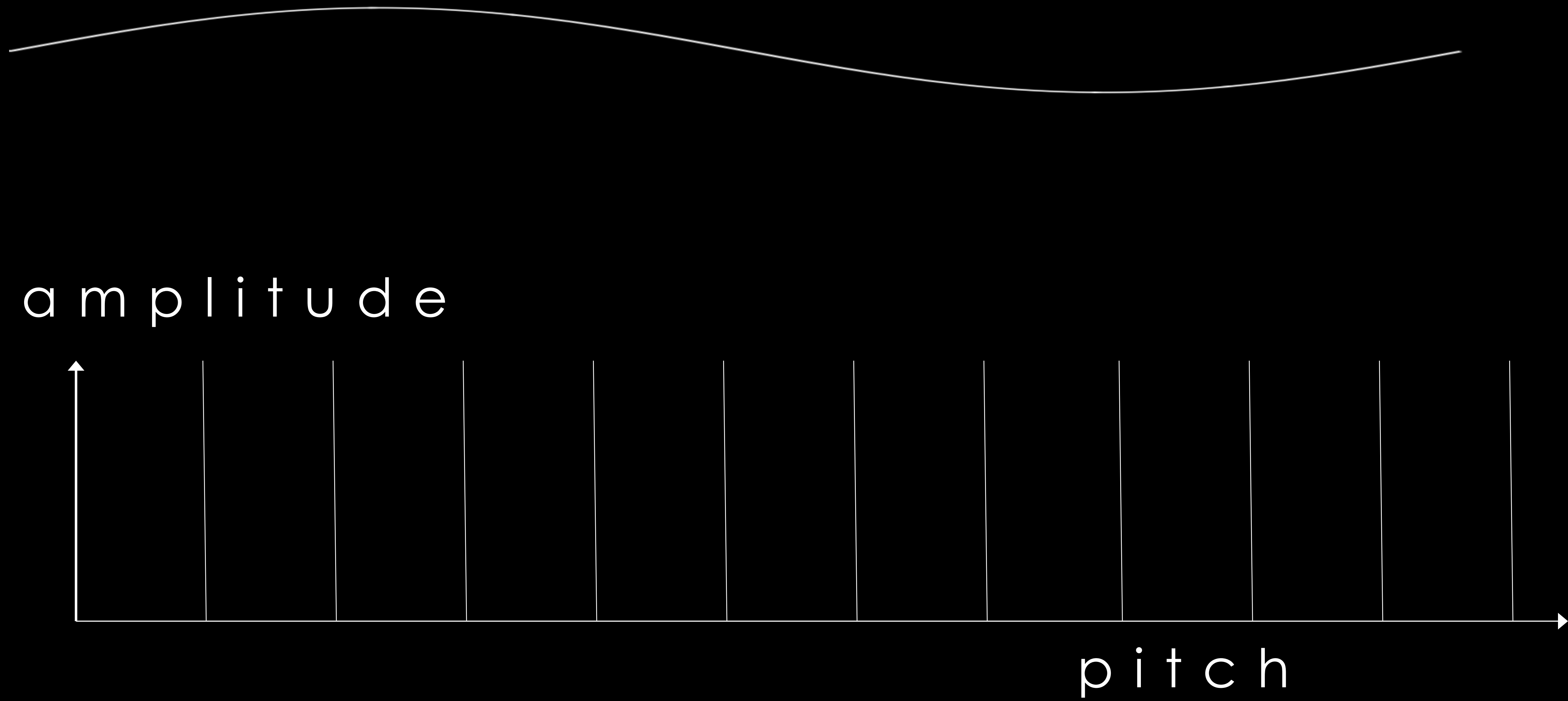
s y m m e t r y

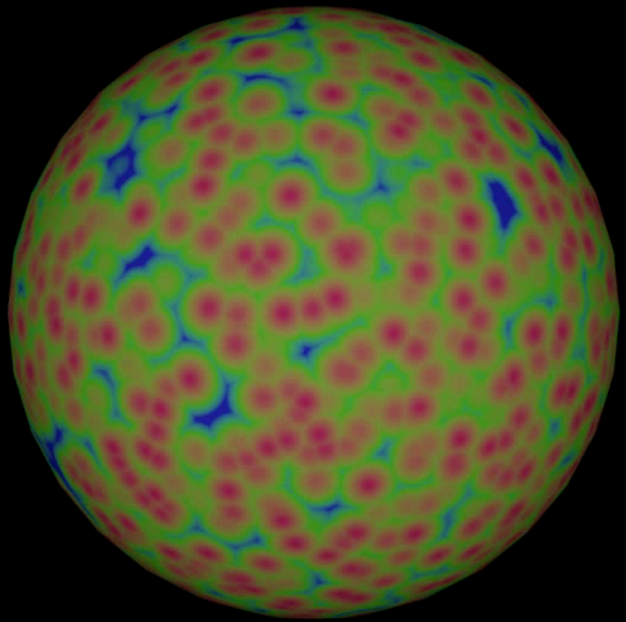


s y n c h r o n i c i t y

Credit: ESA Planck satellite

scale-free initial pattern



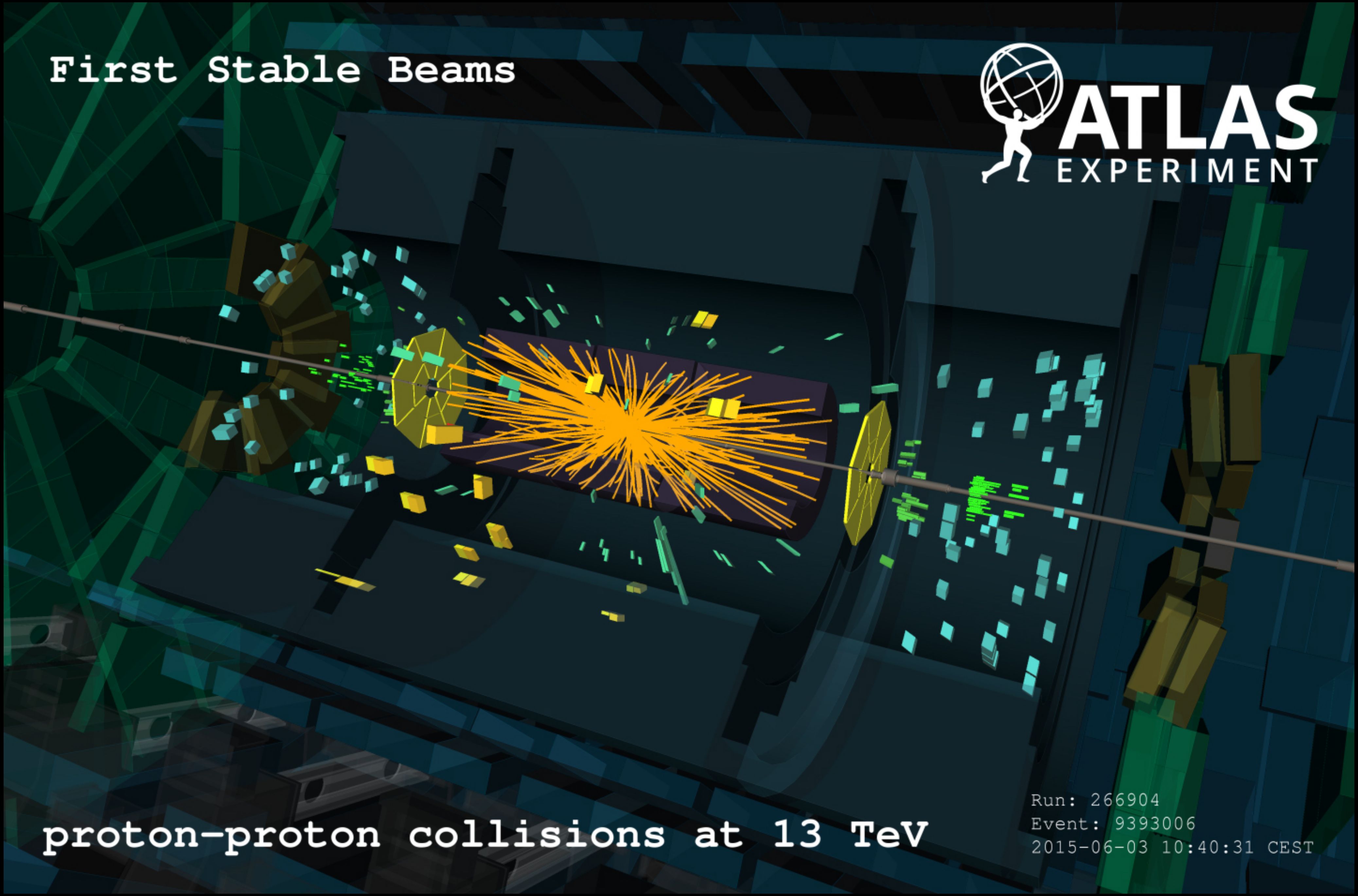


all known physics

$$\Psi = \int e^{\frac{i}{\hbar}\int\left(\frac{R}{16\pi G} - \frac{1}{4}F^2 + \overline{\psi} i \not{D}\psi - \lambda H\overline{\psi}\psi + |DH|^2 - V(H)\right)}$$

Schrödinger
Feynman
Einstein
Maxwell-Yang-Mills
Kobayashi-Maskawa
Lagrange
Euler
Planck
Newton
Dirac
Yukawa
Higgs

plus neutrino masses and mixing and dark matter

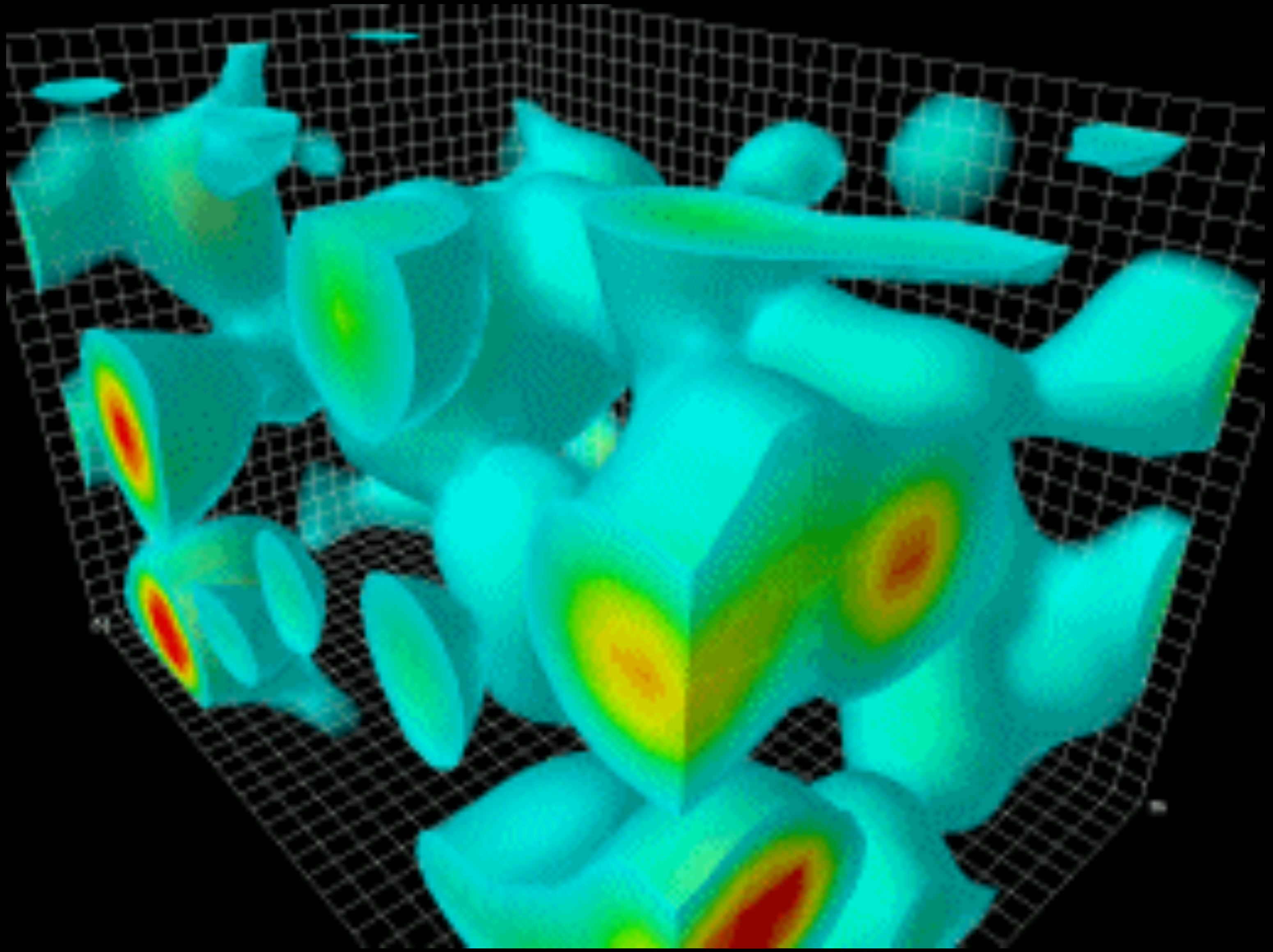

First Stable Beams
ATLAS
EXPERIMENT
proton-proton collisions at 13 TeV
Run: 266904
Event: 9393006
2015-06-03 10:40:31 CEST

d a r k   m a t t e r

1E 0657-558
"bullet cluster"

dark energy

QCD vacuum



Credit: D Leinweber

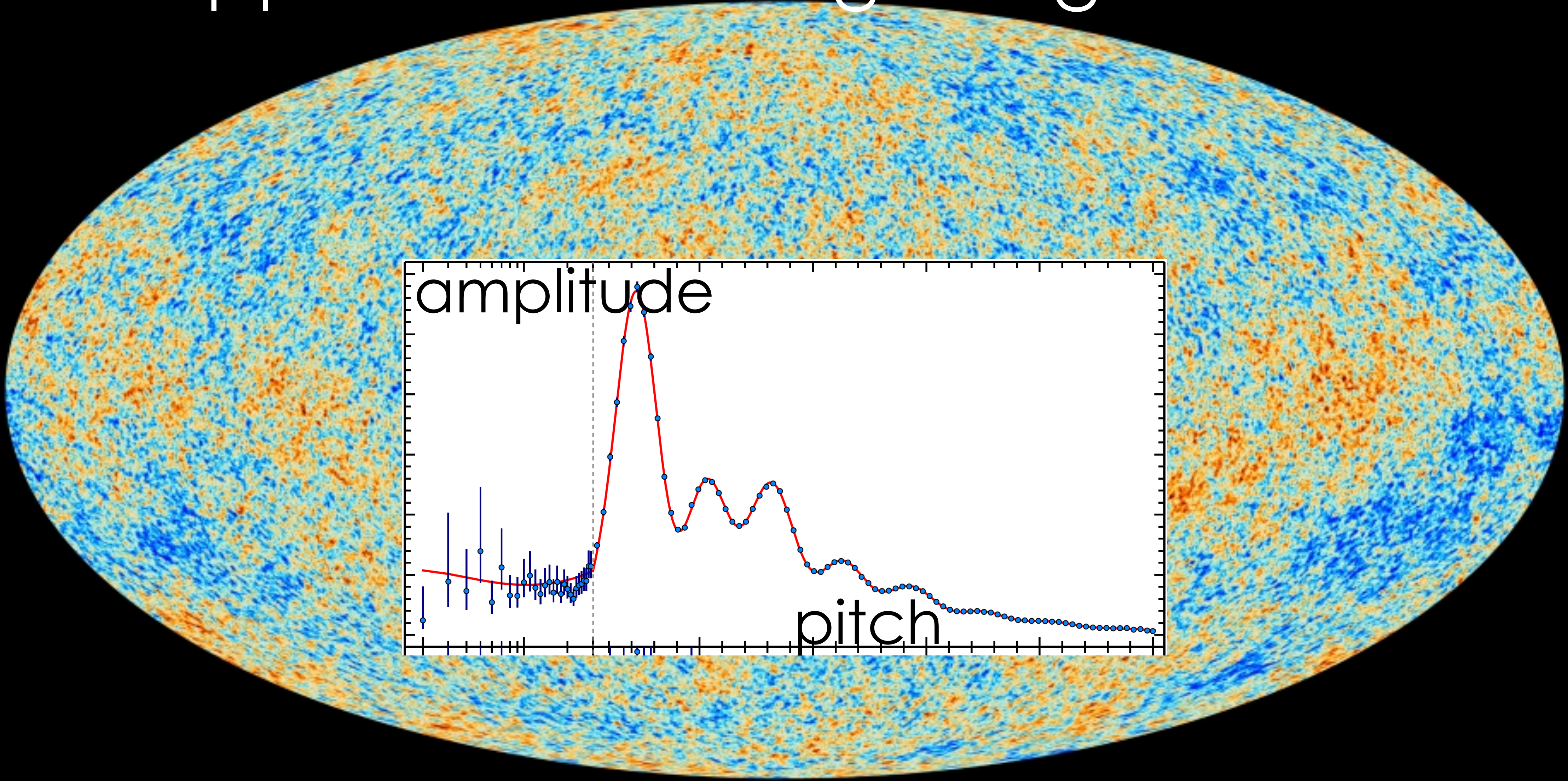
measured vacuum energy

0.0000000000000000000000000000000000000000
00000000000000000000000000000000000000000
00000000000000000000000000000000000000001

in the natural units

how did this fine adjustment happen?

What happened at the big bang?



Credit: ESA Planck satellite

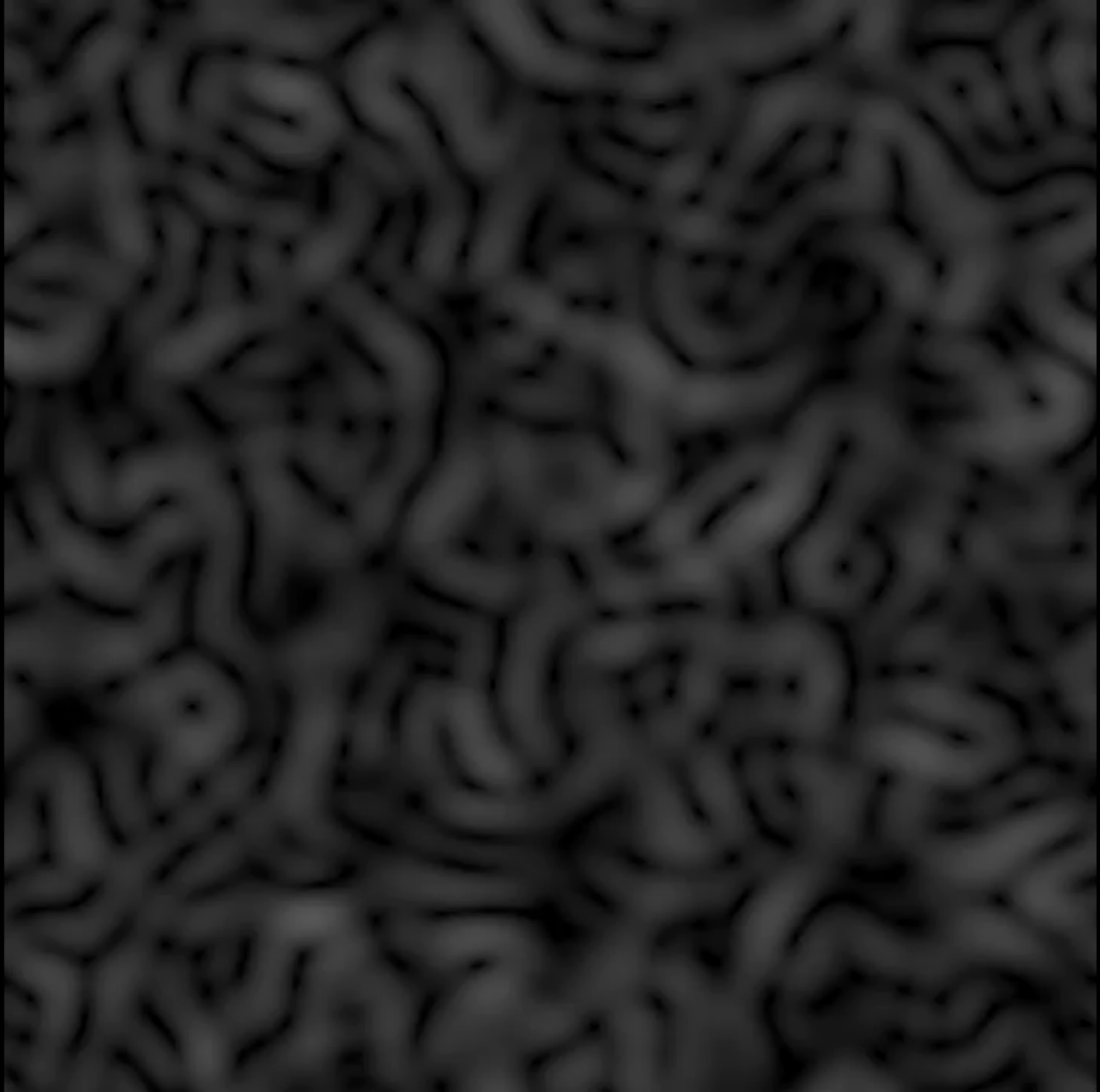
relativistic fluid dynamics

Simplification: since gravitational backreaction is negligible on subhorizon scales, and radiation is conformal invariant, work in a Weyl frame in which the background is Minkowski

$$T^{\mu\nu} = \tfrac{4}{3}\rho u^{\mu} u^{\nu} + \tfrac{1}{3}\rho\eta^{\mu\nu};\ u^2 = -1,\ T_{\lambda}^{\lambda} = 0;$$

$\partial_{\mu} T^{\mu\nu} = 0$ are 4 equations for 4 unknowns

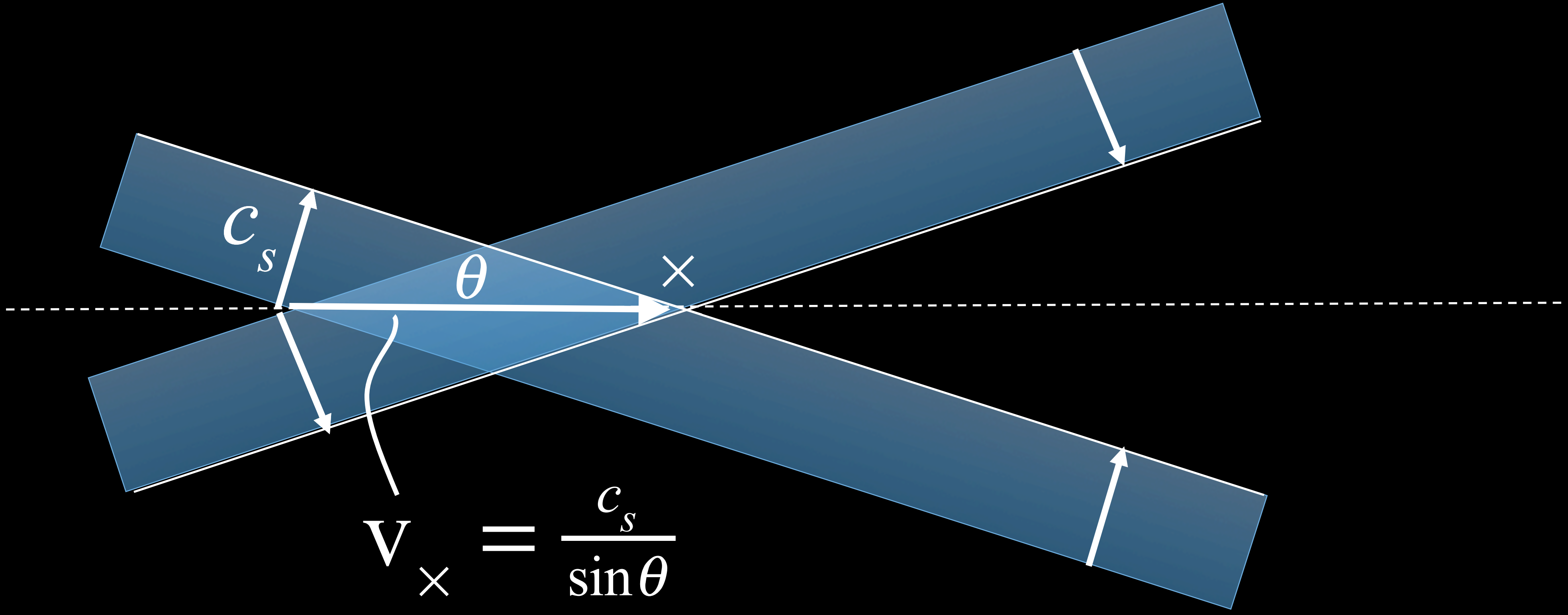
In the absence of viscosity, these equations imply entropy and vorticity conservation. However, when shocks form the differential equations break down and entropy and vorticity are generated.



Credit: Ue-Li Pen

g-waves from shocks

Cherenkov mechanism

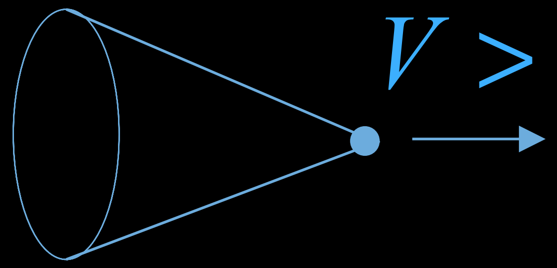


spatial stress at intersection moves faster than light

Cherenkov wedges: electromagnetism

$$\phi = \frac{1}{\sqrt{x^2+y^2+z^2}}$$

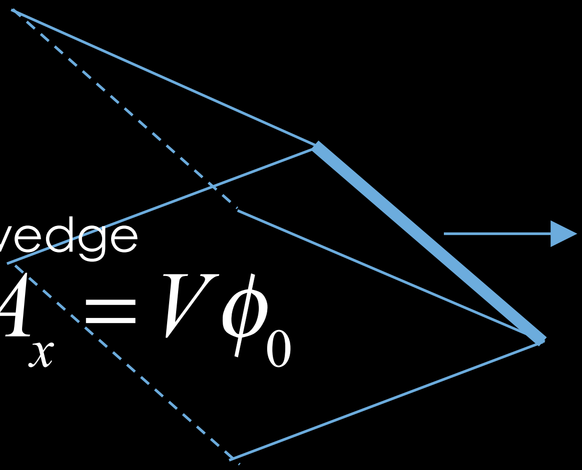
$$\phi = \frac{\gamma}{\sqrt{\gamma^2 (x-\frac{V}{c}t)^2+y^2+z^2}} = \frac{1}{\sqrt{(x-\frac{V}{c}t)^2-(\frac{V^2}{c^2}-1)(y^2+z^2)}}$$



$V > c$

inside cone, zero outside

Integrate over z

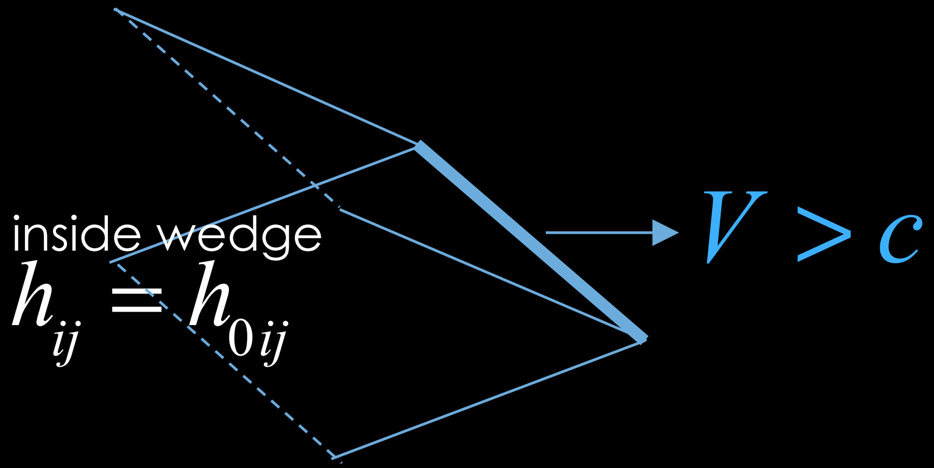


inside wedge

$$\phi = \phi_0,\ A_x = V\phi_0$$

$V > c$

Cherenkov wedges: gravitational waves



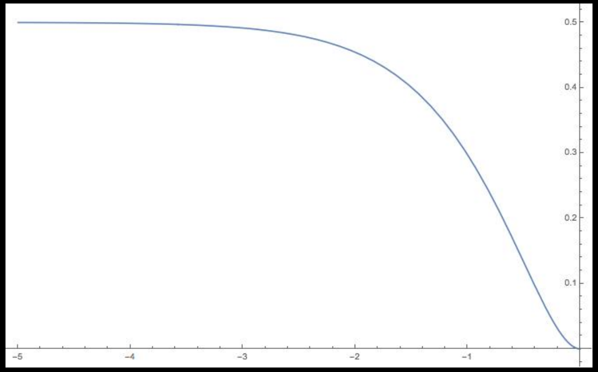
$$(-\partial_t^2 + \partial_x^2 + \partial_y^2) h_{ij}^T (x - \tfrac{t}{\sin\theta}, y) = 16\pi G T_{ij}^T$$

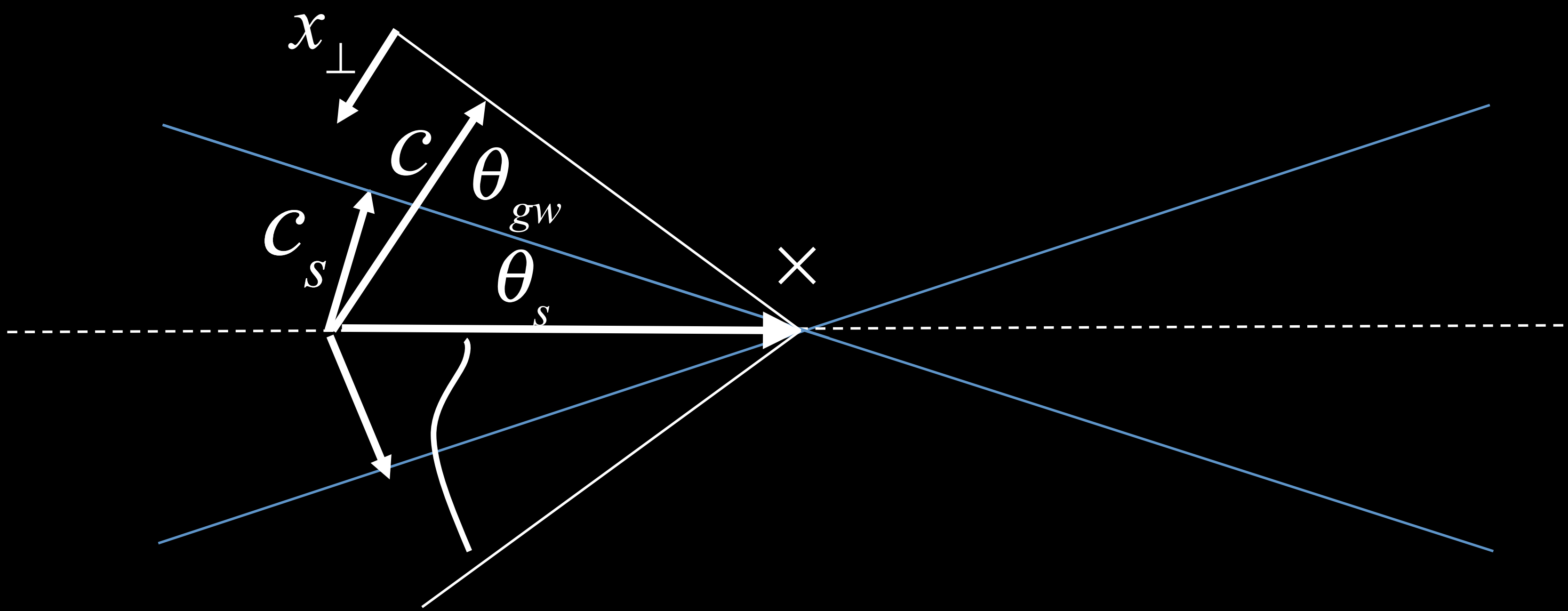
$$\Rightarrow (-\partial_x^2 + (\tan\theta)^2 \partial_y^2) h_{ij}^T = (\tan\theta)^2 16\pi G T_{ij}^T$$

$$T_{ij}^T = \tfrac{2}{3} \bar{\rho} (\Delta \mathrm{v})^2 (x) (\sin\theta)^2 O \begin{pmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -1 \end{pmatrix} O^T ; O = \begin{pmatrix} \cos\theta & \sin\theta & 0 \\ -\sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

g-waves from shocks

$$h_{ij}^{T}(x_{\perp})$$





$$\mathrm{V}_{\times} = \frac{c_s}{\sin\theta_s} = \frac{c}{\sin\theta_{gw}}$$

Did LIGO detect dark matter?

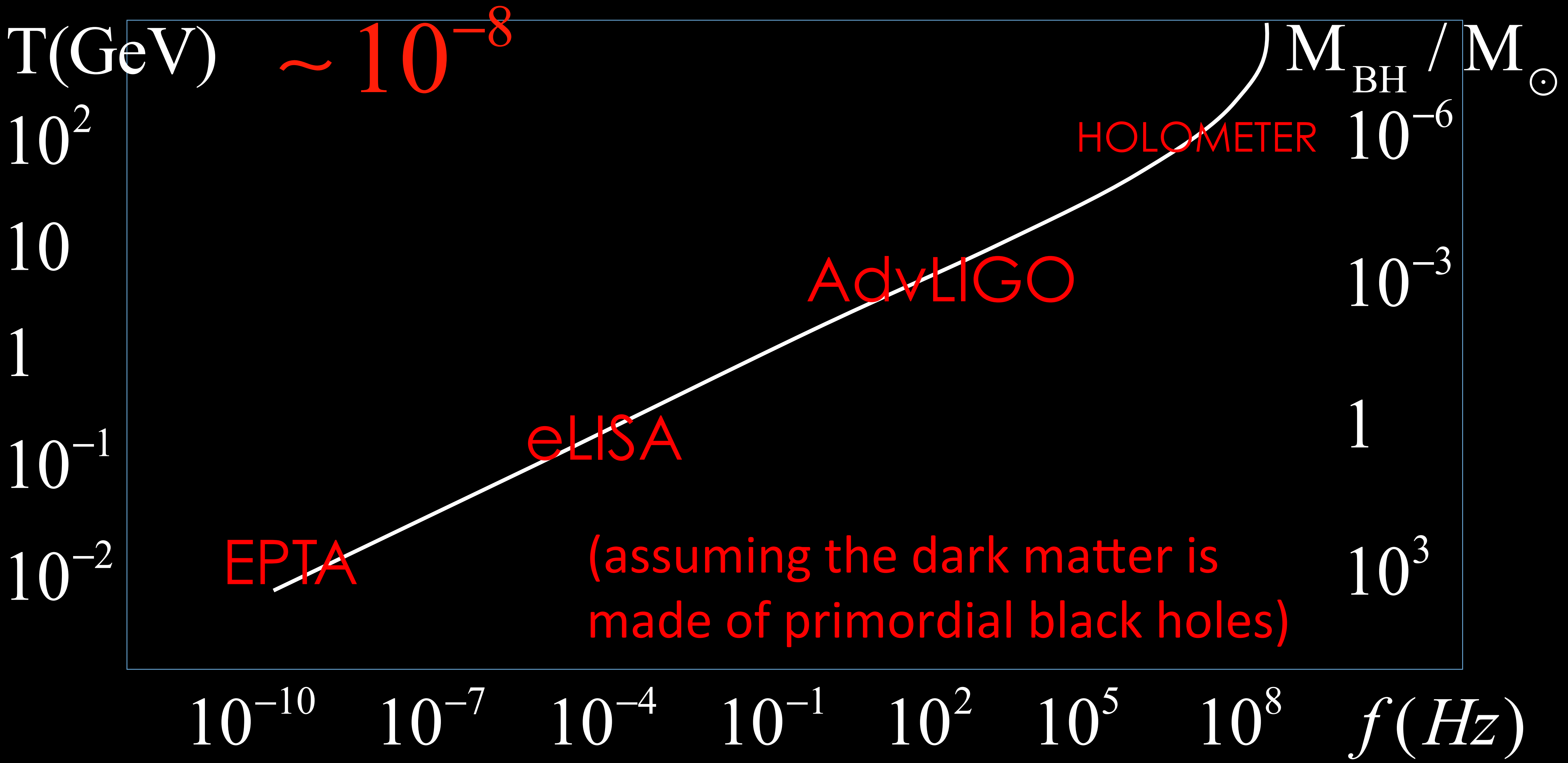
Simeon Bird,* Ilias Cholis, Julian B. Muñoz, Yacine Ali-Haïmoud, Marc Kamionkowski, Ely D. Kovetz, Alvise Raccanelli, and Adam G. Riess[1]

[1] *Department of Physics and Astronomy, Johns Hopkins University, 3400 N. Charles St., Baltimore, MD 21218, USA*

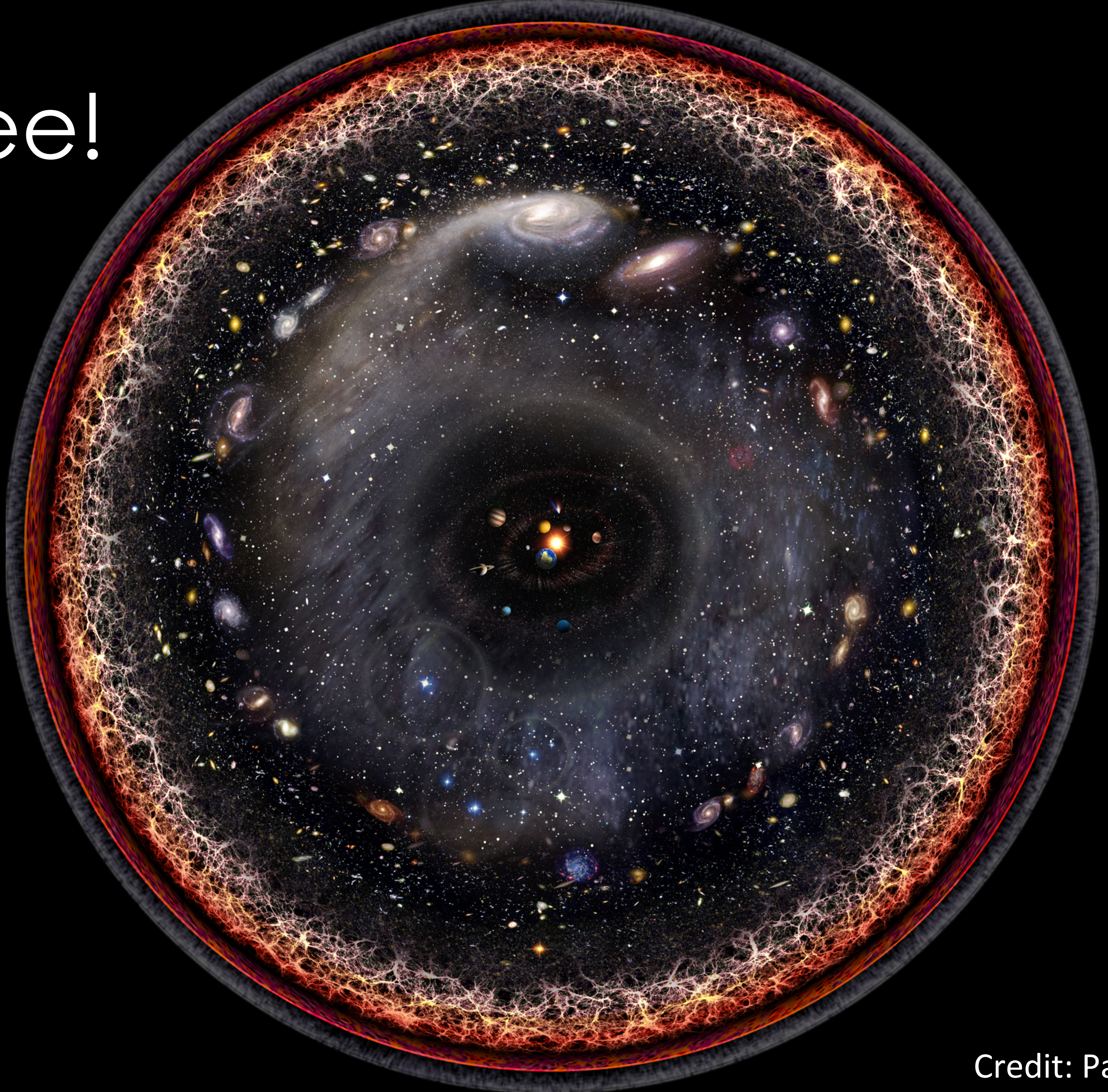
We consider the possibility that the black-hole (BH) binary detected by LIGO may be a signature of dark matter. Interestingly enough, there remains a window for masses $10\,M_\odot \lesssim M_{\rm bh} \lesssim 100\,M_\odot$ where primordial black holes (PBHs) may constitute the dark matter. If two BHs in a galactic halo pass sufficiently close, they can radiate enough energy in gravitational waves to become gravitationally bound. The bound BHs will then rapidly spiral inward due to emission of gravitational radiation and ultimately merge. Uncertainties in the rate for such events arise from our imprecise knowledge of the phase-space structure of galactic halos on the smallest scales. Still, reasonable estimates span a range that overlaps the $2-53$ Gpc^{-3} yr^{-1} rate estimated from GW150914, thus raising the possibility that LIGO has detected PBH dark matter. PBH mergers are likely to be distributed spatially more like dark matter than luminous matter and have no optical nor neutrino counterparts. They may be distinguished from mergers of BHs from more traditional astrophysical sources through the observed mass spectrum, their high ellipticities, or their stochastic gravitational wave background. Next generation experiments will be invaluable in performing these tests.

arXIv 1603.00464

$$\Omega_{gw}(f) \approx \# \varepsilon^4 \Omega_{rad} \, ; h \approx \# 10^{-10} \varepsilon^2 (\mathrm{MeV} / T_s) \text{ at horizon}$$



we shall see!

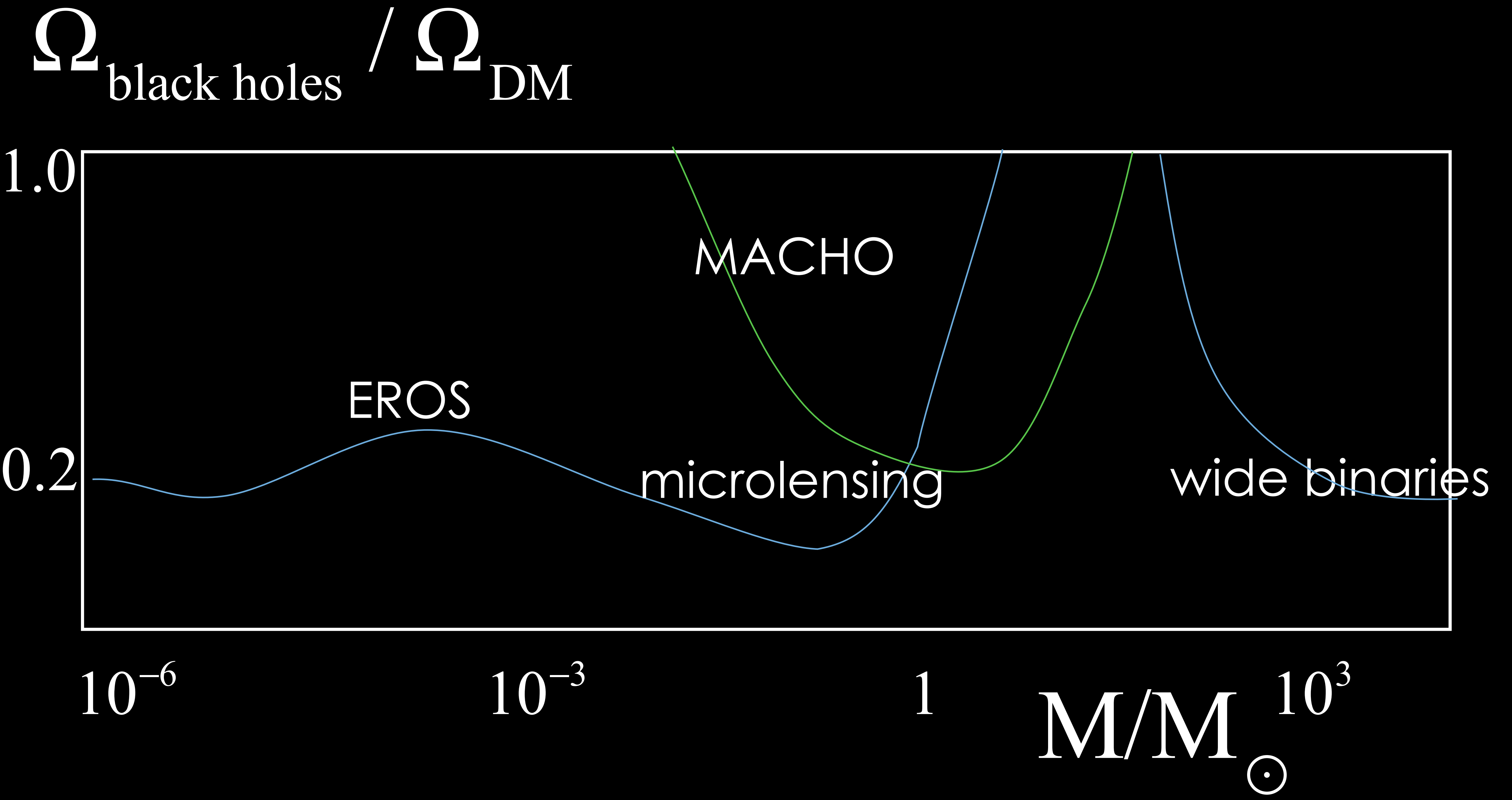


Credit: Pablo Carlos Budassi

will Africa produce the next Einstein?

we shall see!


Thank you!



$\Omega_{black\ holes} / \Omega_{DM}$
1.0
0.2
MACHO
EROS
microlensing
wide binaries
10^{-6}
10^{-3}
1
10^{3}
$M/M_{\odot}$

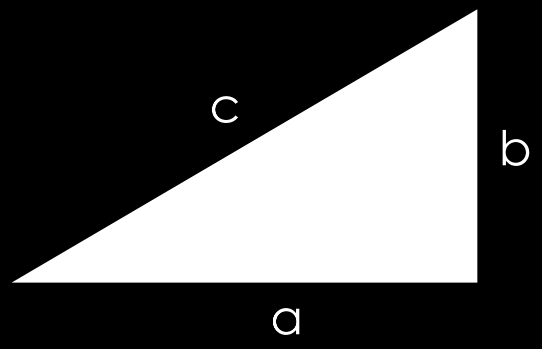
For black holes to contribute Ω_{BH} today, need

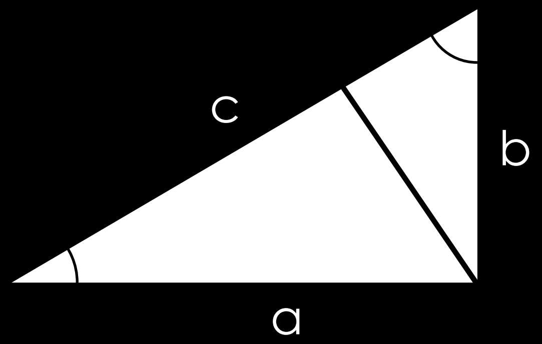
$$\mathrm{erfc}[\frac{1}{\varepsilon^2}] \sim \frac{T_{eq}}{T_{form}} \Omega_{BH}$$

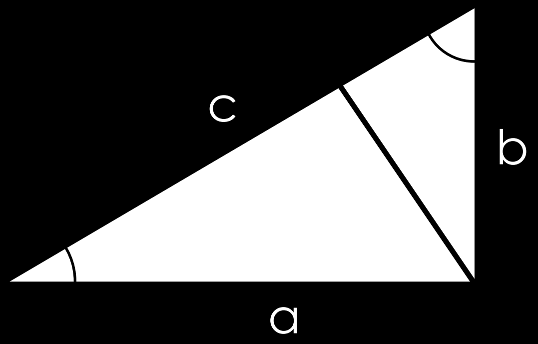
on the corresponding comoving scale, *i.e.*,

$$\varepsilon \sim \frac{1}{\sqrt{\ln(\frac{T_{eq}}{T_{form}} \Omega_{BH})}} \sim 0.2 \text{ for } T_{form} \sim 1 \text{ GeV}$$

Note: depends only logarithmically on Ω_{BH}, so constraint improves *exponentially* with bound on gravitational wave background

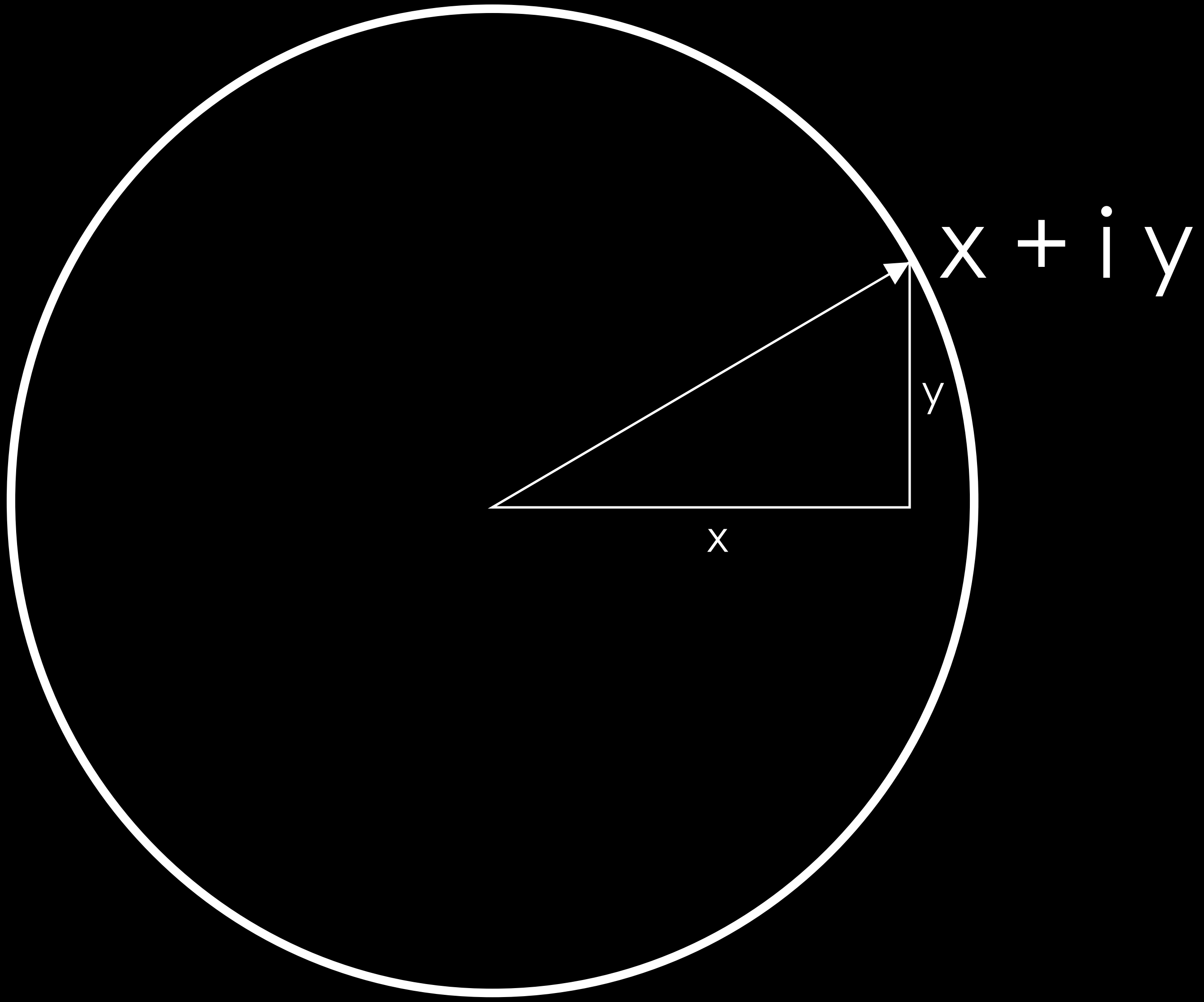

c
b
a

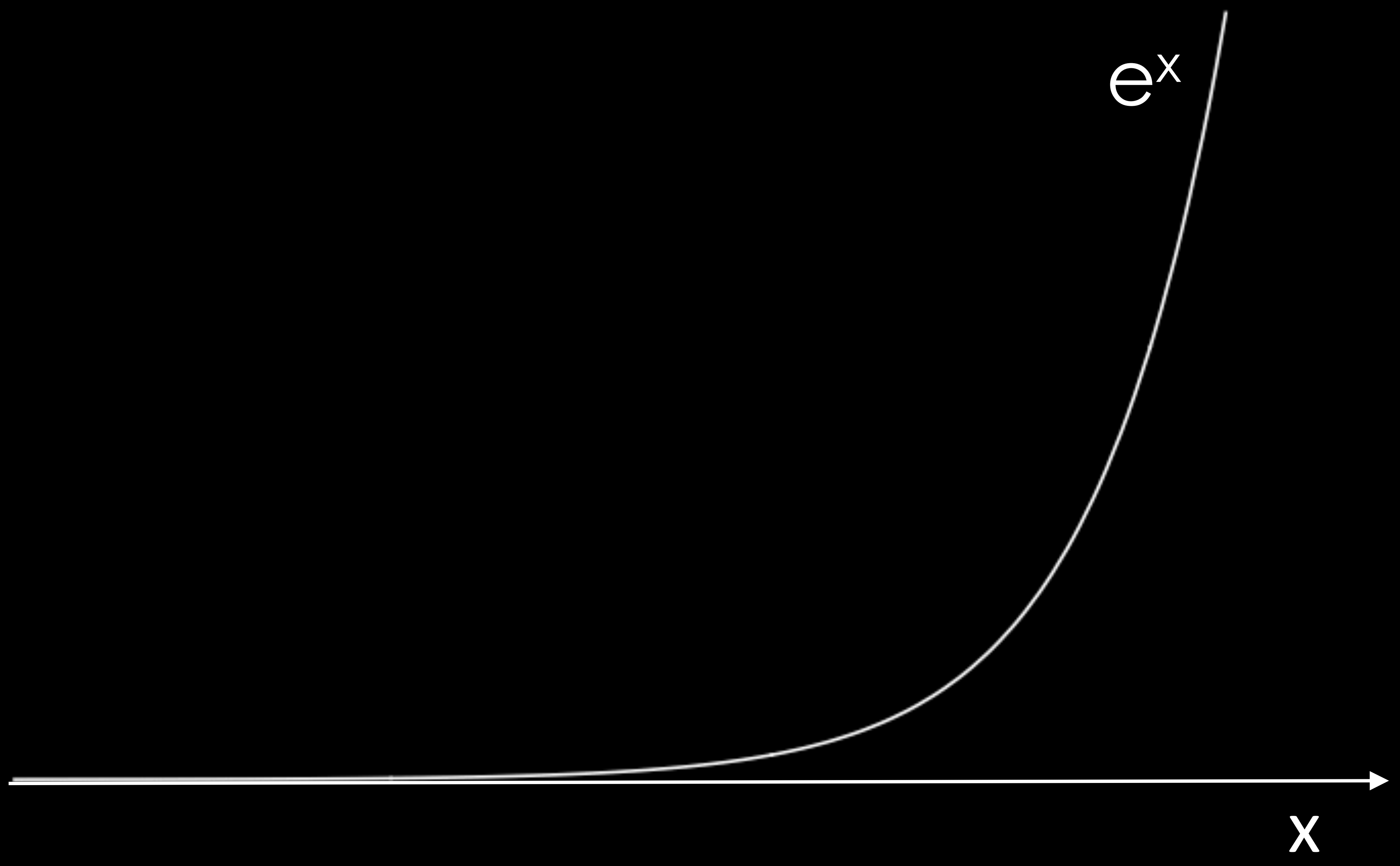

c
b
a



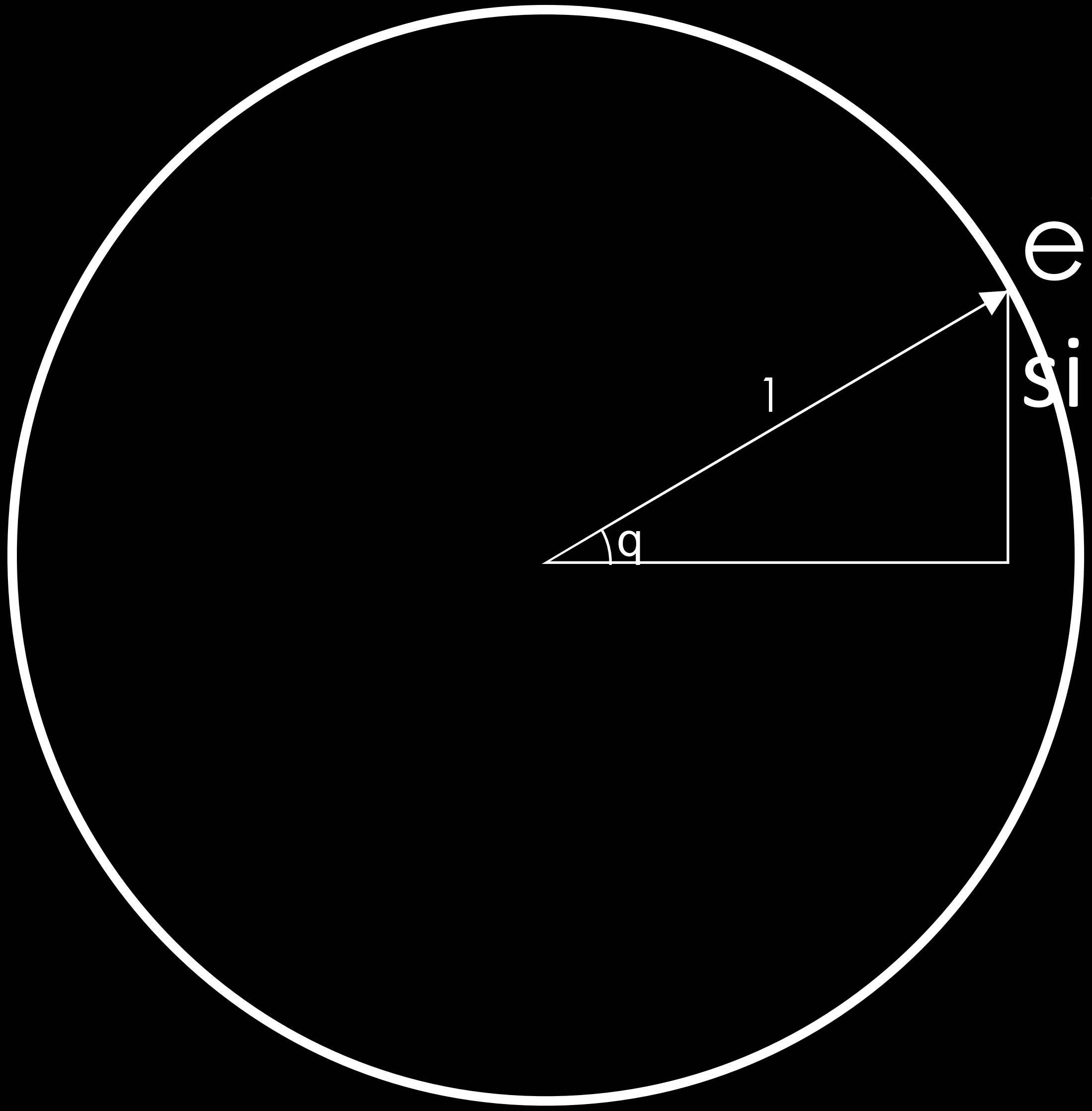
$$a^2+b^2=c^2$$

$$i^2 = -1$$

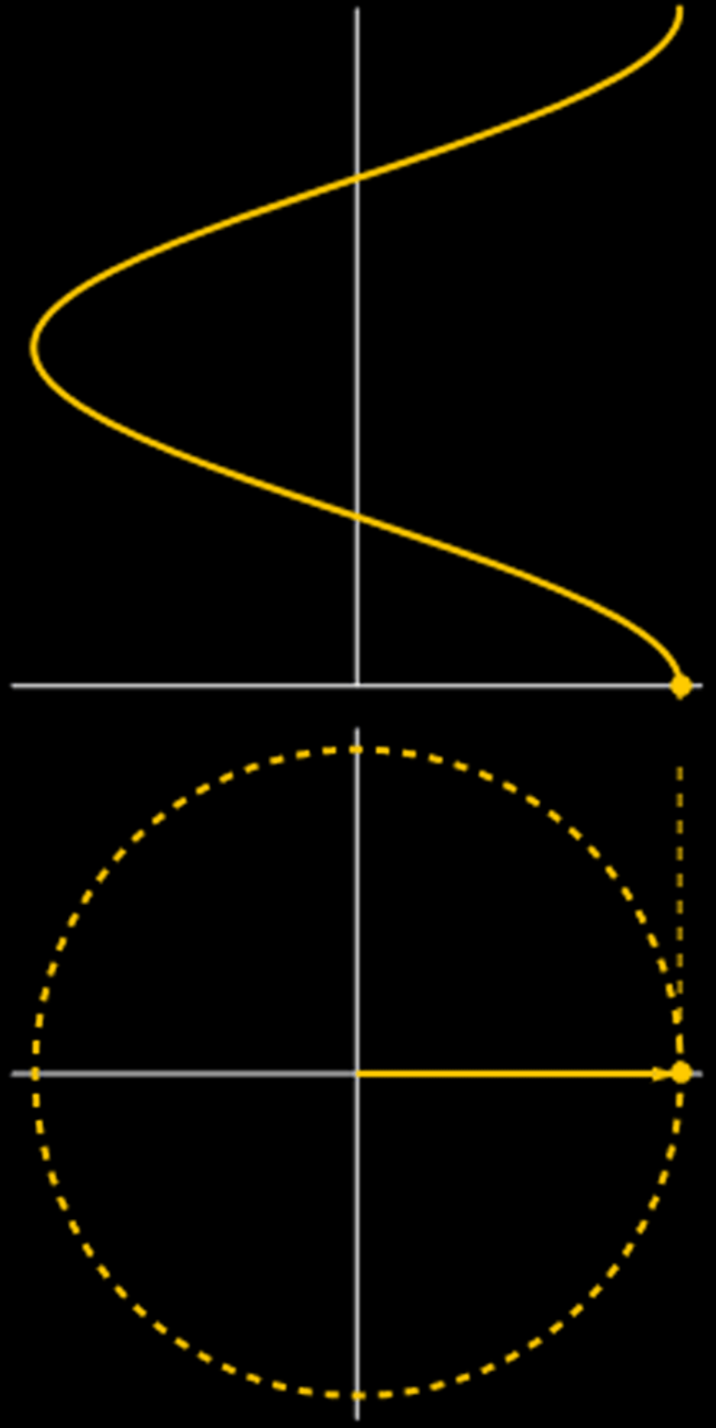

x + i y
y
x



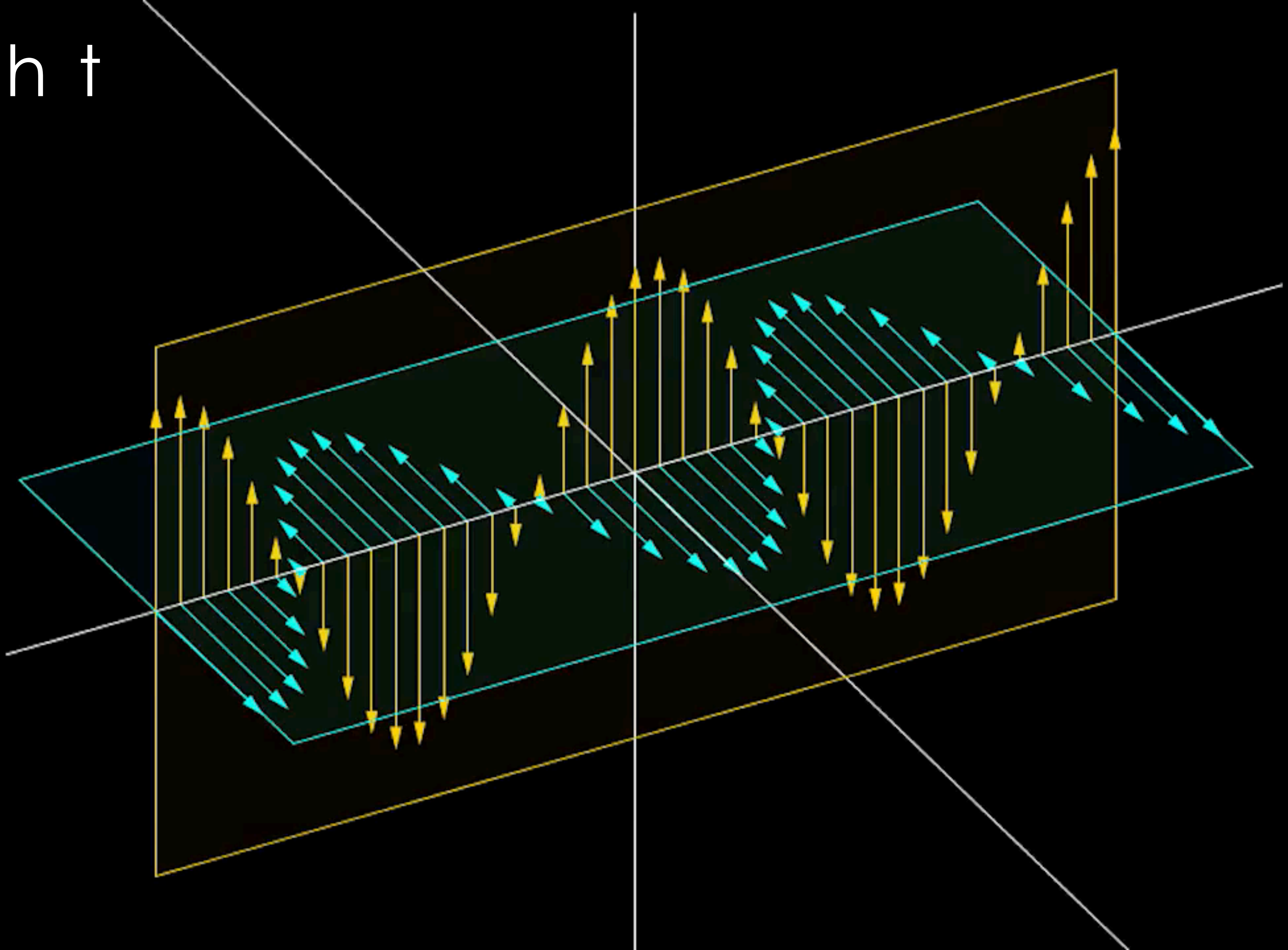
e^x
x



e^{iq} = cosq +i sinq



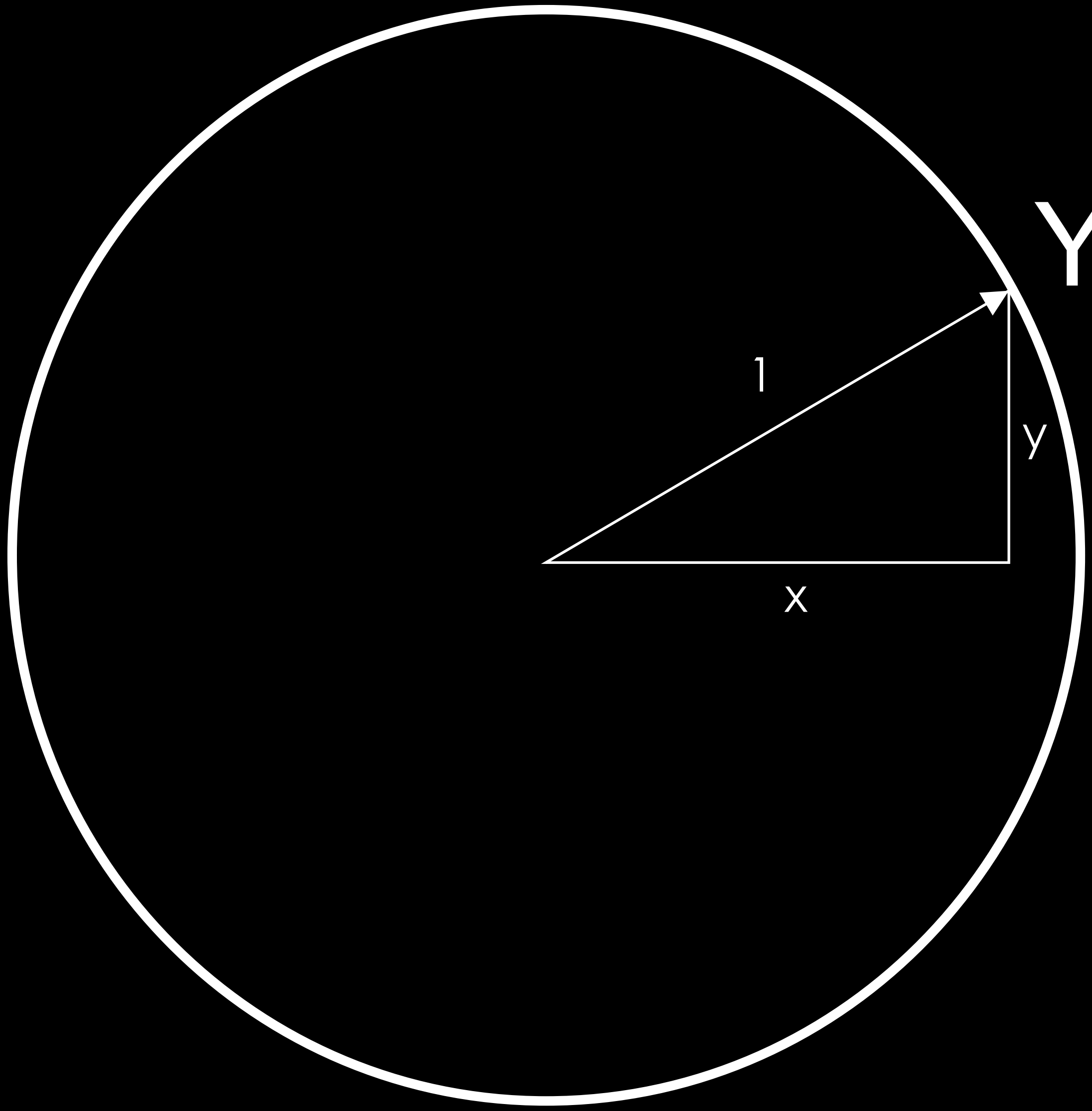
light



all is waves

p o s s i b i l i t y   w a v e s

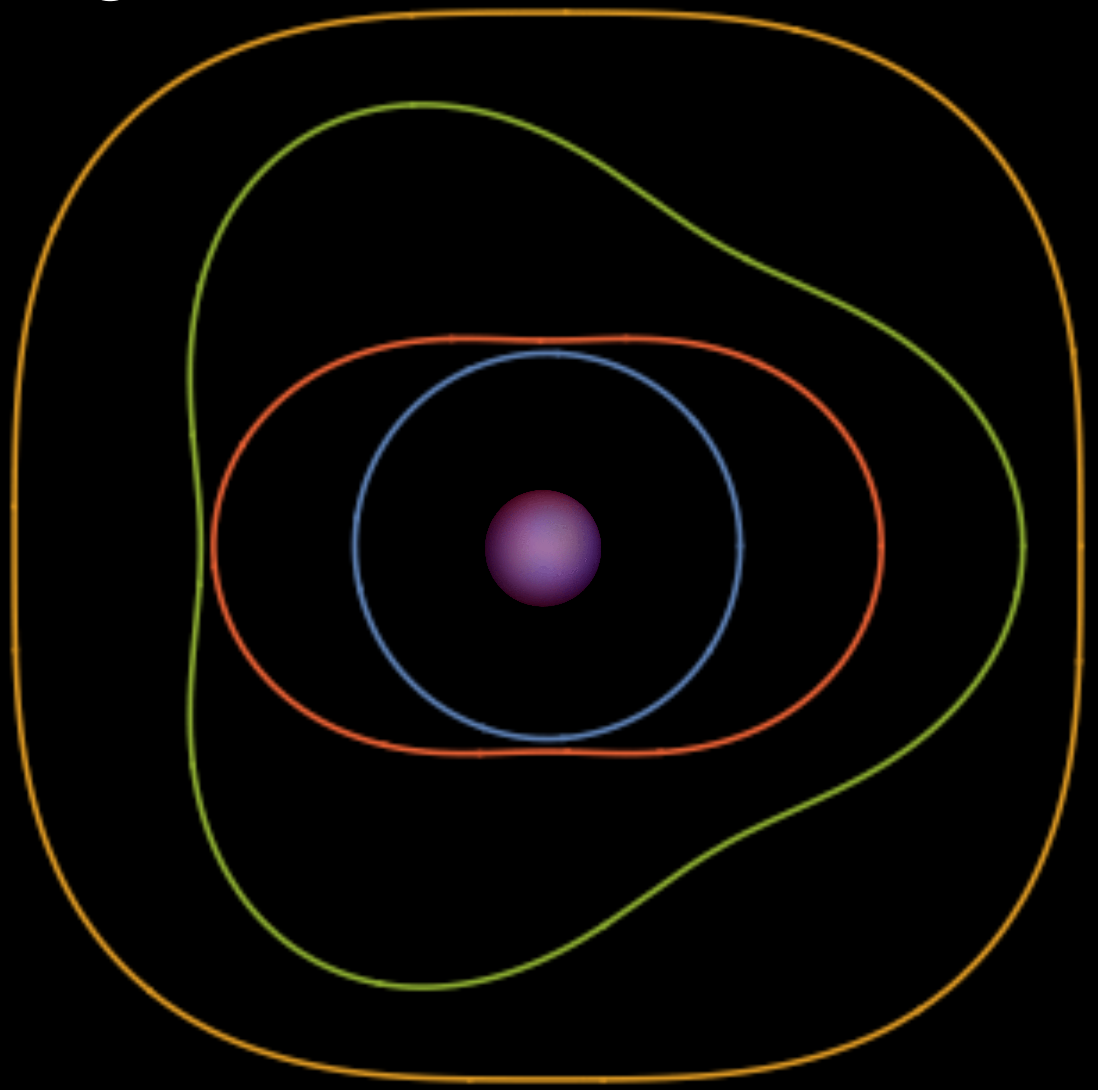
p r o b a b i l i t y



$$Y = x + iy$$

$$|Y|^2 = x^2 + y^2 = 1$$

b o h r   a t o m



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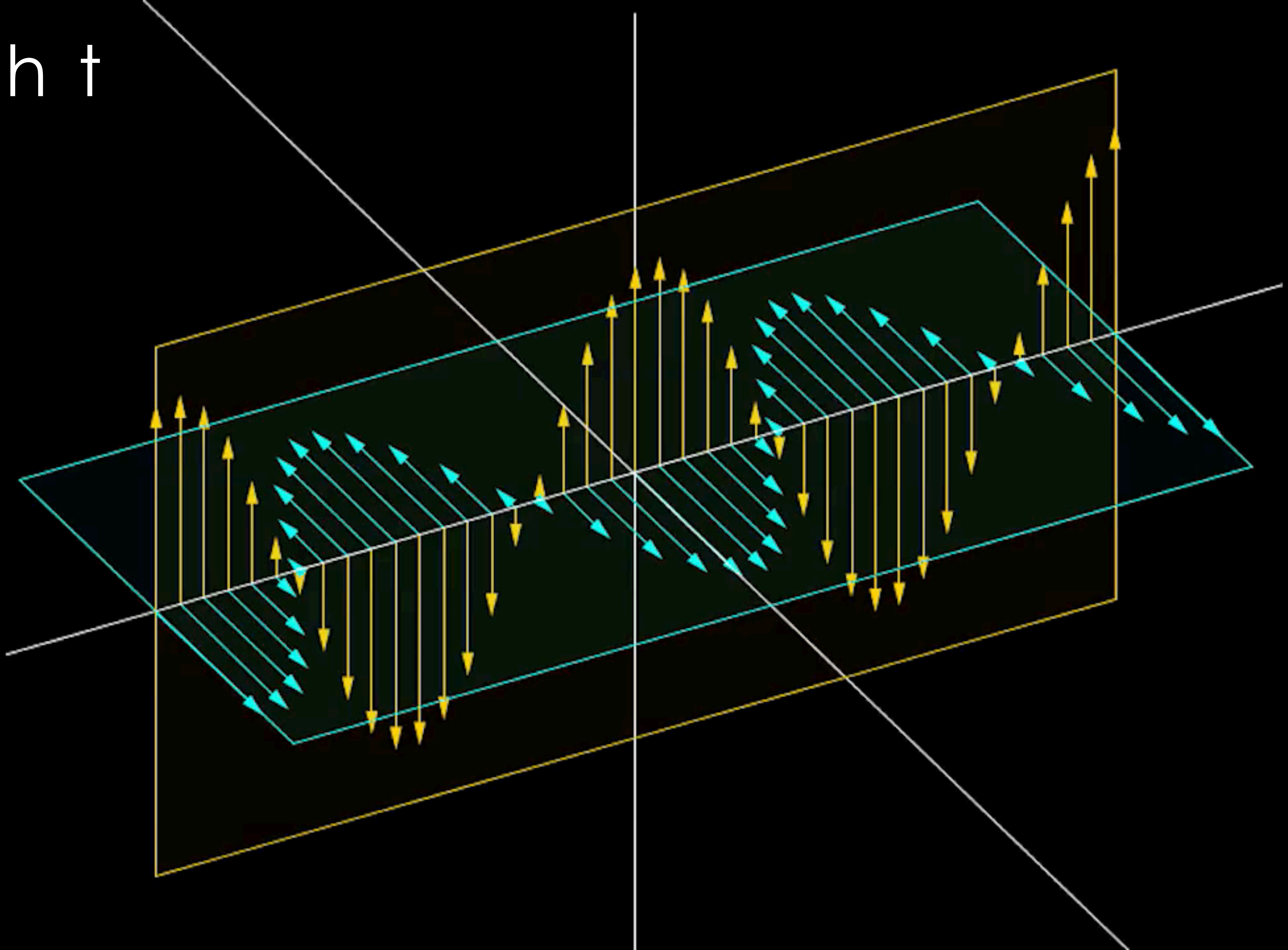
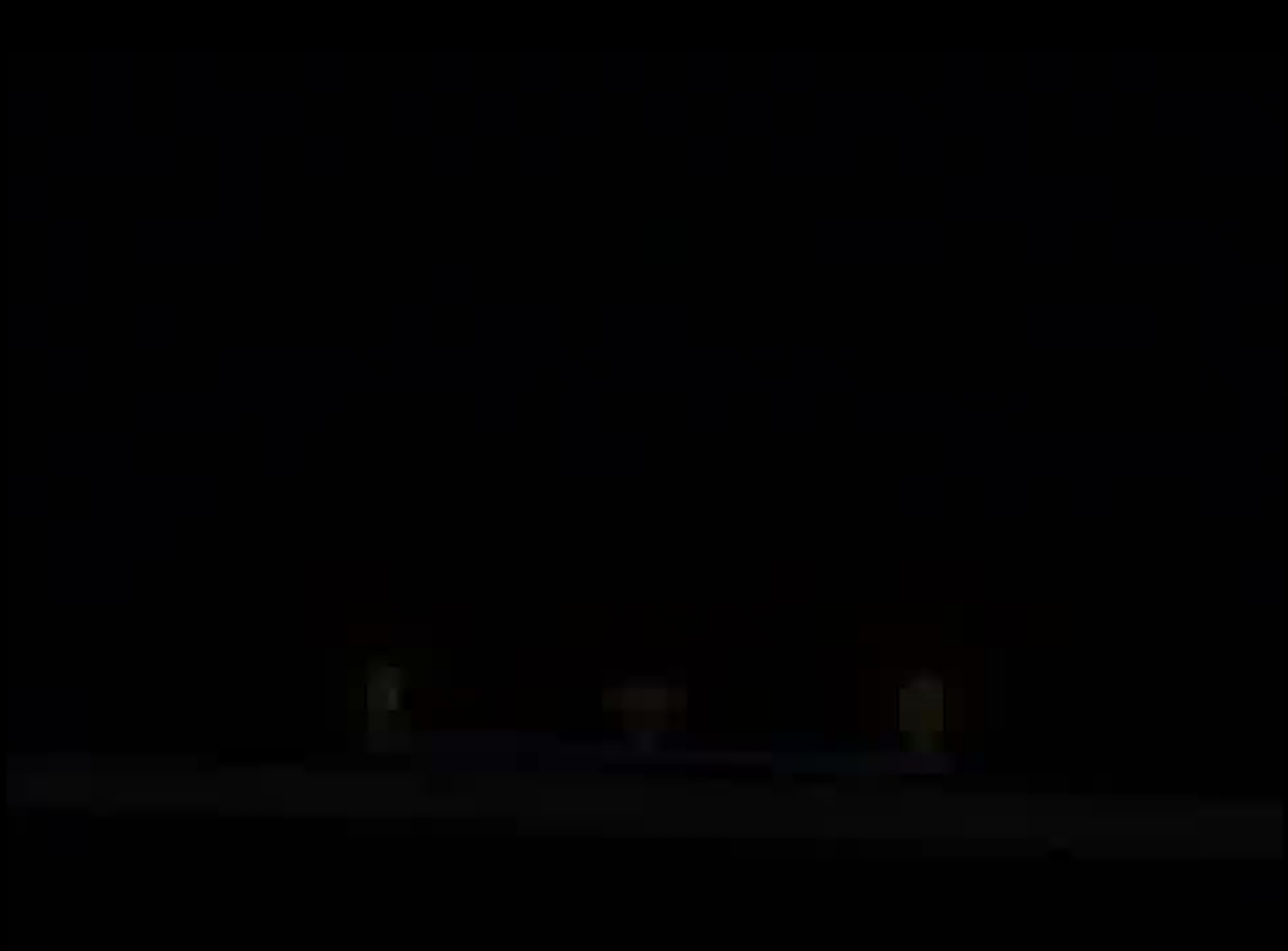
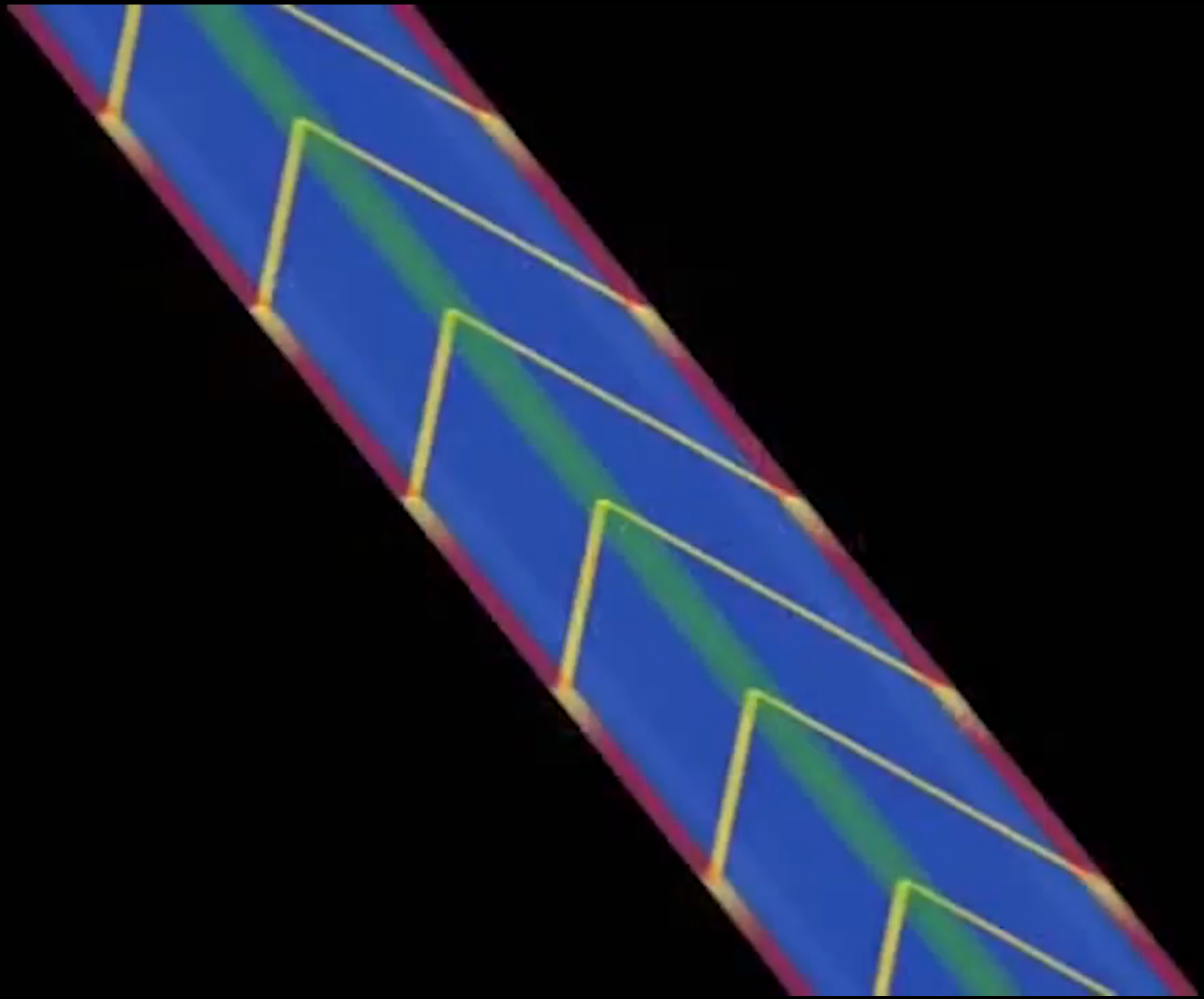




Credit: udiprod



Credit: udiprod

Credit: udiprod

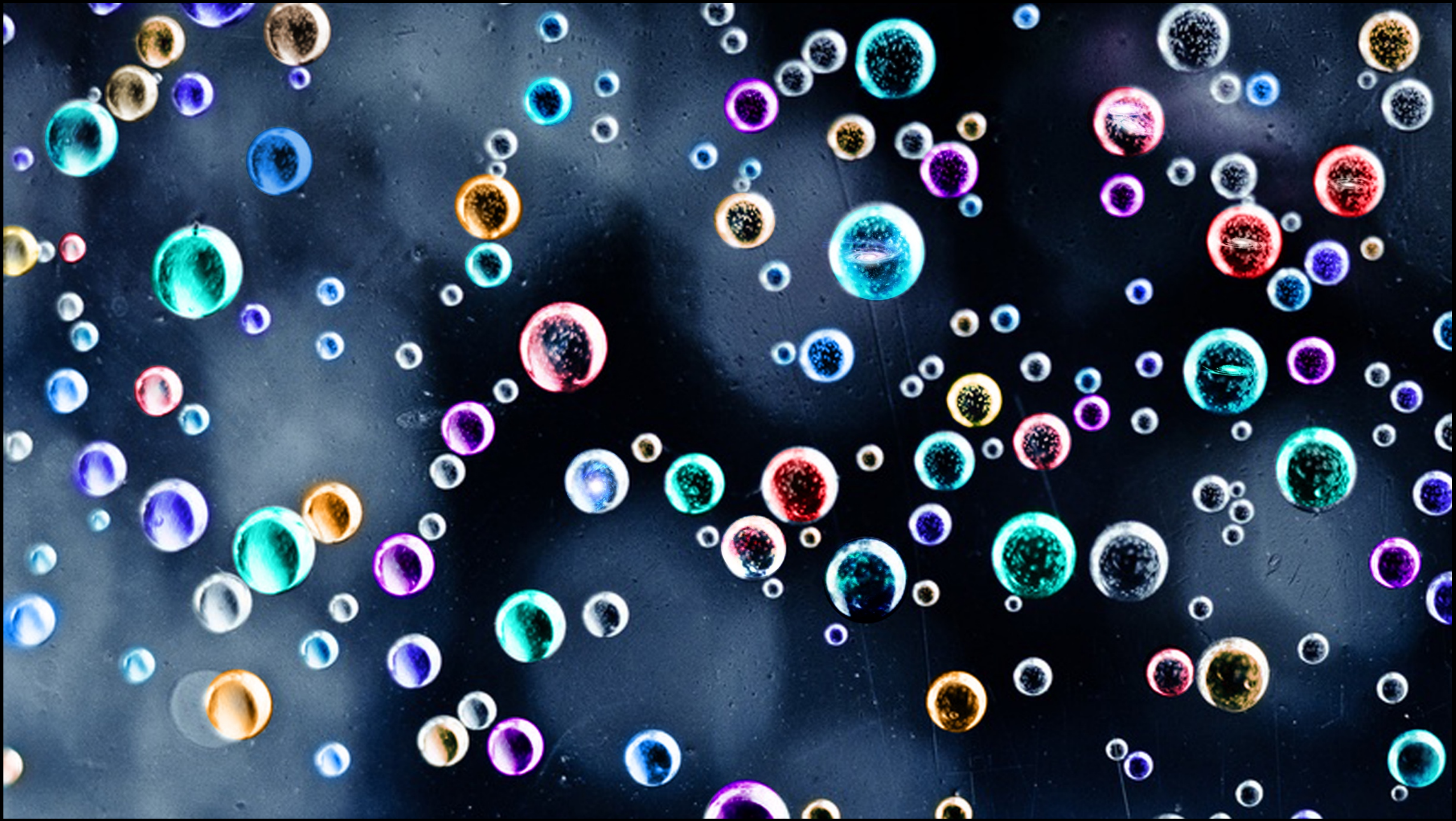
l o o k i n g   b a c k   i n   t i m e

???

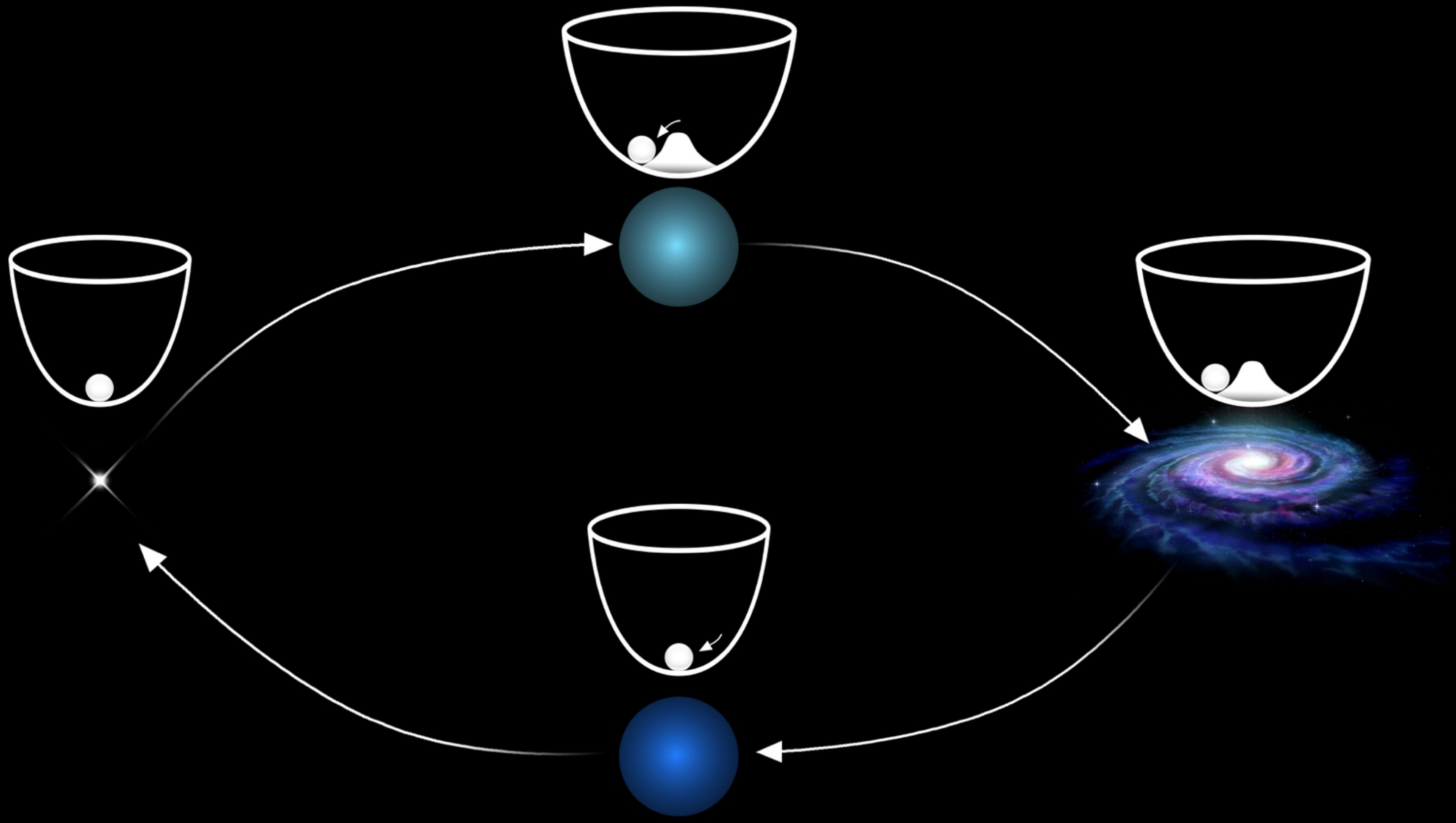
the smallest puzzle

b o u n c i n g   u n i v e r s e

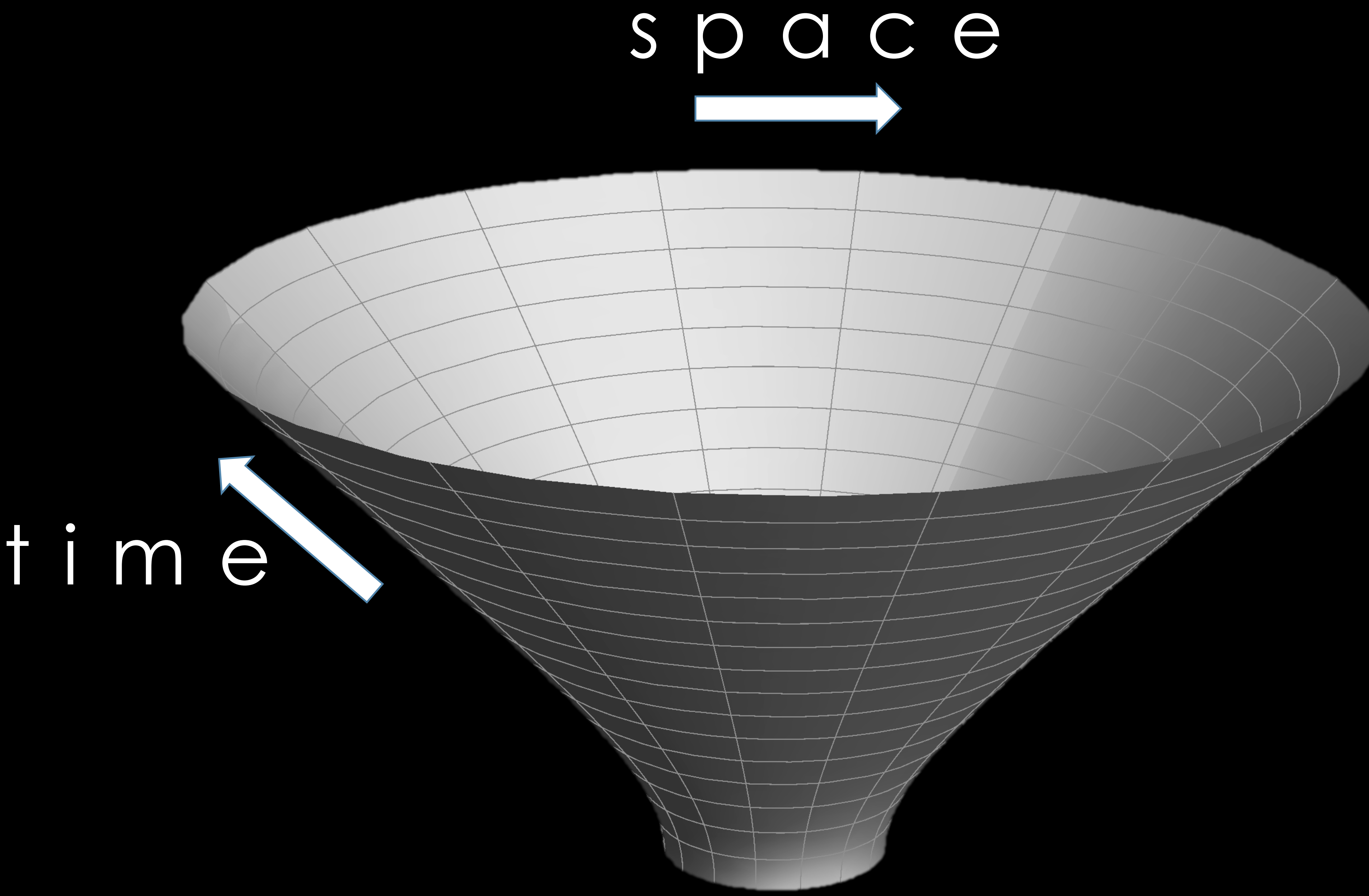
a multiverse?



or cyclic universe?



thank you


space
time