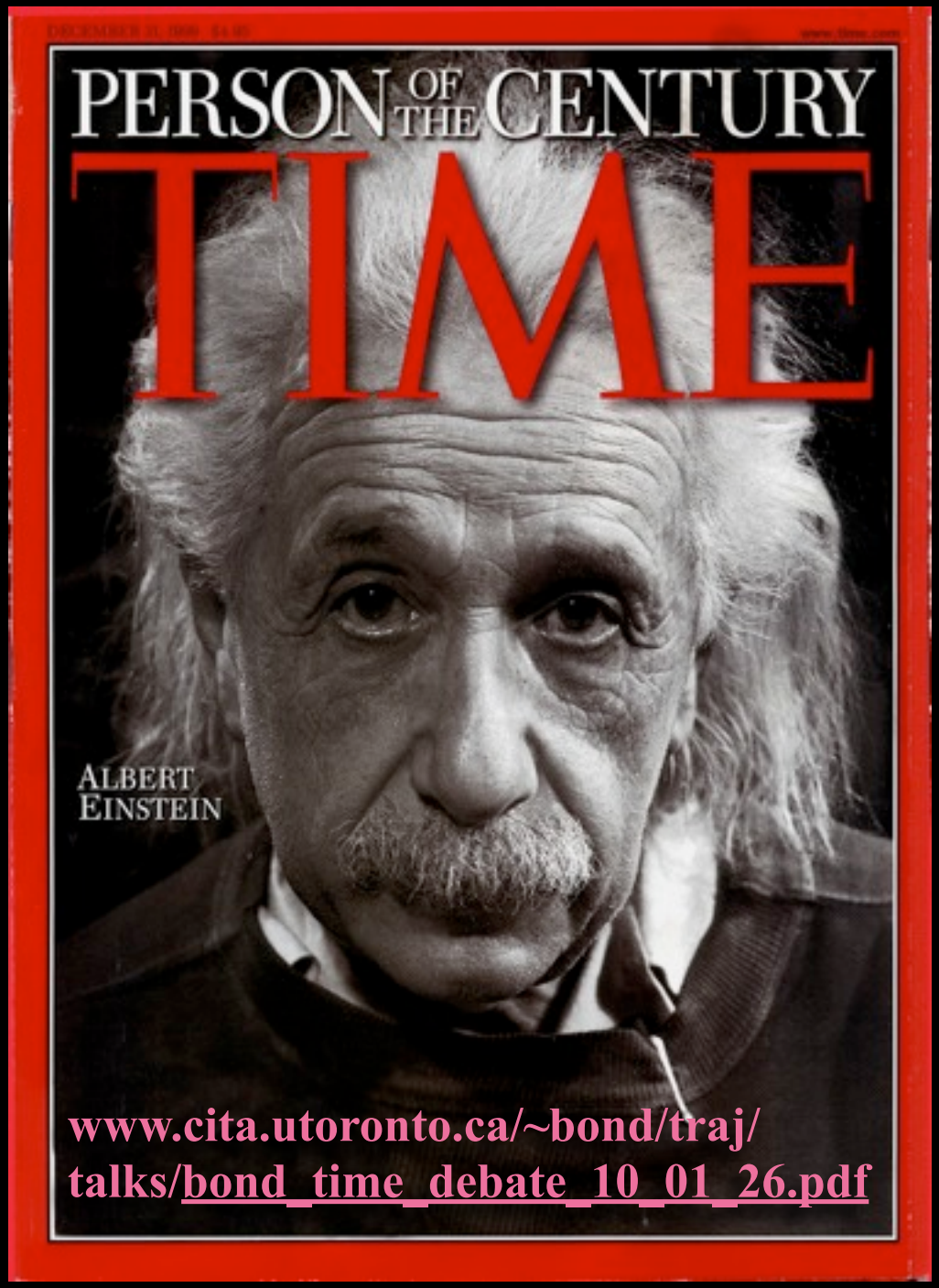
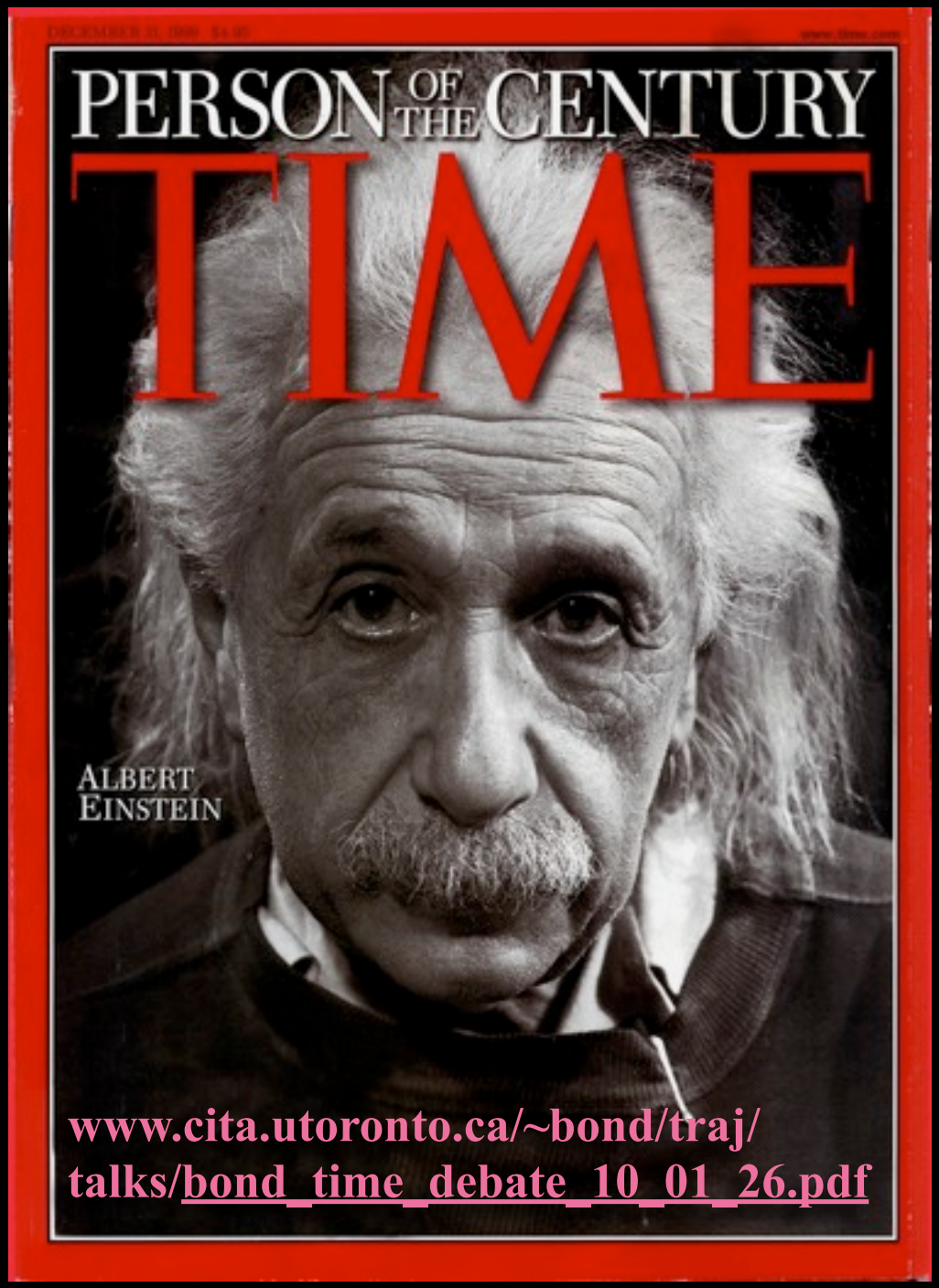


MY TIME I, me, you, U

ASTRONOMICAL TIME

PHYSICS TIME

COSMIC TIME



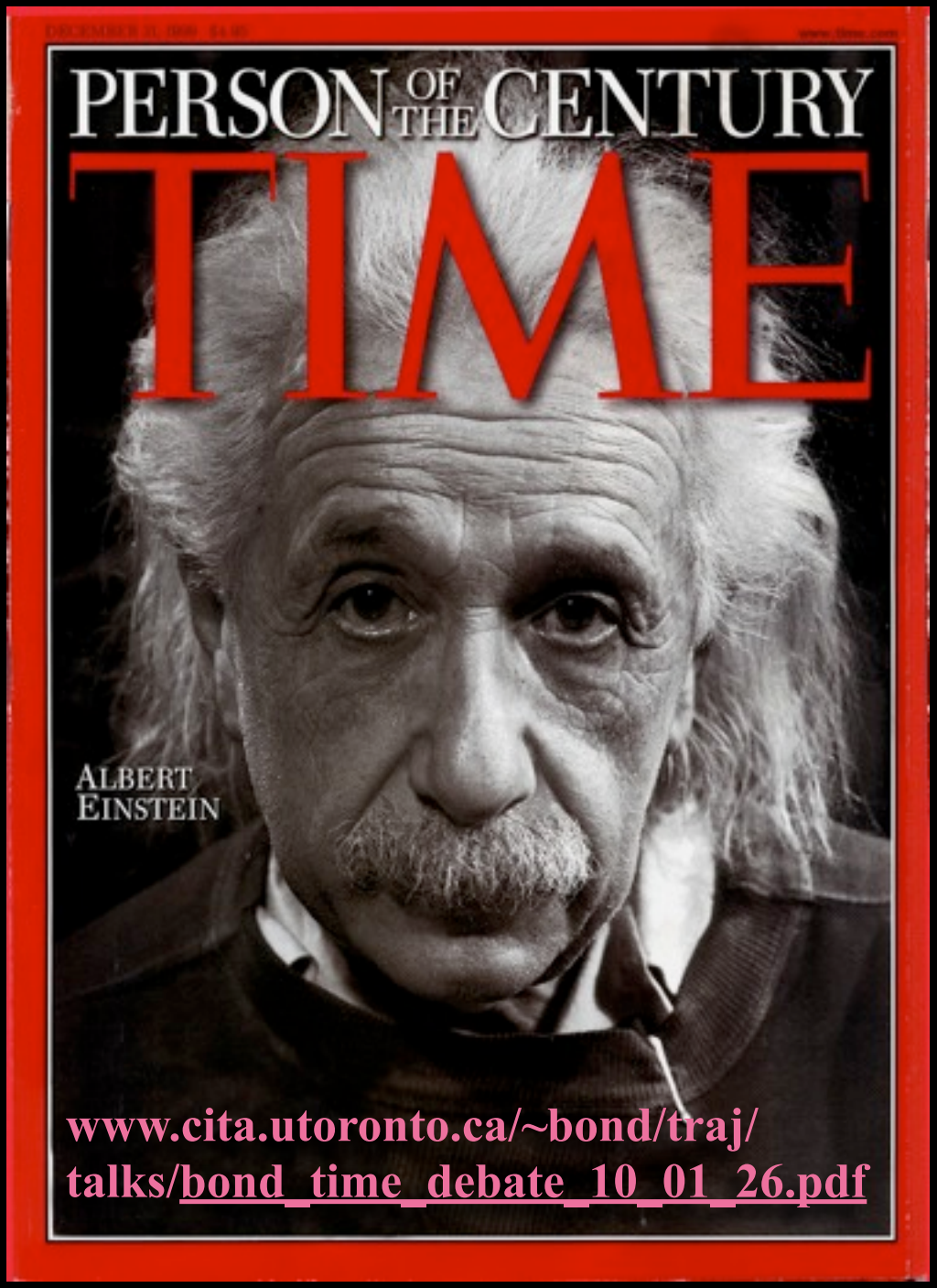
www.cita.utoronto.ca/~bond/traj/talks/bond_time_debate_10_01_26.pdf

MY TIME **I(t), me(t), you(t), U(t)**
coherence of being; in the NOW;
past & future, history & forecasting

ASTRONOMICAL TIME

PHYSICS TIME

COSMIC TIME

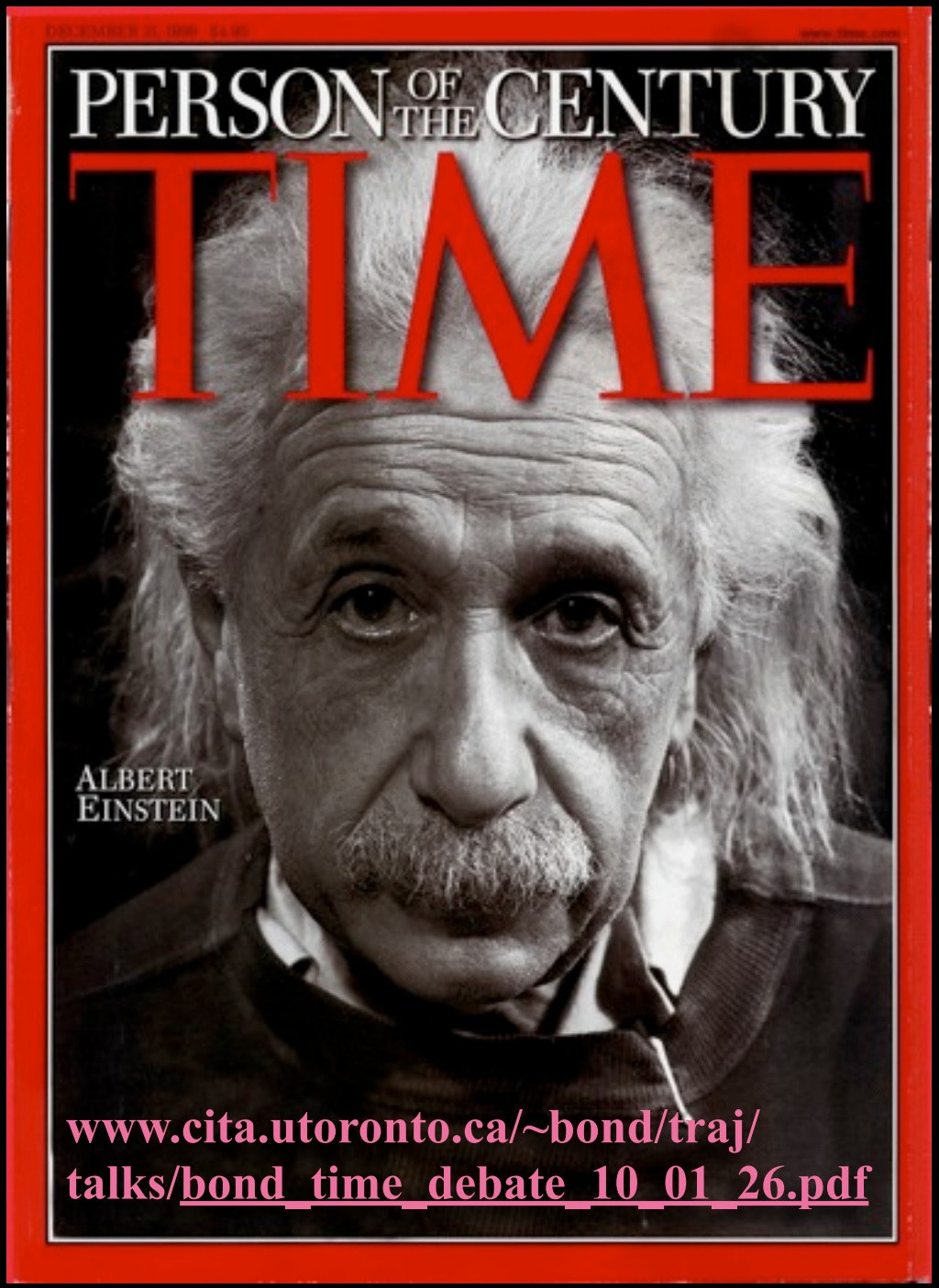


MY TIME I(t), me(t), you(t), U(t) coherence of being; NOW; past & future, history & forecasting

ASTRONOMICAL TIME counting cycles = clock: years *(seasons & agriculture)*, **moons** *(wax &wane)*, **days** *& nights*, **hours** *(medieval)*; **sundials & calendars**

PHYSICS TIME

COSMIC TIME



MY TIME I(t), me(t), you(t), U(t) coherence of being; NOW; past & future, history & forecasting
ASTRONOMICAL TIME counting cycles = clock: years *(seasons & agriculture)*, **moons** *(wax &wane)*, **days** & *nights*, **hours** *(medieval)*; *sundials, water clocks* ***& calendars***

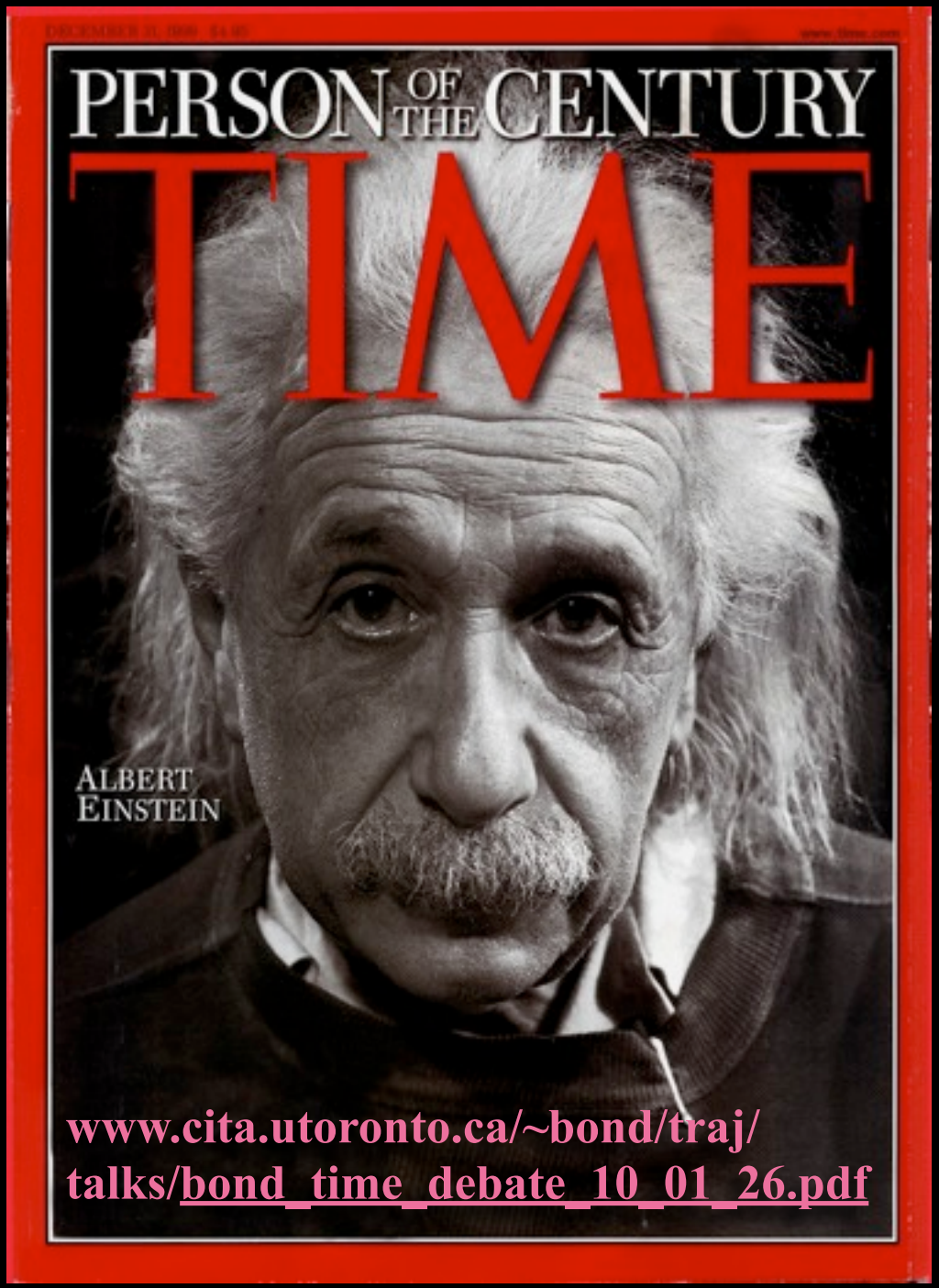
PHYSICS TIME pythagoras
frequency ν harmonics in music

cycles per minute, second; to millisec, microsec, nanosec, picosec, femtosec; ***pendulum, spring & crystal clocks,*** **cesium atom standard to ± 30 nanosec** 1955-67 0.11 nsec

from string oscillations to the cosmic music of the spheres
frequency = conjugate to time
the quantum:
energy E=hν conjugate to time

(wavelength)$^{-1}$ & momentum conjugate of space, of light and structure; ***phase-space, phase & action***

COSMIC TIME



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MY TIME I(t), me(t), you(t), U(t) coherence of being; NOW; past & future, history & forecasting

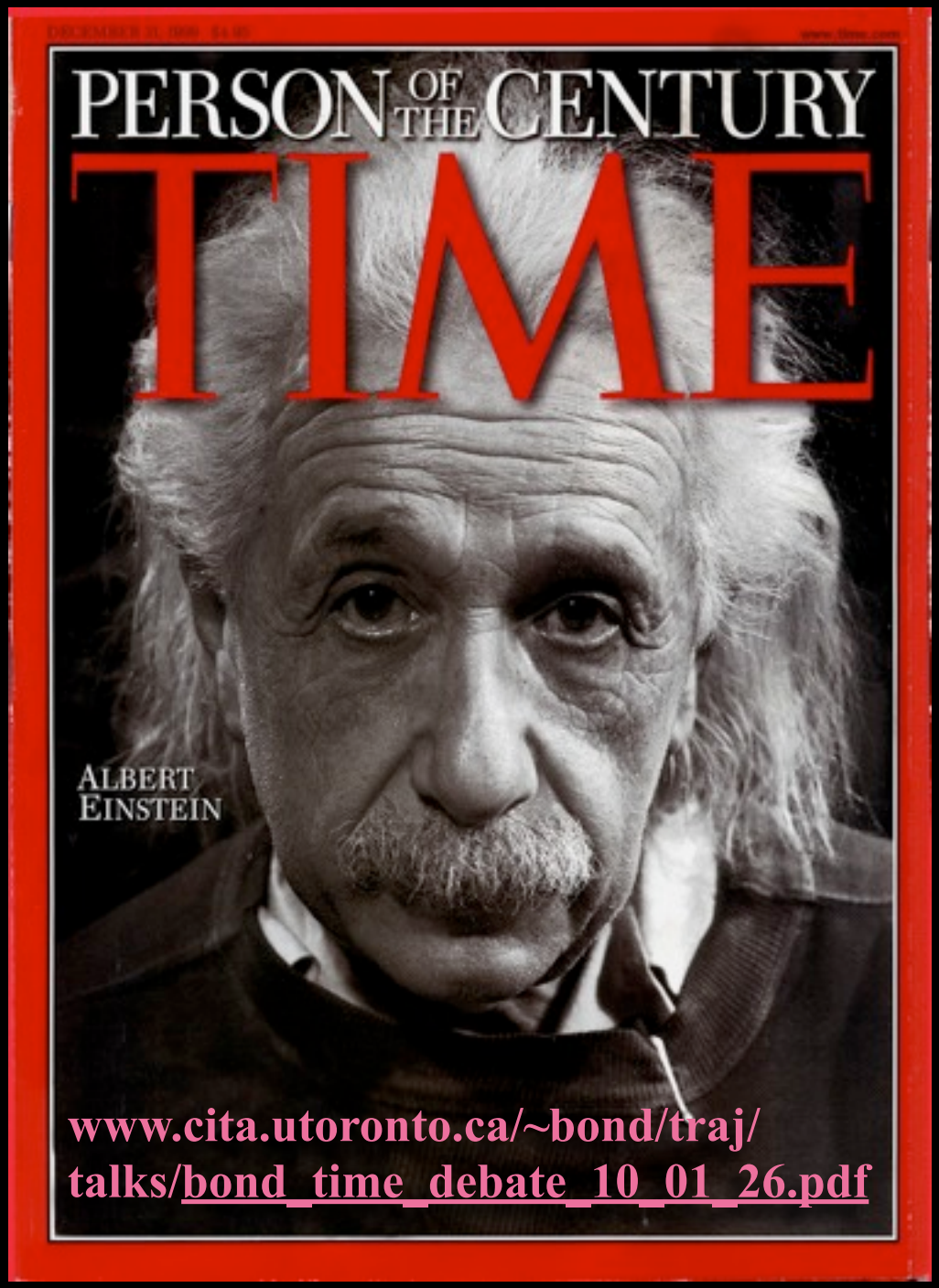
ASTRONOMICAL TIME **counting cycles = clock: years** *(seasons & agriculture)*, **moons** *(wax &wane)*, **days** *& nights*, **hours** *(medieval)*; **sundials & calendars**

PHYSICS TIME *pythagoras frequency* ν *harmonics in music cycles per minute, second; to* ***milli, micro, nano, pico, femtosec;*** *spring clocks, digital clocks, cesium standard from string oscillations to the cosmic music of the spheres frequency = conjugate to time the quantum: energy* $E=h\nu$ *conjugate to time* $(\text{wavelength})^{-1}$ *& momentum conjugate of space, of light and structure; phase-space, phase & action*

shortest usable times: ultrafast lasers pulses femtosec ⇒ attosec (10^{-18})

CERN quark-gluon plasma light pulses **yoctosec (10^{-24}); LHC** collisions **(10^{-28})**

COSMIC TIME longest 14 Gyr ($10^{17.6}$)



www.cita.utoronto.ca/~bond/traj/talks/bond_time_debate_10_01_26.pdf

PHYSICS TIME:
points move thru *phase*-space as time progresses worldline: x(t), p(t)

Special Relativity 1905
spacetime (x,t: p,E)
*The views of space and time which I wish to lay before you have sprung from the soil of experimental physics, and therein lies their strength. They are **radical.** Henceforth **space by itself, and time by itself, are doomed to fade away** into mere shadows, and **only a kind of union of the two will preserve an independent reality.** Minkowski 1908 after Einstein 1905*

the relativity of time and space t(x)⇒ so many times

BUT time IS fundamentally different from space. 1 time dimension, 3 (⇒ 10) space dimensions, related by:

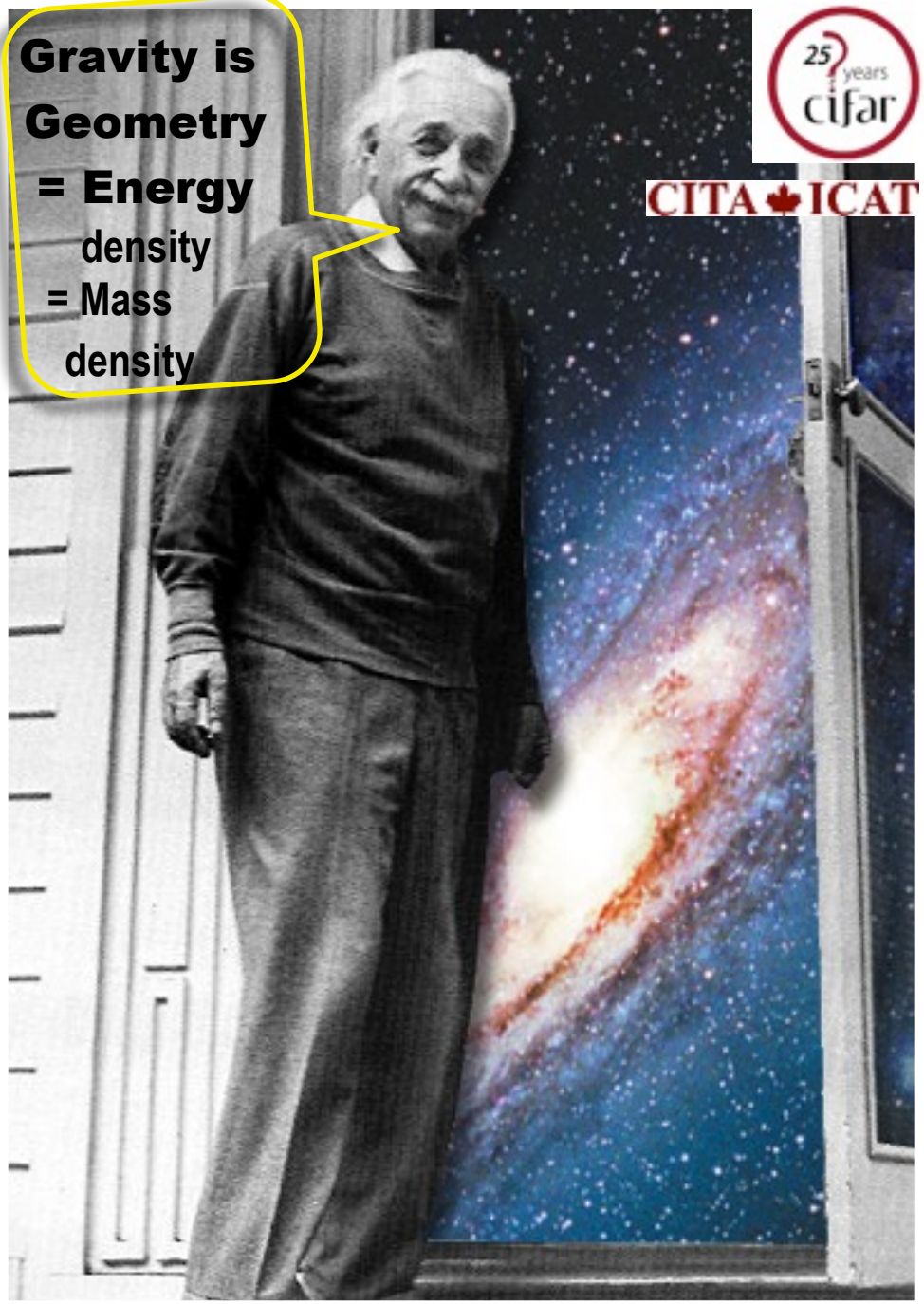
the ultimate speed limit: of light & other signals

way back is far out: *only events in our past light cone influence us, we can only influence our future light cone*

we cannot "see" beyond our past horizon

General Relativity 1916-17 cosmology
gravity warps time

COSMIC TIME



ASTRONOMICAL TIME + PHYSICS TIME =

COSMIC TIMEs *Gigayear = aeon*

Hubble expansion rate H = velocity/distance
1/H 13.6 ± 1.5 Gyr ⇒13.69 ± 0.50 Gyr

many **TIMEs(SPACE)**. dynamical cosmic clocks
expansion factor a = 1/**compression** = 1/ (1+**redshift**)
ln(a) (e-foldings) is better, **>130 ABang, 67 AMatter**

early Universe physical clocks *ln*a, *ln*H, *ln*Ha
but they fluctuate by QUANTUM vacuum effects - this is the origin of all cosmic structure!!!!; quantum breakdown in the **ultra-early Universe** ***Time emerges?***

later Universe, no expansion in earth, star & galaxy gravity wells ⇒*bad clocks even reversing in collapse*

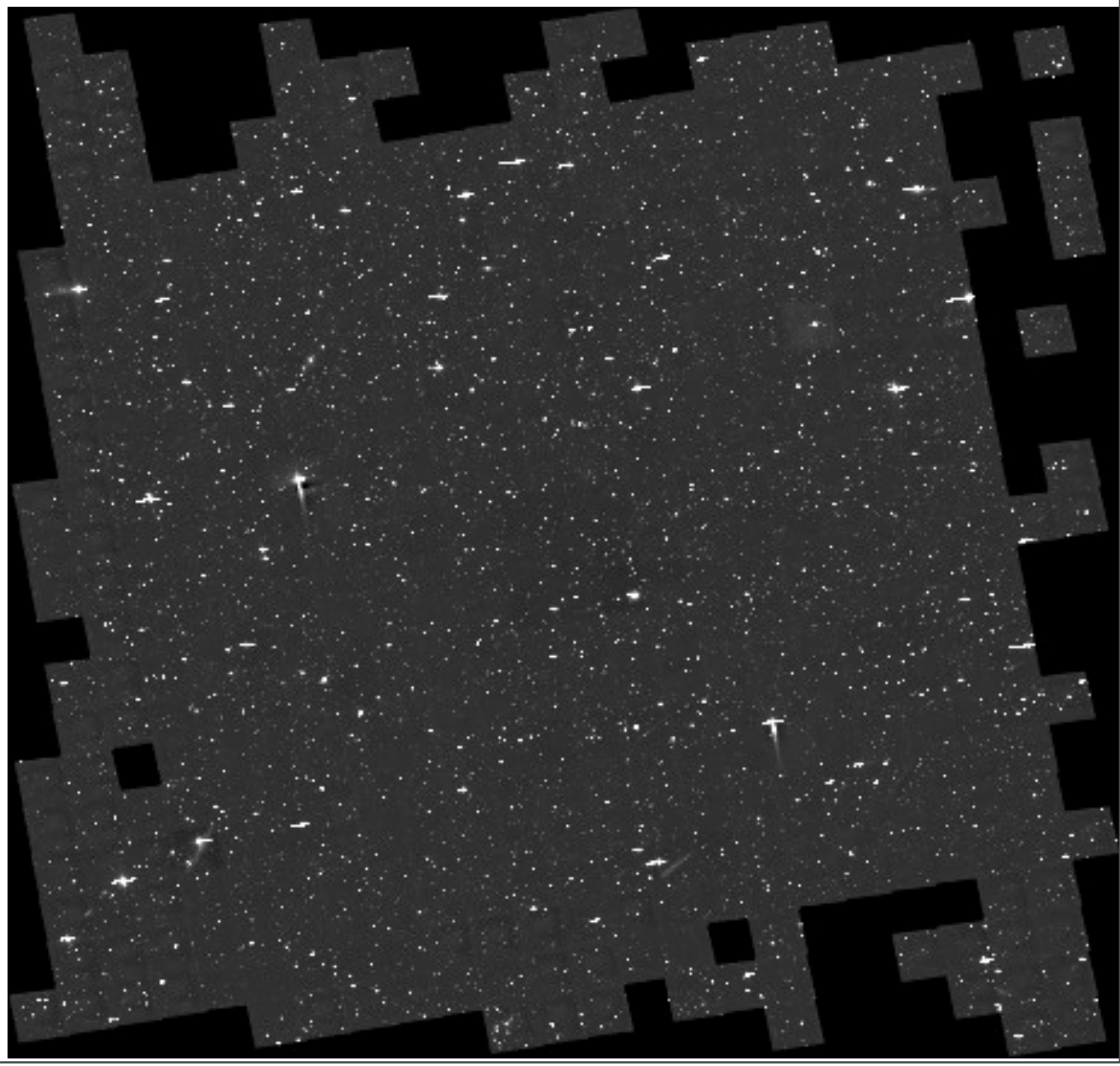
atomic, nuclear clocks OK but ticks vary with gravity: clocks speed up climbing out of gravity wells (redshift), slow down dropping into gravity wells (blueshift)

cosmic veil: the ***first light*** is released 13.7-.00038 Gyr an effective ***horizon***, but there is ***beyond*** our horizon

Hubble "Cosmic Evolution Survey"

- 2 deg^2 Hubble Space Telescope data (largest ever Hubble program)
- > 2 million faint galaxies with measurable shapes

& Beyond Hubble: JWST (+TMT+)



Hubble "Cosmic Evolution Survey"

- 2 deg^2 Hubble Space Telescope data (largest ever Hubble program)
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& Beyond Hubble: JWST (+TMT+)

a **starless "dark age"** before the **most distant galaxies**

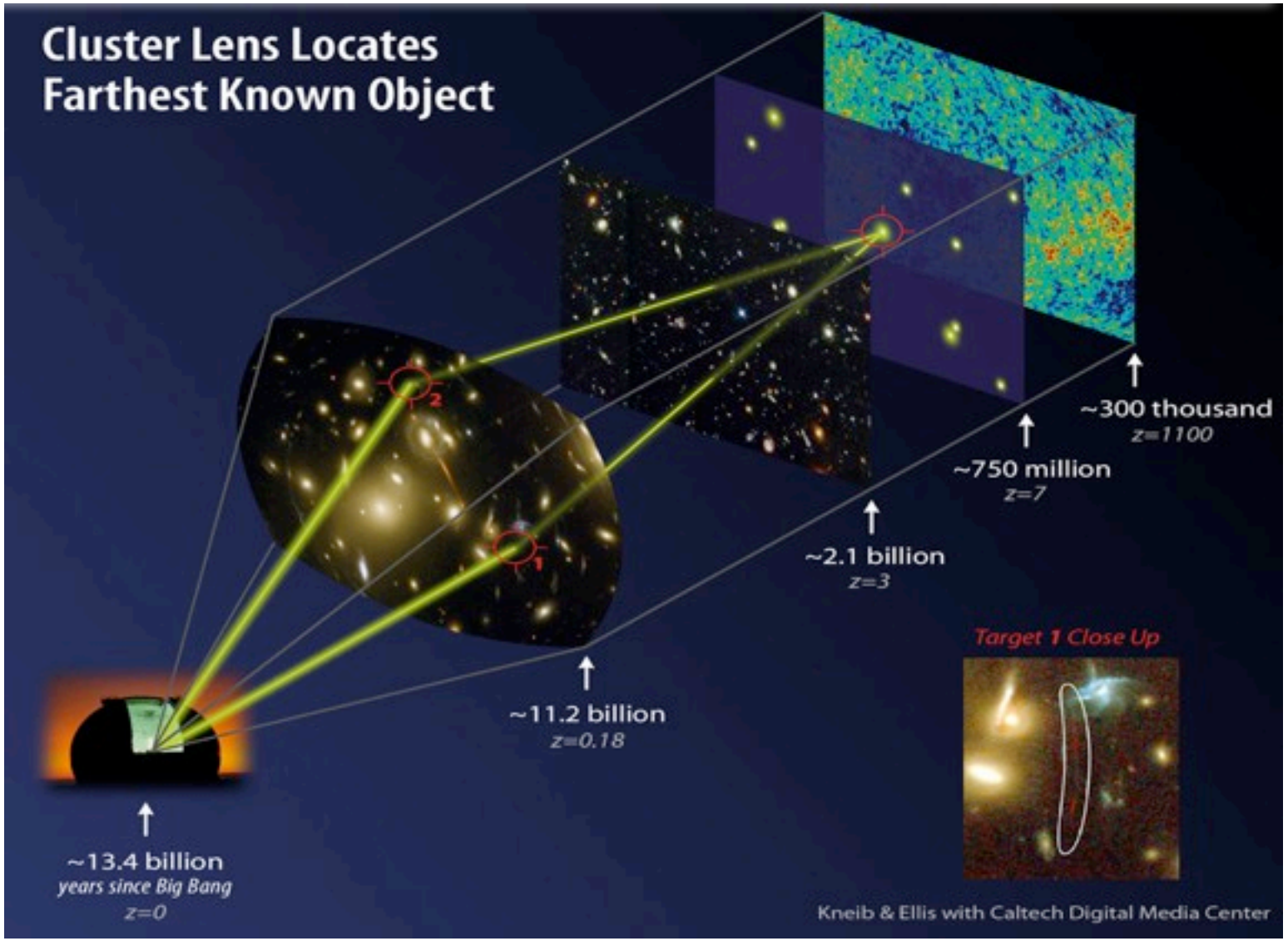
dwarflets & the 1st stars

form at compression 13

1st light: Cosmic Microwave Background

released at compression 1100; formed at ~10^{30}

most distant explosion (gamma ray burst) known, 0.63 Gyr AfterBang, 13.1 Gyr ago, @compression 9.2 *2009*



cosmic ages Gigayear = aeon

Galactic year earth orbital period around the Milky Way centre **0.22 Gyr**; *centre* **25000 lyrs**

nuclear chronometers, radioactive elements

Uranium-lead for **earth** (hence sun) **4.54 ± 0.02 Gyr** (created **9.15 Gyr AB** After the Big Bang)

Uranium dating in old stars **12.5 ± 3 Gyr** 2001

Uranium/Thorium dating of old stars **11.8 ± 3.7, 10.9 ± 2.9** and **13.5 ± 2.9 Gyr** 2009

ages of oldest Milky Way (evolution of **globular cluster stars**) **~ 13.4 ± 0.9 Gyr** 2001

expansion of the universe, using stars **1/Hubble = 13.6 ± 1.5 Gyr** HST 1999

CMB+ 13.7 ± 1.9 1999 ⇒**13.8 ± 0.3** 2002 ⇒**13.6 ± 0.2** 2005 ⇒**13.7 ± 0.1 AB** 2010

age when the "first stars" were created: **0.68 Gyr AB**

age when the **first light (CMB)** was released: **380081** (**± 1.5%) years AB**

Big Bang Nucleosynthesis age when hydrogen and helium were created **~1 minute**

Dark Matter synthesis age if dark matter are WIMPS ~ **nanosecond** - microsecond

Matter genesis, entropy genesis, Baryogenesis: ~ 10^{-35} seconds???

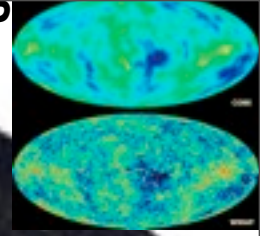
quantum gravity epoch: **2.8 x 10^{-43}** seconds **Planck time (quantum+gravity+light-speed)**

LHC@CERN proton collisions will soon probe **~10^{-28}** sec physics

$$t_P = (hG_{Newton}c^{-5})^{1/2}{}_2$$

our newest & best time machine
ESA/NASA/CSA

WMAP 2001

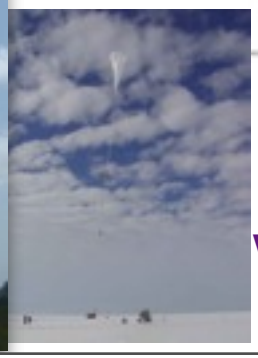


1st Light Survey Aug 09, 1st all sky Feb 2010; 5 in all

WMAP5+ACT 2010 **age = 13.70 ± 0.13 Gyrs, 1/Hubble = 13.69 ± 0.50 Gyrs**

entering the Planck Era

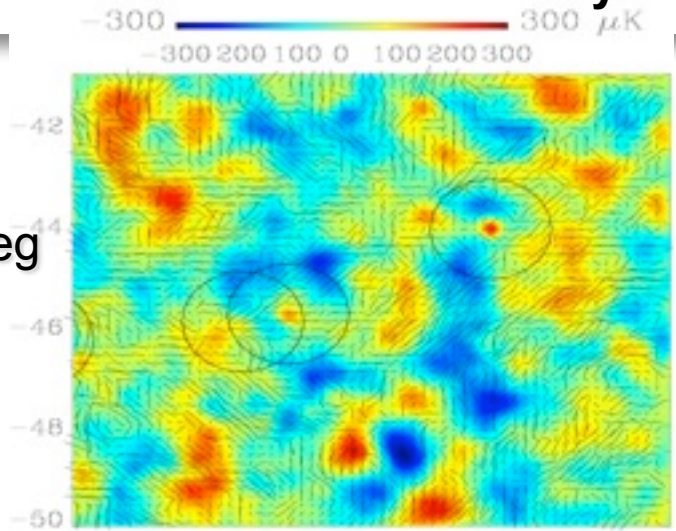
May 2009



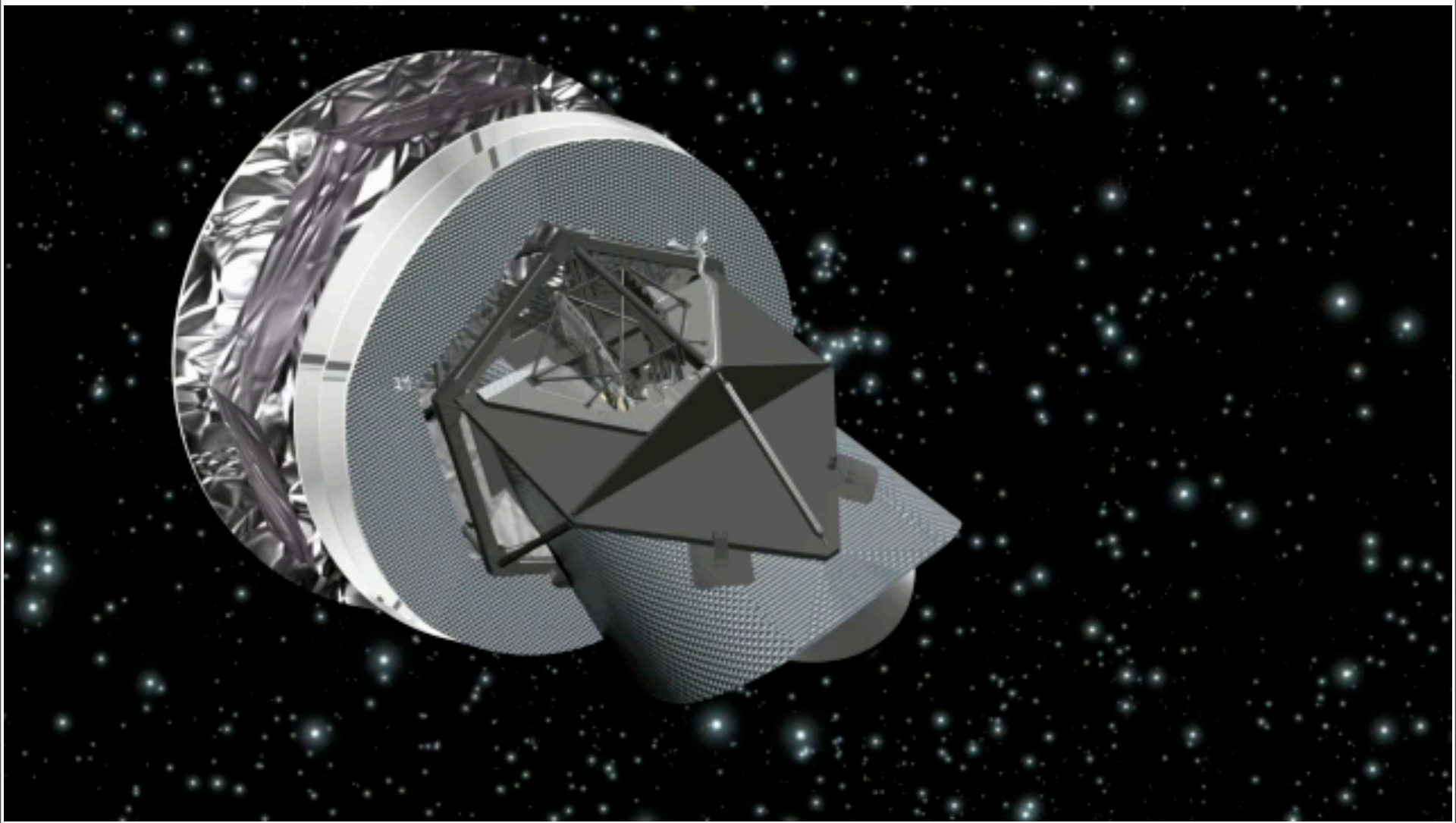
BoomPol deep
2003.1, Jul05

125 hours, f_{sky}=**0.28%** 115sq deg

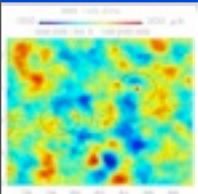
Planck is ~ as deep, but all sky, 350 patches like this!!! with similar bolometers (but more) and better resolution

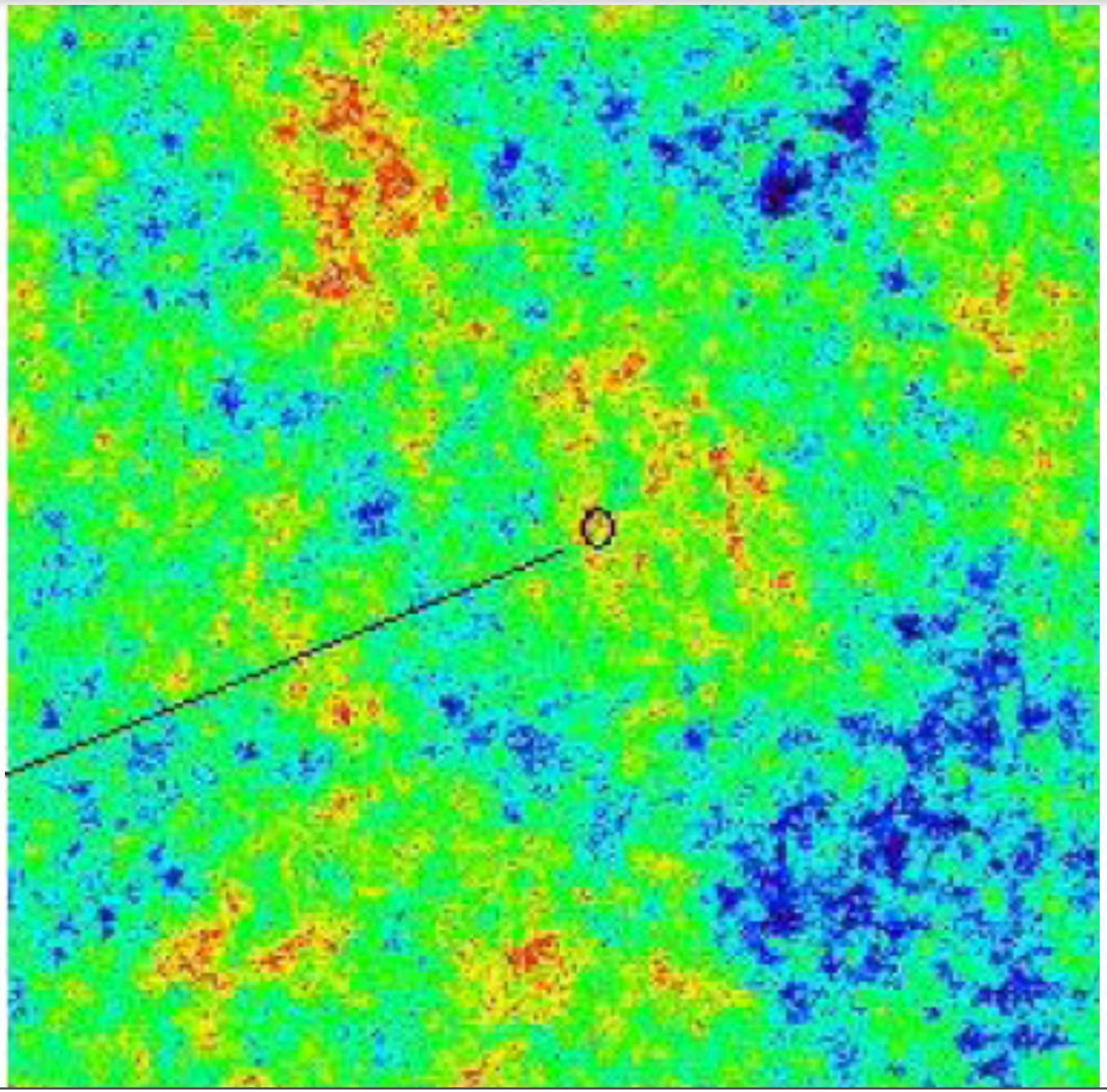


Planck 1st of 5 all Sky Surveys 09.7-10.1



fluctuations in the early universe "vacuum" grow to *all* structure





current Hubble patch ~10 Gpc

speed limit horizon

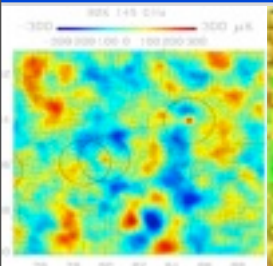
ln a(x, ln H)

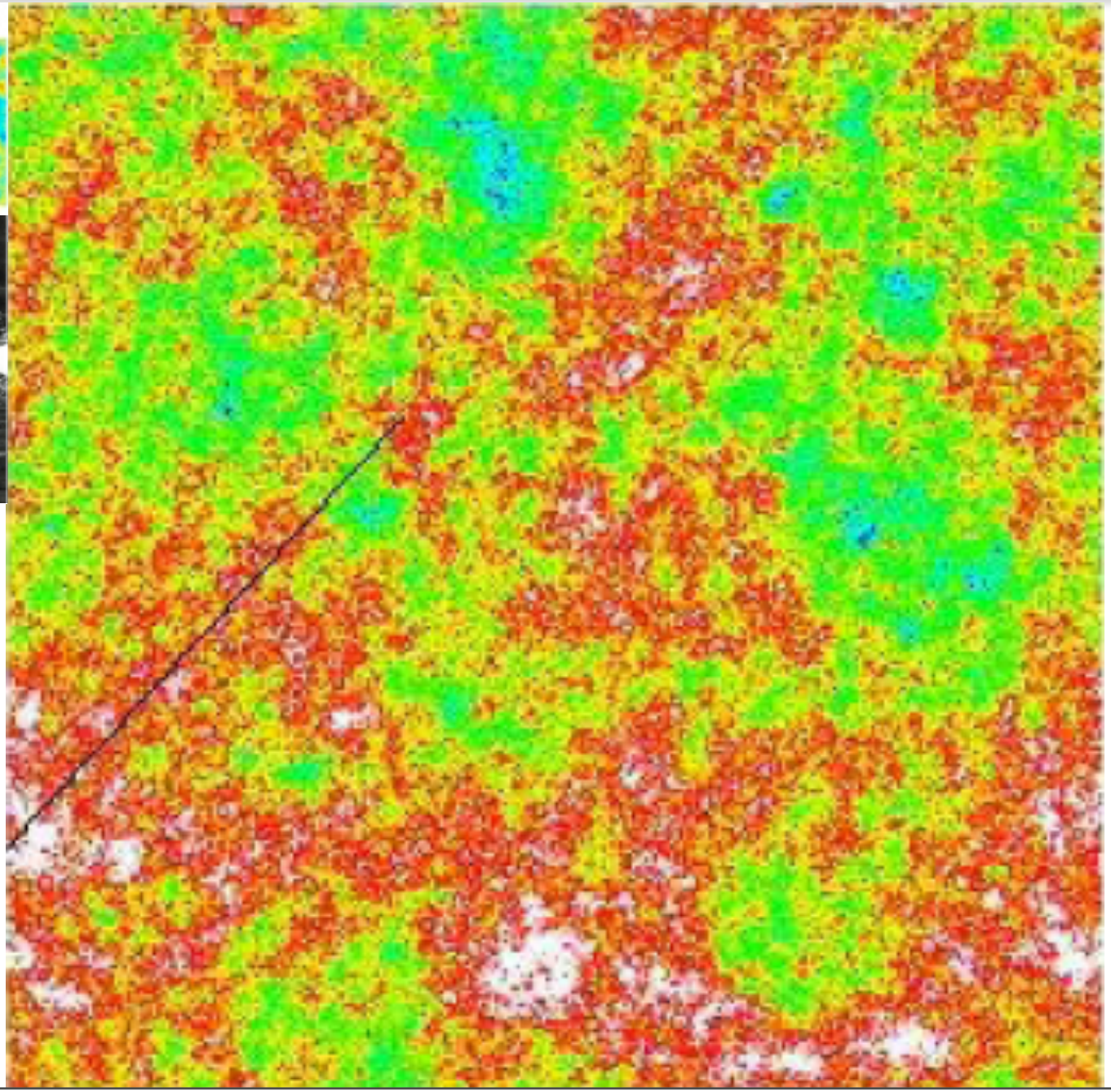
spatial patterns in the quantum jitter of time evolve under gravity

(& gas dynamics)

1000 Gpc

fluctuations in the **early universe "vacuum" grow** to *all* **structure**





$\ln a(x, \ln H)$

all this can

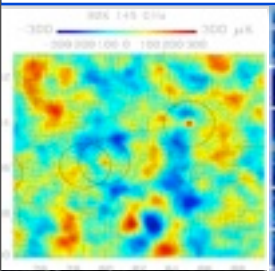
evolve from early U vacuum potential and vacuum noise

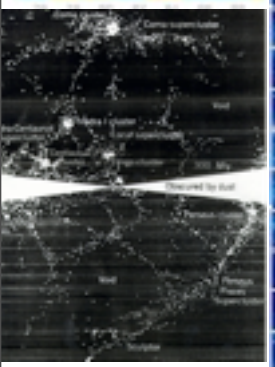
in the presence of late U vacuum potential

aetherial!

10 Gpc

fluctuations in the **early universe "vacuum" grow** to *all* **structure**





400Mpc

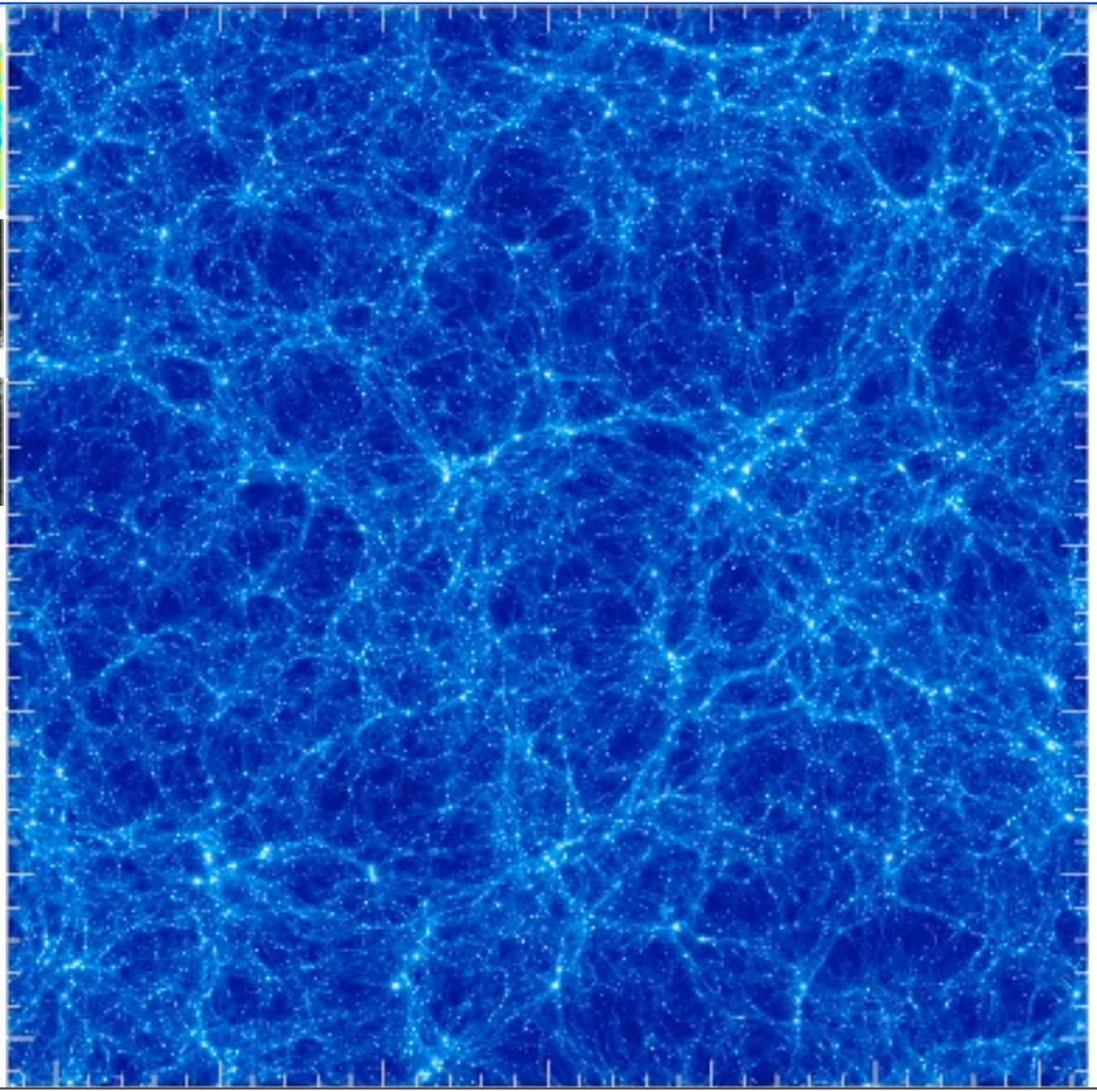
ΛCDM

WMAP5

gas density

Gadget-3
SF+SN E
+winds
+CRs

512^3



ln**a(x,**ln**H)**

all this can

evolve from early U vacuum potential and vacuum noise

in the presence of late U vacuum potential

aetherial!

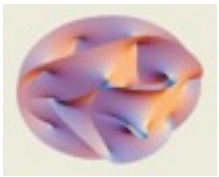
0.4 Gpc

the **quantum stochastic non-G landscape** cf. the **stringy landscape**

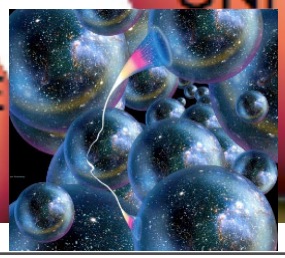
Starobinsky, Vilenkin, **Linde**, ..., stringy Susskind etal

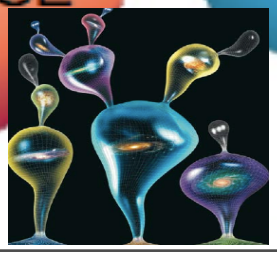
UNIVERSE

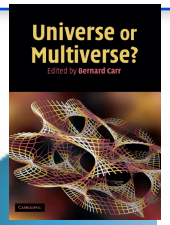
$\ln a(x, \ln H)$



our horizon







a natural consequence of quantum mechanics of the U's uuUULSS

$\ln a(x, \ln Ha)$

quantum diffusion > drift at **high H**

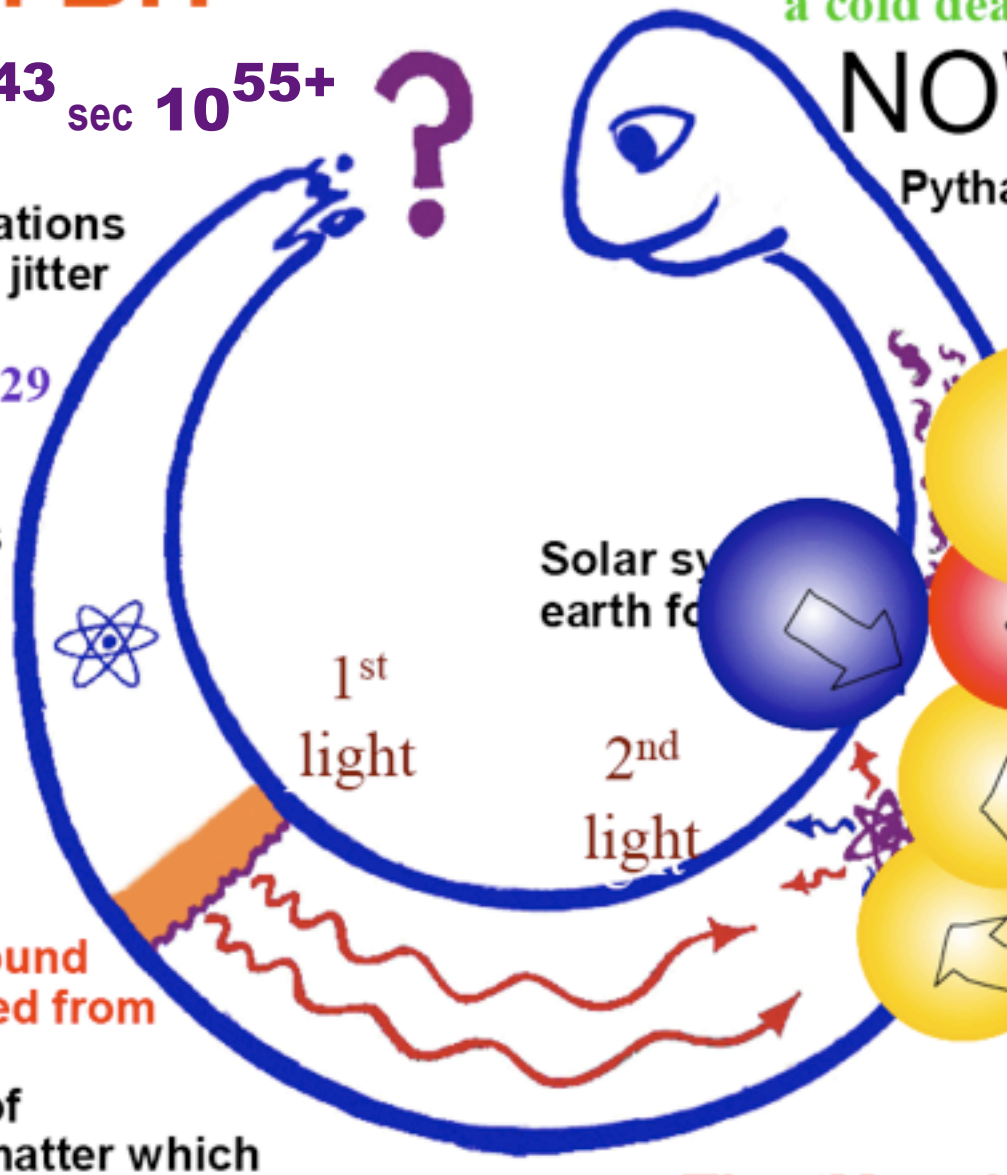
cf. our ***observable horizon (patch) at*** **low H**

this eternal inflation can happen even at

low H

SB91: non-G

"IT from BIT"



FATE U inflate (again)

a cold death? reheat/rebirth?

NOW 14 Gyr 1

Pythagoras formed

Galaxies Cluster

Cosmic "web" of vast filaments + membranes

Life forms on earth

9 Gyr 1.4

Carbon/oxygen/etc form

Galaxies form

2 Gyr 4

Planck era 10^{-43} sec 10^{55+}

Inflation fluctuations form: quantum jitter

10^{-37} sec 10^{29}

Protons/Neutrons form

Helium forms

100 sec 10^{9}

Solar sy
earth fo

1st light

2nd light

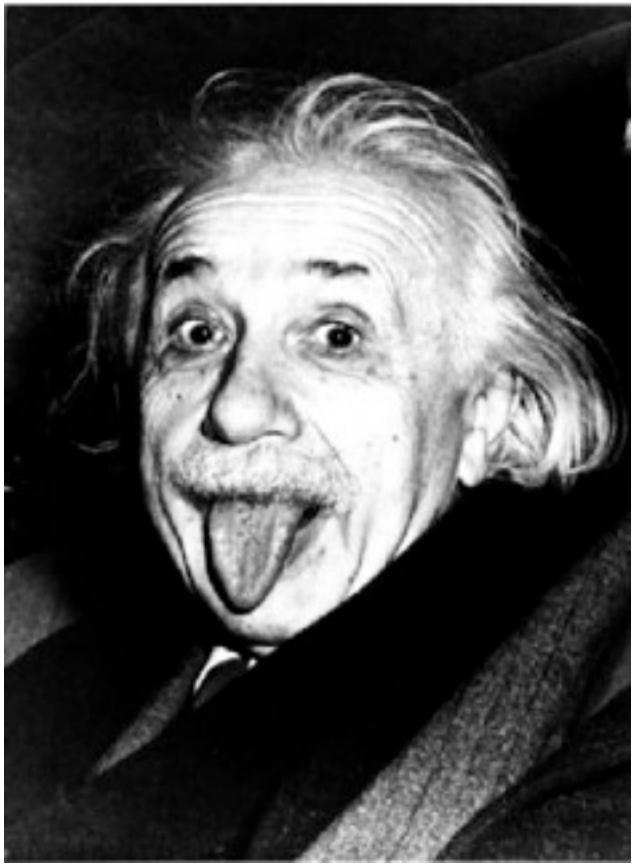
Cosmic background radiation released from matter

carries imprint of fluctuations in matter which grow to generate galaxies etc.

0.4 Myr 1100

The 'Meaning' may change
But the facts will remain

end



time-ordered events, oriented mfd, histories, trajectories, time as coherence associations, constrained probabilities/correlations, time and space distances and near and far as ordering organizer/illusion

eternal and stochastic inflation, quantum diffusion cf. drift. cannot tell if eternal or semi-internal. cannot tell time zero, date from preheat event. or from last drift > diffusion event; (non)-meaning of T-surface in quantum jitter; multiverse, irrespective of landscape. anthropic and time, no sentient beings at nsec, msec, min, > Myr, if heavy elements, ... so we are time selected.

age = 13.69 ± 0.09 Gyrs, 1/Hubble = 14.1 ± 0.20 Gyrs zhiqi

intro on types of time: I/me psychological coherence in time; here and NOW, be in the NOW; past and history, future and forecasting and commitment. time philosophers/writers

physics time: pythagoras frequency, string oscillation, music as frequency and time split, micro/macro, sound, music of the spheres, mathematical reality, cycles per second, cyclical counts = clock; space and wavelength, light; quantum E=h\nu, makes energy the conjugate of time; phase and action

astronomical cyclic **clocks** and frequency/time moons (wax and wane), years (seasons, agriculture), calendars, the hours of the medieval, whence minute, second; onward to millisec, microsec, nanosec, picosec, femtosec, when measurable. shortest time measured, longest time measured; physical clocks, water clocks, sundials, spring coils - precision, digital clocks, cesium, best atomic clock now

worldline, space points move in time. relativity, spacetime, the same but different, signal propagation limit, light cone, horizon, time-space asymmetry: higher dimensions many space one time, imaginary time;

cosmic time t (tau). volume, lna(x,t) as time. hubble rate. redshift, aE~abar*exp(phi)E, exp(Phi_N)dt; clocks/atoms in gravitational wells: redshift climb out of wells, blueshift dropping into wells; oldest and farthest. the cosmic veil, recombination, horizon, beyond our horizon; entropy increase with time

ages: radioactive chronometers, ages of stars, hubble age, age from CMB (history of this determination, 11, 13, 15 sequences, but then boomerang98 and CMB-now, as std output)

U(t)@UofT, **cosmic time hypersurfaces** (patches): t, tau, ln a (but we are in a-equilibrium), ln Ha (accelerate/decelerate), ln H (expand/collapse); breakdown of times; time-ordered events, oriented mfd, histories, trajectories, time as coherence associations, constrained probabilities/correlations, time and space distances and near and far as ordering organizer/illusion

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