The realization of some cosmological gedanken experiments seems to favor the ideas of Sakharov

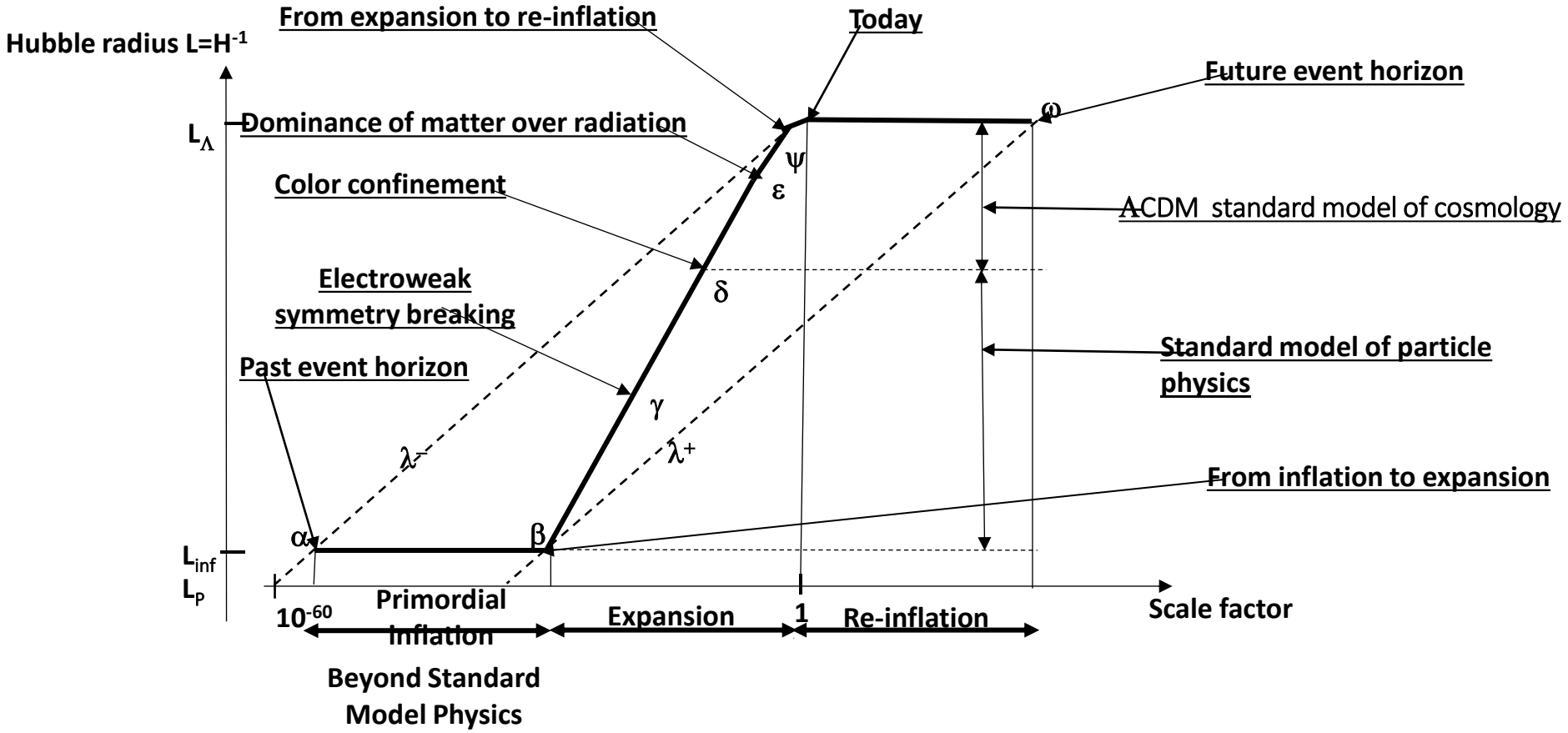
Gilles Cohen-Tannoudji and Jean-Pierre Gazeau

The gedanken experiment performed by ΛCDM

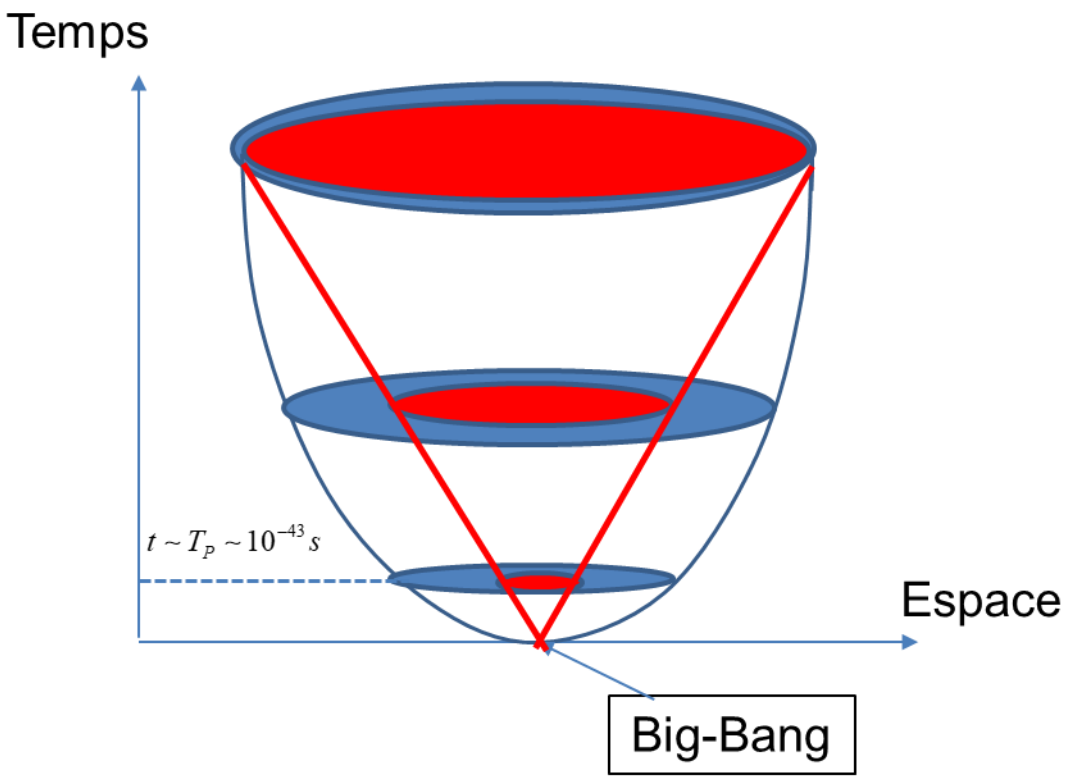
Cosmology does not describe the entire Universe (with upper case U) but only the universe that is observable to us (with lower case u). Dark matter and energy densities are integration constants used to define the universe as the horizon of the Universe towards the far future with dark energy and towards the distant past with dark matter.

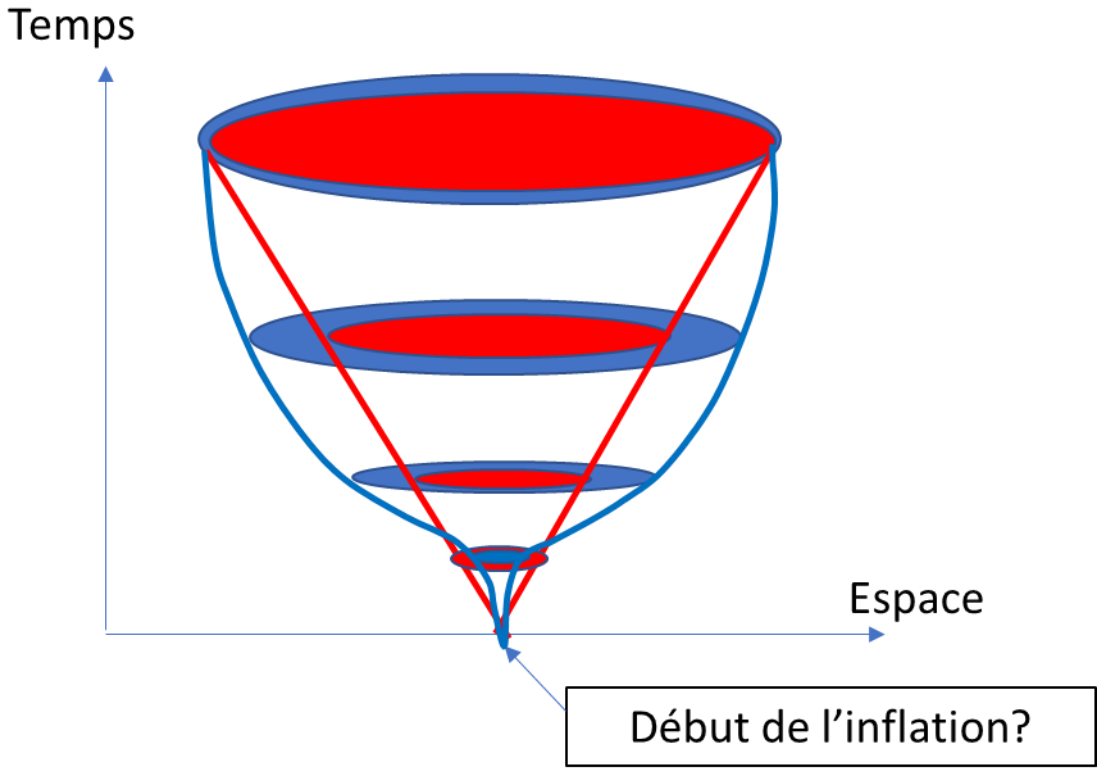
Thanks to the observation of cosmic microwave background (CMB), it was possible to carry out the thought experiment consisting in “removing” the visible matter (known as baryonic) and to draw the map of what remains, the dark universe or quantum vacuum. In fact, when we measure the temperature and the polarization of the CMB, we obtain, thanks to the use of theoretical knowledge of general relativity and quantum mechanics, two maps, that of dark energy and that of dark matter.

The assets of ΛCDM



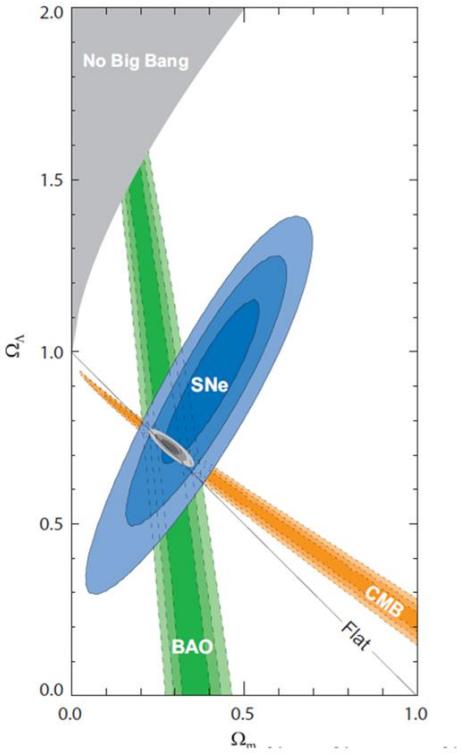
From the « big bang » to the primordial inflation

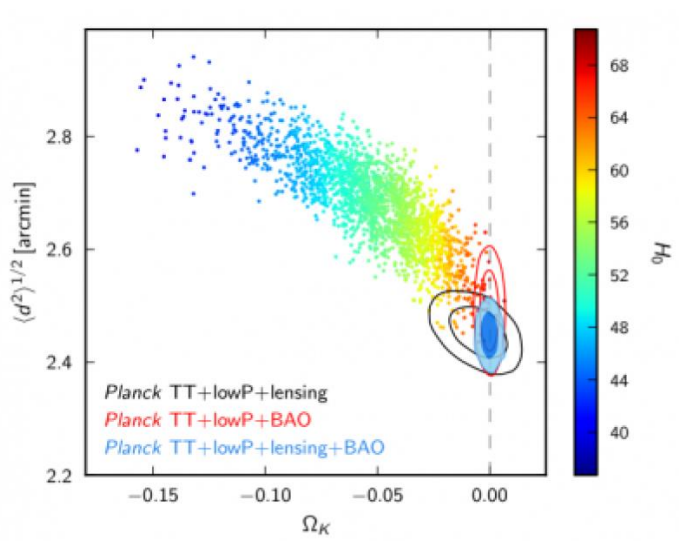


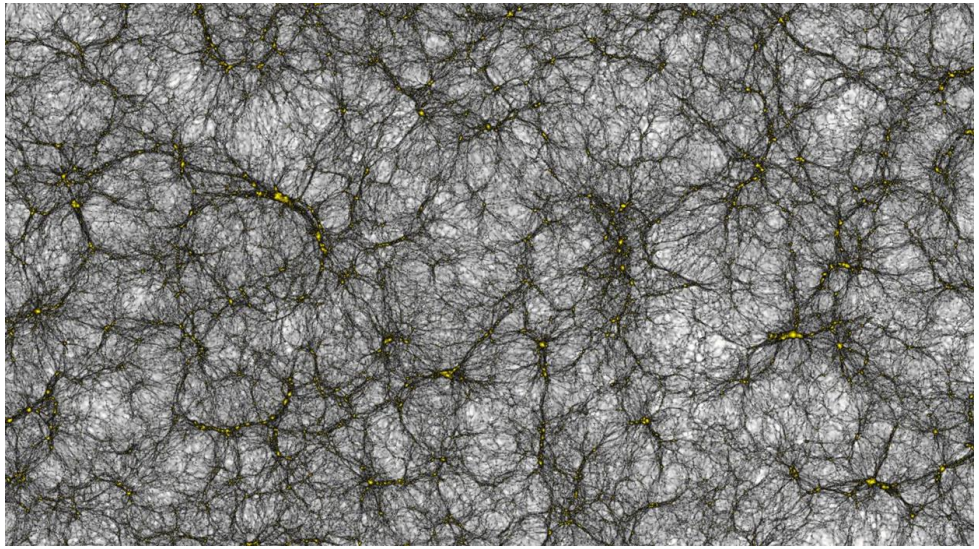


The algorithmic performance of the gedanken experiment

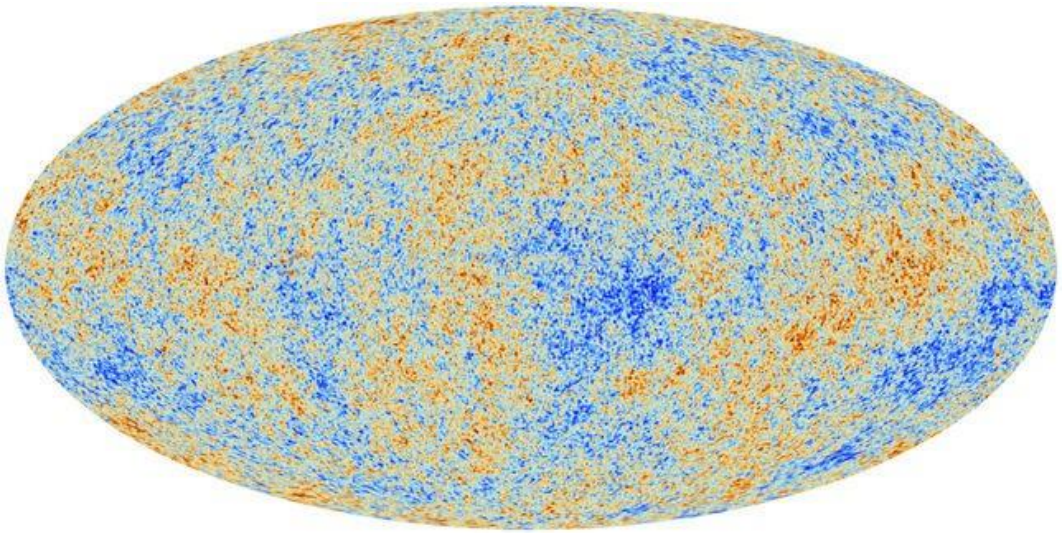
The rest of the performance of the gedanken experiment consists in bringing back the visible matter into the tableau in which it will be possible to carry out other thought experiments, such as traveling in space and in time. This is what the reconciliation of all observations and simulations do.

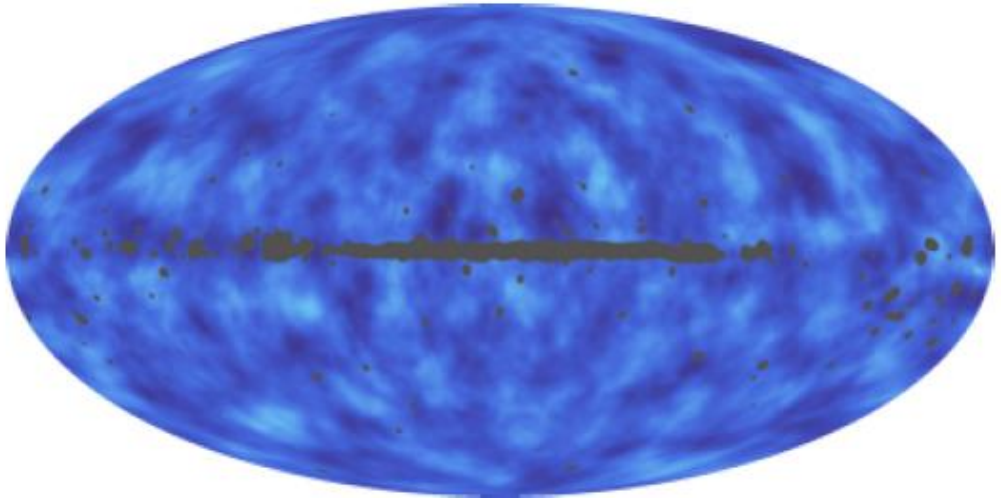




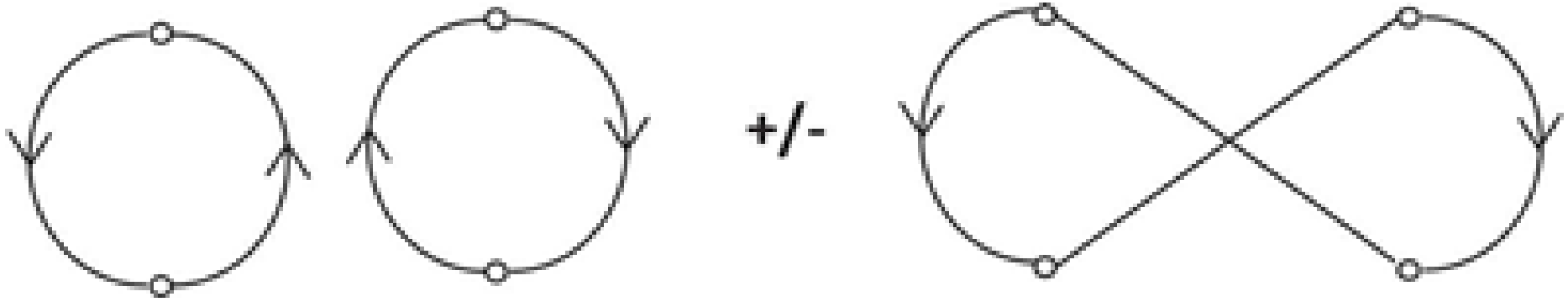


Le two maps of the dark universe

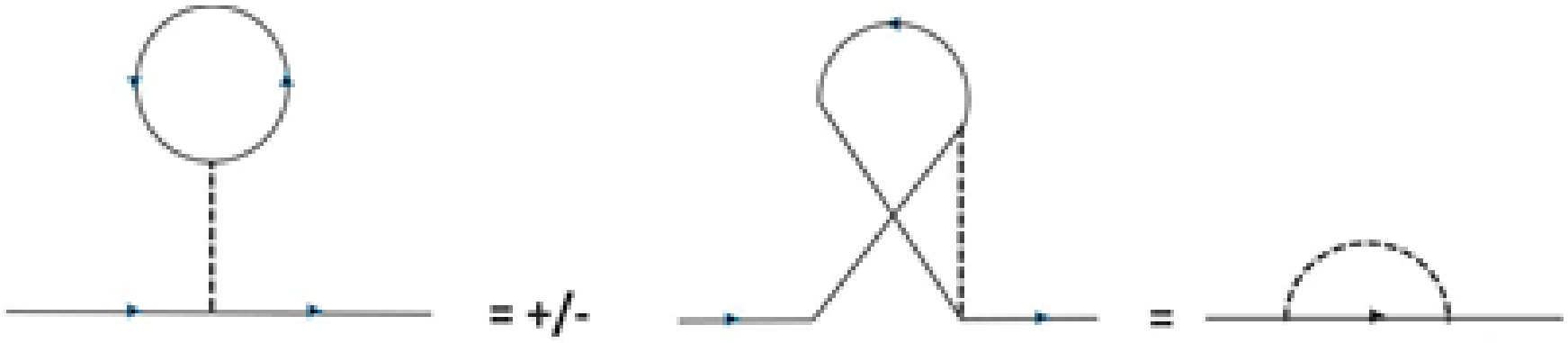




The dark universe as the ground state of Fock space in QFT



Vacuum-vacuum quantum statistics: (Bose-Einstein + sign) or (Fermi Dirac- sign) correlations

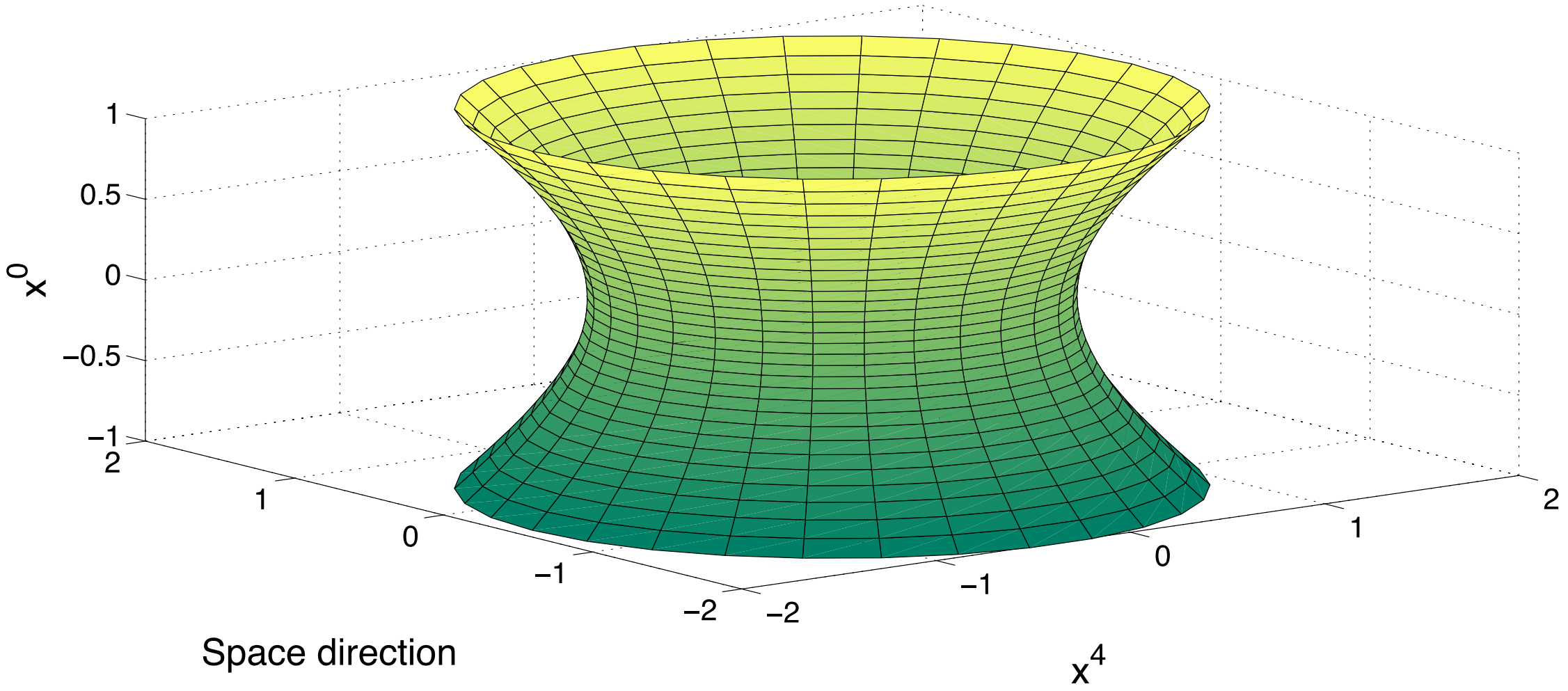


A " tadpole" diagram in which a boson (resp. fermion) exchanges a virtual dilaton with a vacuum loop involving a particle identical to it, is transformed through the interchange of identical particles, into a positive, i.e. increasing the mass (resp. negative, i.e. increasing the energy) self energy diagram.

Fermionic deSitterian dark energy

Bosonic Anti deSitterian dark matter

de Sitter space–time

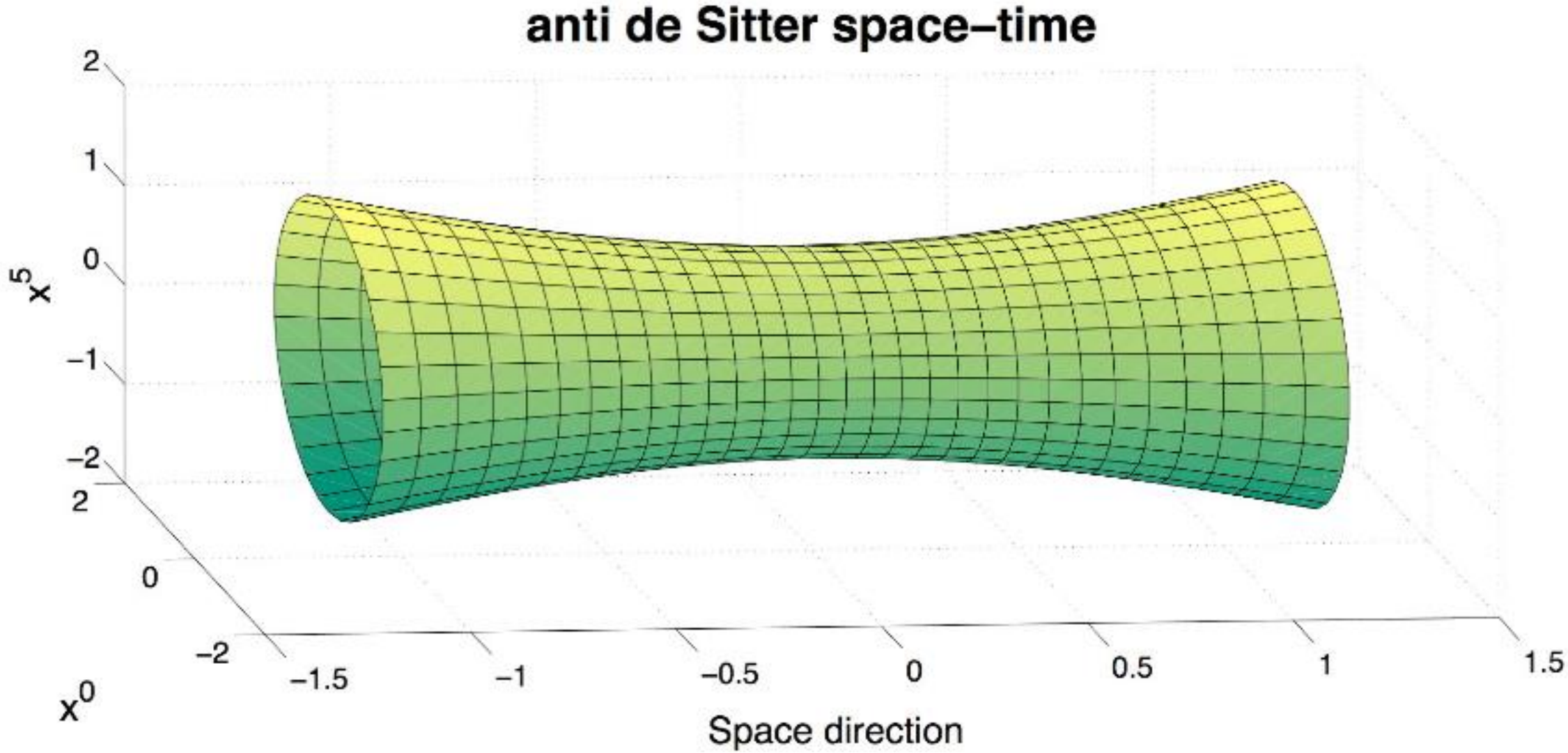


Mass in a dS background

Garidi mass formula in dS for an elementary system with spin s and dS invariant ζ_{dS}

$$m^2 = = \frac{\hbar^2 \Lambda}{3c^2}\left(\varsigma_{\mathrm{dS}}^2 + \left(s - \frac{1}{2}\right)^2\right)$$

There exists energy ambiguity in de Sitter relativity, exemplified by the possible breaking of dS irreducibility into a direct sum of two Poincaré UIR's with positive and negative energy respectively. This phenomenon is linked to the existence in the de Sitter group of a specific discrete symmetry which sends any point (x_0, P) into its mirror image (x_0,-P) with respect to the x_0-axis.


anti de Sitter space–time
2
1
0
−1
−2
x5
2
0
−2
x0
−1.5
−1
−0.5
0
0.5
1
1.5
Space direction

Mass in a AdS background

Mass formula for an elementary system in AdS with spin s and invariant ς_{AdS}

$$m^2 = \frac{\hbar^2 |\Lambda|}{3c^2}\left[\left(\varsigma_{\mathrm{AdS}} - \frac{3}{2}\right)^2 - \left(s - \frac{1}{2}\right)^2\right]$$

No energy ambiguity in Anti de Sitter relativity. AdS reveals universal pure curvature or vibration energy besides matter energy: an AdS elementary system can be viewed as a deformation of both a relativistic free particle with rest energy mc^2 and a 3d isotropic quantum harmonic oscillator with ground state energy $\frac{3}{2}\hbar c\sqrt{\frac{|\Lambda|}{3}}$

dS & AdS invariant ς —> Energy at rest $E^{\text{rest}} := \hbar c \sqrt{\frac{|\Lambda|}{3}} \varsigma$

For s=1/2

for dS : $E^{\text{rest}}_{\text{dS}} = mc^2$

for AdS: $E^{\text{rest}}_{\text{AdS}} = mc^2 + \frac{3}{2}\hbar \sqrt{\frac{|\Lambda|}{3}} c$

For m = 0

for dS : $E^{\text{rest}}_{\text{dS}} = \pm i\hbar c \left(s - \frac{1}{2} \right)$

for AdS: $E^{\text{rest}}_{\text{AdS}} = \hbar c (s + 1)$

Anti-de-Sitterian Nature of Dark Matter

X: Quark, Gluon, BE Condensat …from primordial quark-gluon plasma (QGP)

at the « quark epoch »

$$E_{\mathrm{AdS}}^{\mathrm{rest}} = \underbrace{m(X)c^2}_{\text{visible}} + \underbrace{\frac{3}{2}\hbar\sqrt{\frac{|\Lambda|}{3}}c}_{\mathbf{E}_{\mathrm{darkmatterm}}(\mathbf{X})\geq} \qquad E_{\mathrm{darkmatter}}(X) = r(X)m(X)c^2$$

Like the cosmic microwave background (CMB) is a remnant from the recombination epoch of the universe (~379,000 years, at T ~ 3000 K), when protons and electrons combined to form neutral hydrogen atoms, the dark matter may be thought as a « relic » of the QGP epoch, totally free of any interaction but the gravitational one

X

The Brout-Engler-Gunzig (BEG) mechanism: “creation” of matter with no energy cost

R. Brout, F. Englert, and E.Gunzig, The Creation of the Universe as a Quantum Phenomenon ANNALS OF PHYSICS 115, 78-106 (1978)

"Cosmology, because it is concerned with the variation of $g_{\mu\nu}$ within a distribution of matter and not without, is described-at least in the mean by only that part of $g_{\mu\nu}$ which is its determinant.

Because the embedding Minkowski spacetime is conformally flat,

the determinant may be represented by a massless covariant scalar field, the dilaton ϕ".

$$W_\phi = -1/3; \rho_\phi + 3P_\phi = 0$$

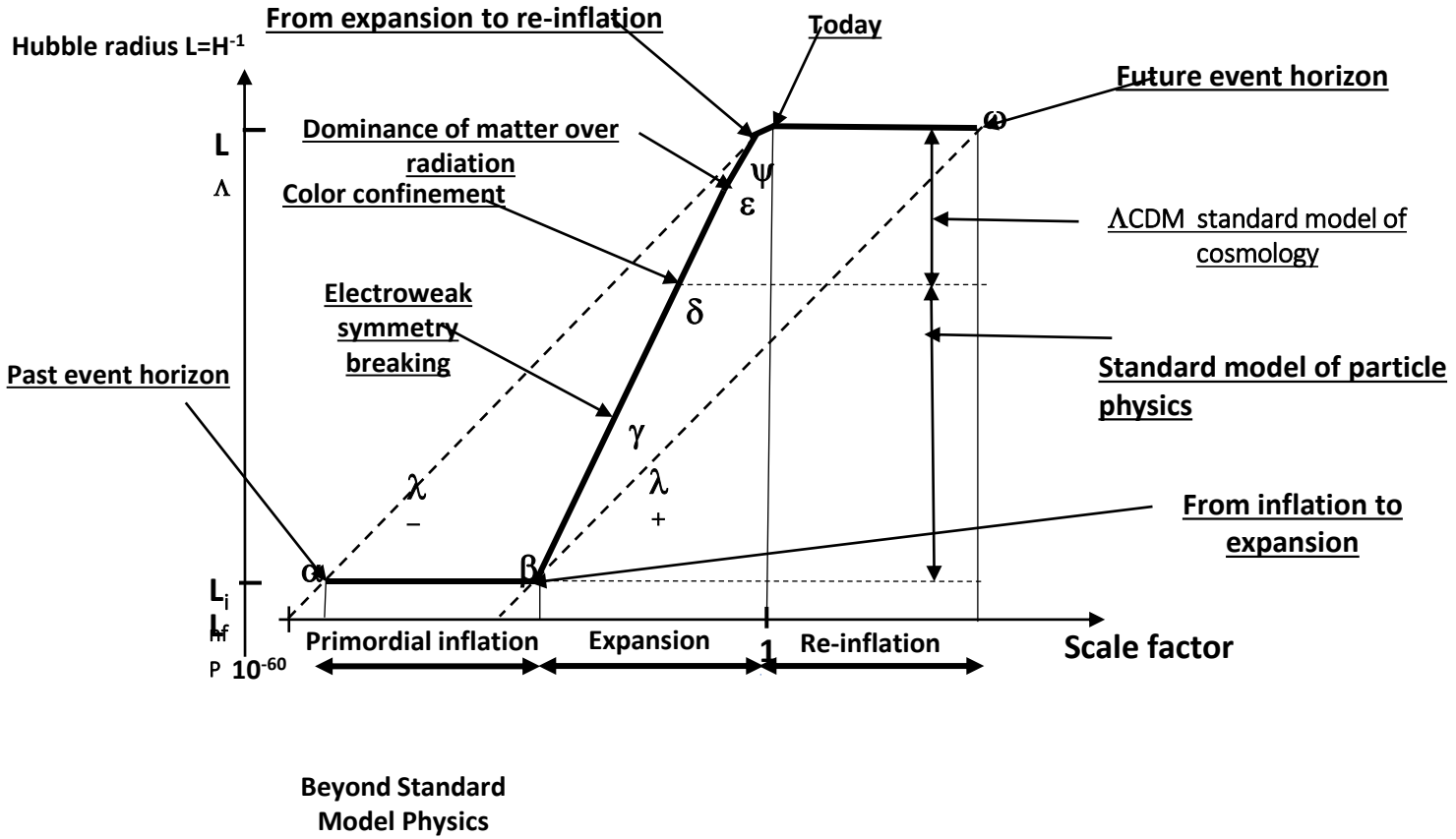
Flatness sum rule:

$$\rho_{\text{vis}} + \rho_{\text{DM}} = -P_\phi; \rho_\Lambda = -2P_\phi$$

$$\rho_{\text{vis}} + \rho_{\text{DM}} + \rho_\Lambda = \rho_c = \rho_\phi$$

The BEGHS mechanisms at work in ΛCDM

- In the primordial inflation phase (from α to β), here the dilaton field is the Goldstone boson of the matter/antimatter symmetry breaking (obeying the Sakharov's conditions),
- In the electroweak symmetry breaking (γ), here the dilaton field is the Higgs boson
- In the transition from the quark gluon plasma to the colorless hadron phase (δ), here the dilaton is the Goldstone boson (σ) of the chiral symmetry breaking



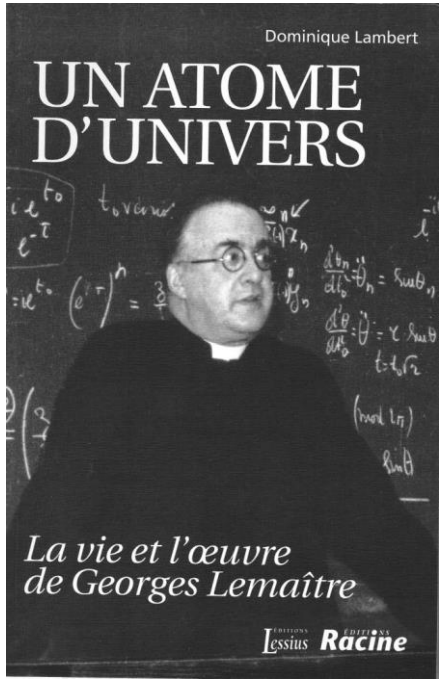
Gilles Cohen-Tannoudji, *Lambda, the fifth foundational constant considered by Einstein*, Metrologia, 2018

$$\mathrm{CosmIn} = \frac{3c^3 k}{\hbar G \Lambda}$$

large but finite

ΛCDM is a quantum relativistic cosmology that is quasi-classical (*h* small but not zero), quasi-Newtonian (*c* large but not infinite, *G*, Λ, small but not zero), quasi-perfect (*k* small but not zero)

What does scientific cosmogony consist of?



"The object of a cosmogonic theory is to seek ideally simple initial conditions from which, through the interplay of known physical forces, the current world in all its complexity could have resulted" *Georges Lemaître, the atom hypothesis primitive - Cosmogony test -*

From the Lemaître's primeval atom to the Wheeler's bit (qubit)

I'm trying to learn about what people are trying to say with the phrase "it from qubit." Wheeler talked about "it from bit," but you have to remember that this essay was written probably before the term "qubit" was coined and certainly before it was in wide currency. Reading it, I really think he was talking about qubits, not bits, so "it from qubit" is actually just a modern translation.

Ed Witten, *A ponders the Nature of Realty,* Quanta Magazine, 2017

ON COSMOPARTICLE PHYSICS

. Cosmoparticle. physics (the name is not yet finally fixed) is the new fundamental science formed at_the Joint of particle physics and cosmology. It has great scientific and general philosophical s1gruficance.

. In the present paper ... the reasons and circumstances of fornation of cosmoparticle physics are presented, as well as the problems, it is aimed to solve, and the prospects of its development m USSR are discussed.

In the paper there are proposed some concrete studies, which, on the opinion of the authors, should be undertaken in USSR, the development of cosmoparticle physics in our country to correspond the level of its problems and the world progress of such development.

Some of these stu.dies may take place on already existing and planned for other purposes facilities with the1r significant reorientation on cosmologically relevant problems and with modernization of their equipement (with the increase of sensitivity of receivers, especially), some imply creation in the near and far future new large special facilities on the Earth and in space.

Among many important projects I can mention space and ground based interferometers in radio and infrared ranges, studies of anysotropy and spectrum of relic radiation with the use of ground based and space based devices, development of observational astronomy in infrared, optical and other electromagnetic ranges, the use of systems of aperture synthesis, studies of the large scale structure of the Universe, gravitational experiments, experimental searches of the nature of dark matter.

The long-term project of designing of pennanent space astronomical observatory, including large radiotelescope, large optical telescope, gamma and X-ray telescopes is very interesting. This project should, probably, be international. Its significance for the problems of cosmoparticle physics may be as important, as in its time the importance of 5 meter telescope for extragalactic astronomy. Substantial and enexpected results may be ob,tained also in other fields of studies.

It is very important to extend theoretical studies, to increase the level of their mathematical supply with the aim to proceed a wide program of numerical experiments, linking the theory with observations. In some cases (c.f for the problem of large scale structure of the Universe) these simulations will be very complicated and will imply such computer facilities, which do not exist at present. One may expect, however, that such facilities will be designed in not too far future.

The present paper should draw attention of astronomers, physicists, engineers and mathematicians to the extremely important set of problems, to give the draft prospect of development in this field of knowledge.

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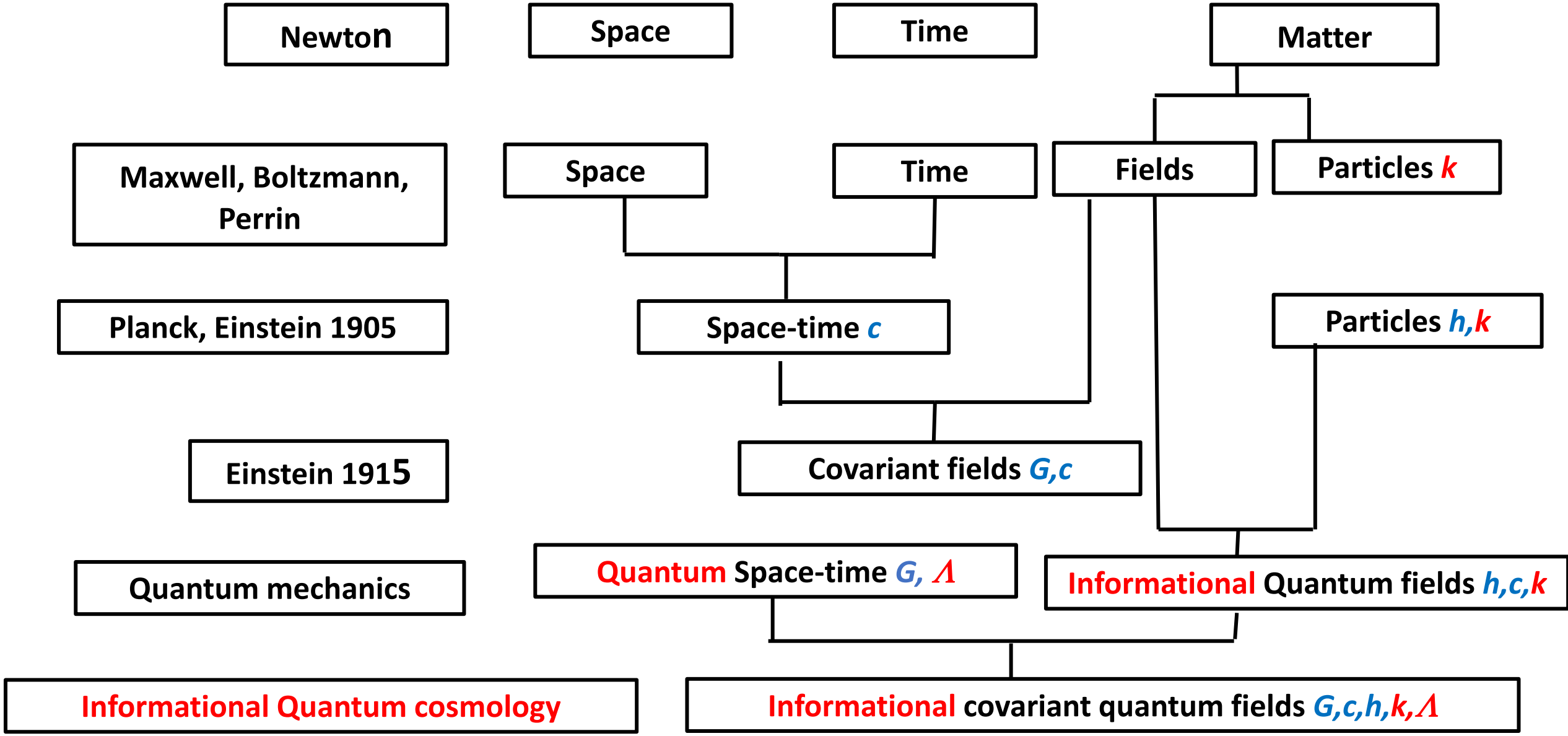
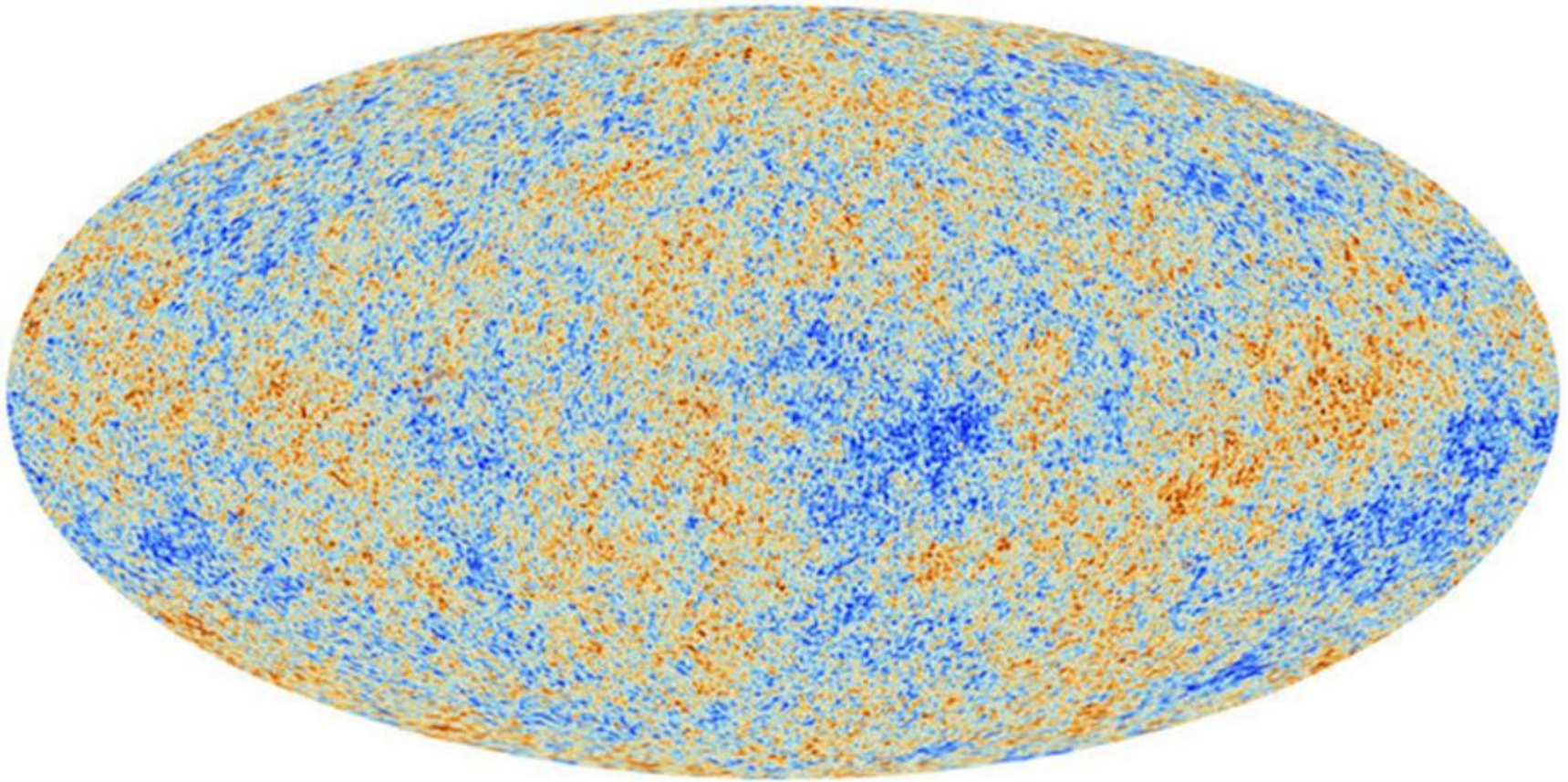
A.Sakharov


Newton
Space
Time
Matter
Maxwell, Boltzmann, Perrin
Space
Time
Fields
Particles k
Planck, Einstein 1905
Space-time c
Particles h,k
Einstein 1915
Covariant fields G,c
Quantum mechanics
Quantum Space-time G, Λ
Informational Quantum fields h,c,k
Informational Quantum cosmology
Informational covariant quantum fields G,c,h,k,Λ

Magritte’s famous painting

Nature preceded man but man preceded the natural sciences



This is not the Cosmos

Tribute to the memory of Georges Lochak who passed on the 4th of February RIP

Cohen-Tannoudji, G. The de Broglie universal substratum, the Lochak monopoles and the dark universe,Annales de la Fondation Louis de Broglie 2019, 44, 187–209 ; (https://arxiv.org/abs/1507.00460v10)

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