Low energy world

Sergej Schuwalow, DESY Hamburg

Low energy ≡ the system is in the ground state

We will start from some very basic assumption
and will try to build step by step our own world.
How it will look like?

Minimization principle:
least radix economy

Example: digital memory to accommodate numbers in 0÷1999 range: Binary system: 11 digits x 2 = 22 hardware states; Ternary system: 7 digits x 3 = 21 hardware states; Decimal system: 4 digits x 10 = 40 hardware states; System on the base 2000: 1 digit x 2000 =2000 states. Obviously the number of states needed depends on the choice of counting system base.

$$r = n \cdot \log_n A$$

Radix economy has minimum at n = e (Euler constant). Integer number (2 for easiest electronics realization) or n=3 (rare attempts) is a common choice.

Least radix economy principle is often used for optimization of data transmission, database search, networking, organizational structures…

Does it help for the choice of space dimension at ground state?

Minimization principle:
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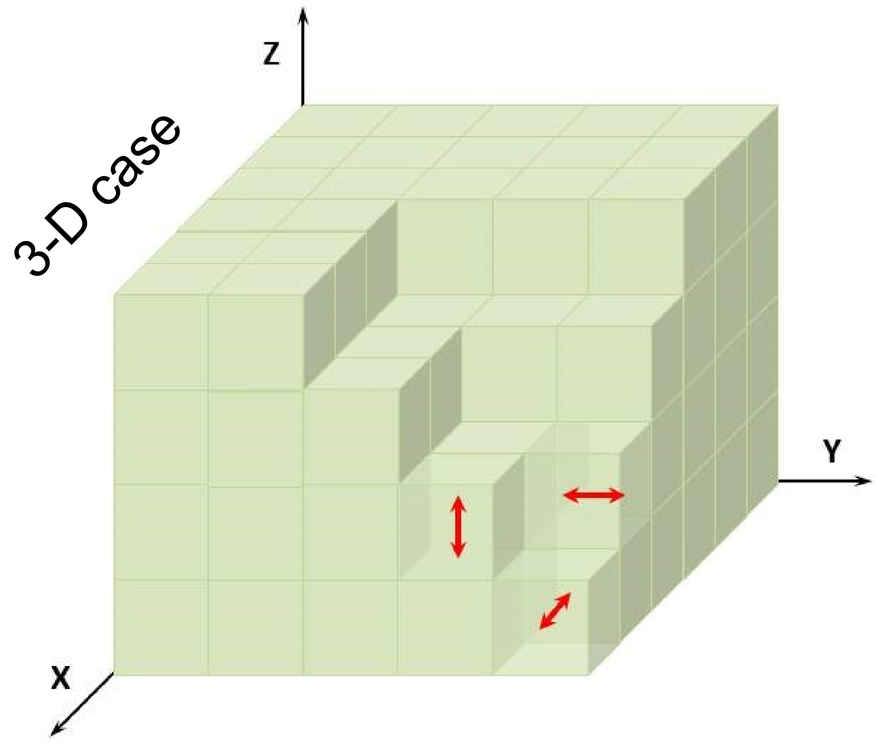

The most compact possible packing of states:

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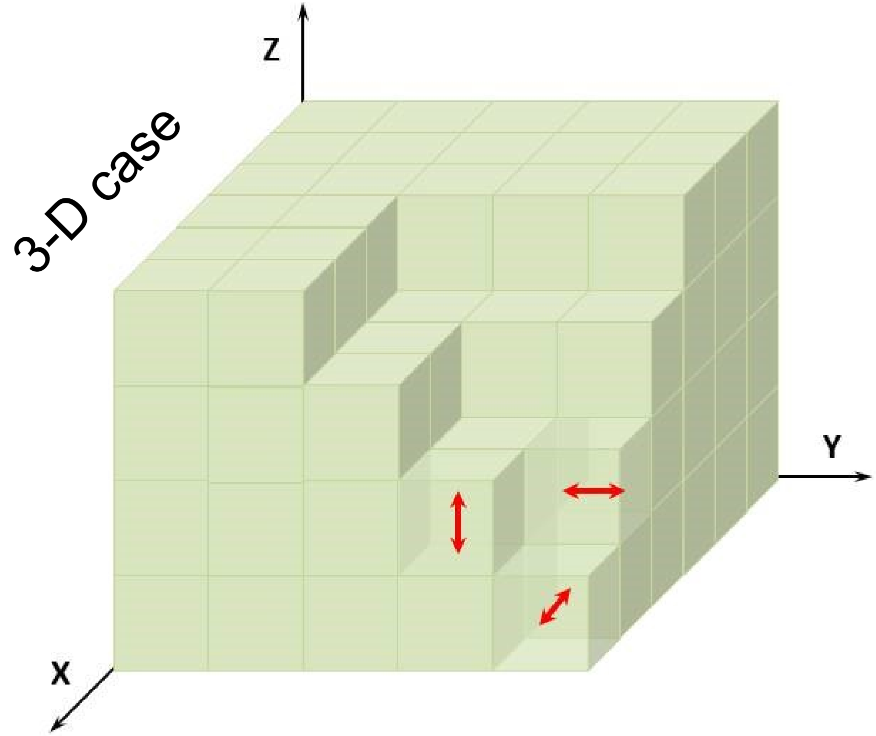

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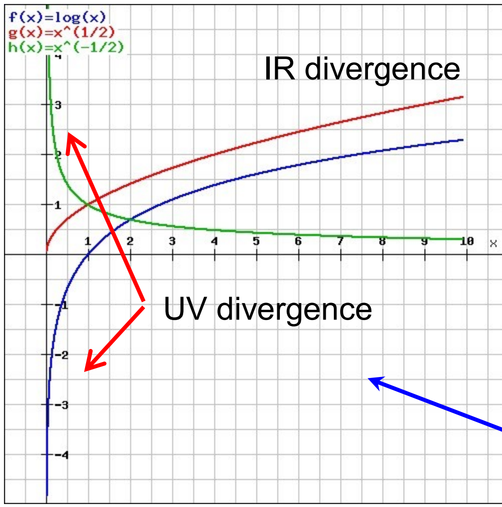
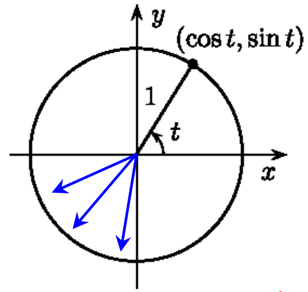
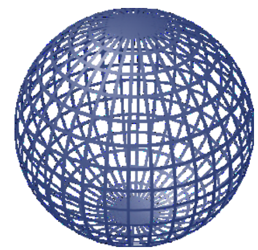
For the cold world with infinite degrees of freedom the ground state is a space with exactly e = 2.71828… dimensions

Divergencies

Example from classical physics: pointlike source vector fields







2-D: E~1/r[1] **3-D**: E~1/r[2]

Power depends on space dimension

Integral of (inverse) power function: $y = \int \frac{1}{x^q}$; $q = 0.5, 1, 1.5$ is diverging either at $x = 0$ or $x = \infty$ or both (for $q = 1$).

If power q depends on x one can get an integral converging at all x . Similarly:

For the case of variable dimension space $(D = f(r))$ one can avoid divergencies

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G.’t Hooft, M.Veltman “Regularization and Renormalization of Gauge Fields” Nucl.Phys. **B44**(1972) 189
C.Bollini, J.Glambiagi “Dimensional Renormalization: The Number of Dimensions…” Nuovo Sim. **12B**(1972) 20
F.Bloch “On the Continuous γ-Radiation Accompanying the β-Decay” Phys.Rev. **50**(1936) 272
F.Bloch, A.Nordsieck “Note on the Radiation Field of the Electron” Phys.Rev. **52**(1937) 54
N.Laskin “Fractional Quantum Mechanics and Lévy Path Integrals” Phys.Letters. **A 268**(2000) 298

Small and large distances at e-D space

- For a pointlike charge (or any source of vector field) – energy integral converges at small distances. There are no singularities and no need for renormalization and regularization ("Half way" of 't Hooft regularization approach, see previous slide for reference)
- For large distances fields in e-D space decrease too slow: IR divergence becomes a problem
- Additional assumption: to minimize overall field energy the space becomes 3-D at large distances (still e-D at small distances), thus avoiding IR strong divergence. Field energy converges everywhere, and has wide minimum at the certain e-D → 3-D transition distance

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What are the properties of such a world?

Properties

- e-D – 3-D transition requires extra complementary dimension, that being added to 3-D will reduce effectively overall dimension to e-D, i.e. some “bridge” between e-D and 3-D is needed.

Consider invariant line element in Cartesian coordinates of n-dimensional flat space $(x_1, x_2, x_3, \cdots, x_n)$:

$$ds^2 = (dx_1)^2 + (dx_2)^2 + (dx_3)^2 + \cdots + (dx_n)^2$$

Note, that for unit intervals in each coordinate, ds^2 will numerically coincide with the dimension of the space. Lets take it as a definition of space dimension and construct 3-D space and try to **reduce** its dimension by extra coordinate:

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$$ds^2 = (dx_1)^2 + (dx_2)^2 + (dx_3)^2 - (dx_4)^2???$$

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$$ds^2 = (dx_1)^2 + (dx_2)^2 + (dx_3)^2 - c^2 \cdot (dx_4)^2$$

where $c = \sqrt{3 - e} = 0.53$ in order to get e dimensions as a result.

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➡ Universal speed – world constant

- Both time and universal speed appear together and exist only at low energy and large distances
- Space at large distances has to have Minkowski metrics

Properties – 2
special relativity

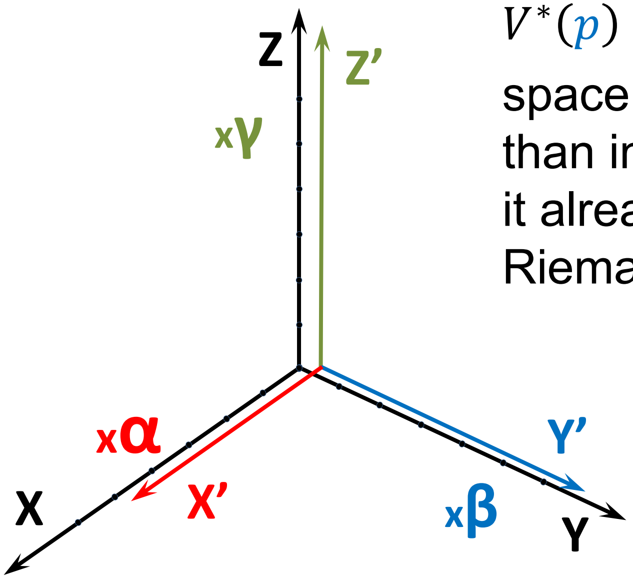
- Our 3-D + ‘new dimension’ space is now described by flat Minkowski space metrics with extra coordinate being time and parameter c – universal speed of light

$$ds^2 = \underbrace{(dx_1)^2 + (dx_2)^2 + (dx_3)^2}_{\text{Flat 3-D space (asymptotically)}} - c^2 \cdot (dx_4)^2$$

- Exact 3-D space will take place asymptotically, when energy density is close to zero. In this case the speed of light is approaching its maximum asymptotic constant value. What happens if we are slightly below 3-D?

Space curvature

Intrinsic curvature in [e÷3]-D space; simplest case – scalar curvature



Consider 3-D flat Euclidean space with dimension modifiers α,β,γ. Volume of the small probe ball at the point *p* is: $V^*(p) = \frac{4}{3}\pi(\alpha\beta\gamma)\varepsilon^3$, where ε is radius of the ball in Euclidean space. Obviously for modified space the ball volume is smaller, than in 3-D space $V^*(p) = (\alpha\beta\gamma)\cdot V_{3D}$, since $\alpha\beta\gamma < 1$. Though it already points to positive (elliptical space) curvature, in Riemann geometry:

$$\frac{V^*(p)}{V} = 1 - \frac{S}{6(n+2)}\cdot\varepsilon^2 + O(\varepsilon^4),$$

where S is scalar curvature (the trace of tensor Ricci),

and $S \neq 0$, only if $\frac{\partial^2(\alpha\beta\gamma)}{\partial\varepsilon^2} \neq 0$

*If **αβγ** is alive function of the distance and /or space point with second derivative being nonzero, the space has curvature (gravitation)!*

Properties – 3
general relativity

$ds^2 = \boldsymbol{a}^2 \cdot (ds_3)^2 - \boldsymbol{c}^2 \cdot (dt)^2$, $\boldsymbol{a}^2$– scale factor,

that may be dependent on time: $\boldsymbol{a}^2 = \boldsymbol{a}^2(t)$

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Friedmann-Lemaître-Robertson-Walker (FLRW) metric of homogeneous and isotropic expanding space – standard model of modern cosmology. Here ds_3^2 does not depend on time and represents 3-dimensional space of uniform curvature, that is, elliptical, Euclidean or hyperbolic space. $\boldsymbol{a}(t) = 1$ today is usual normalization. ***C*** = constant in the general relativity.

Hypothesis:

Taking into account previous considerations: intrinsic curvature means that space dimension is not exactly 3, but slightly less ($\boldsymbol{e} < \boldsymbol{n} < 3$). We should have elliptical space and gravity, described by Einstein equations.

Properties – 4

general relativity+

Following our basic principle, that e-dimensional space is the ground state:

$$ds_e{}^2 = \boldsymbol{a}^2(t) \cdot \left(ds^*{}_3\right)^2 - \boldsymbol{c}^2 \cdot (dt)^2$$ becomes

$$ds_e{}^2 = \boldsymbol{\alpha}^2 \cdot (dx)^2 + \boldsymbol{\beta}^2 \cdot (dy)^2 + \boldsymbol{\gamma}^2 \cdot (dz)^2 - \boldsymbol{c}^2 \cdot (dt)^2$$

and $\boldsymbol{e} = \boldsymbol{\alpha}^2 + \boldsymbol{\beta}^2 + \boldsymbol{\gamma}^2 - \boldsymbol{c}^2$; $\boldsymbol{e} < \boldsymbol{\alpha}^2 + \boldsymbol{\beta}^2 + \boldsymbol{\gamma}^2 < \boldsymbol{3}$

$$0 < \boldsymbol{c} < \sqrt{3 - \boldsymbol{e}}$$

Now $\boldsymbol{c}$ is (world) time dependent, maximum space curvature is limited by $\boldsymbol{e}$-dimensional space. At this extreme conditions (for example black hole surface) the speed of light is zero. Gravitational lensing is similar to the optical one. Gravitation strength is limited, singularities are absent. Interior of black hole is purely spatial $\boldsymbol{e}$-D space. $r_s \neq \sim M$, but $r_{eh} \sim \sqrt[3]{M}$ for BH. Do we have any hints on deviations from standard GR in the nature?

Properties – 5
going to small distances

- Physicists (and other sentients) are existing at large distances (having 3-D space, time and speed of light).
- How e-D space looks from the point of view of 3-D observer? With decreasing of distance the time becomes undefined, "uncertain"…

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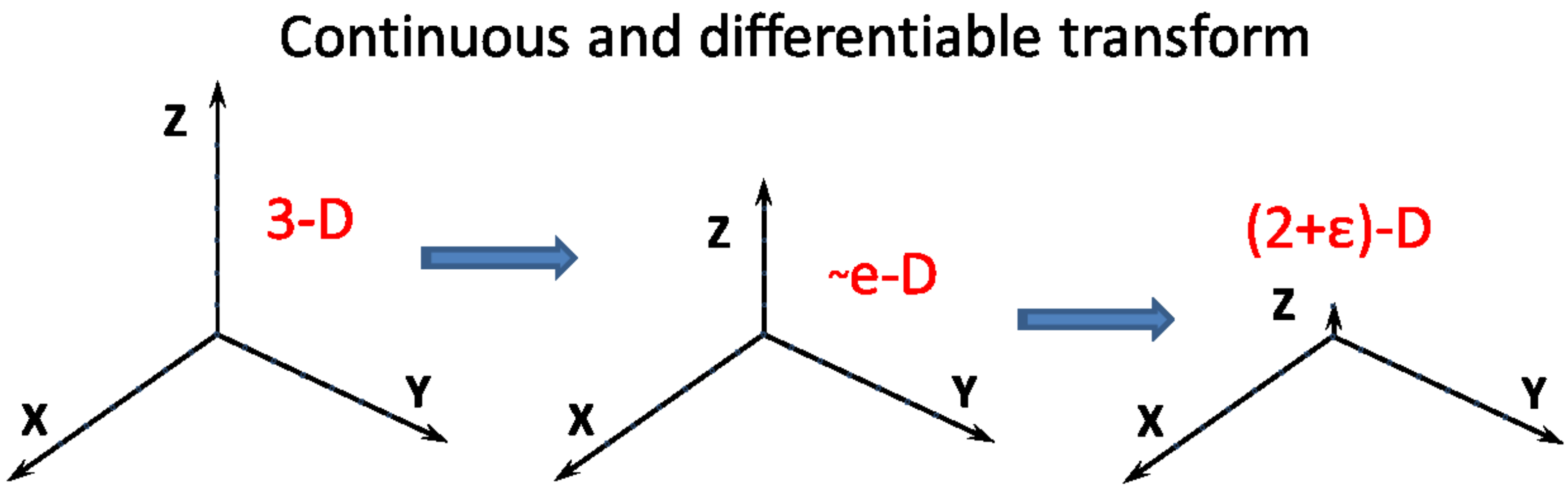
Hypothesis: one can derive Planck’s constant

Asymmetric fractal space concept

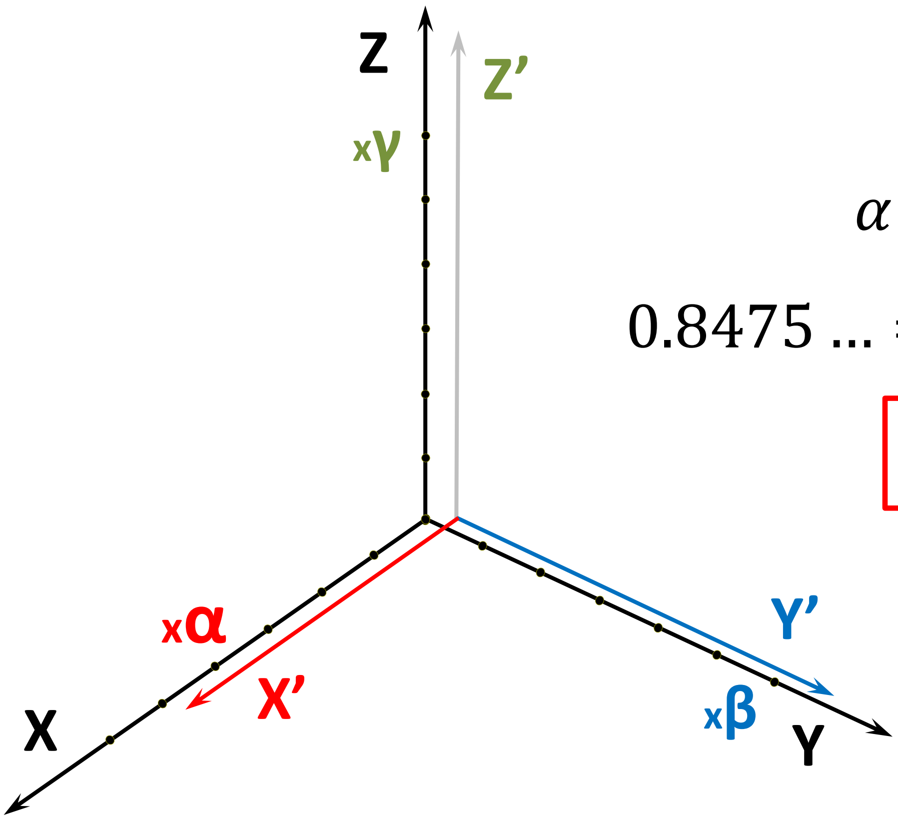
- Lets consider smooth transition from 3-D to 2-D space. ‘2D+ε’ – “almost” 2-D space, becomes 2-D space at ε→0



Space could be asymmetric!

Asymmetric e-D space

the third principle



Constraints:

$$\alpha^2 + \beta^2 + \gamma^2 = e$$

$$0.8475\ldots = \sqrt{e-2} < \alpha < \beta < \gamma < 1$$

$$F(\alpha, \beta, \gamma) = 0 \text{ ???}$$

Still missing to get rid of ambiguity

Properties – 6

particles

- We assume that all sub-dimensions in e-D space are different and e-D space is asymmetric. Stealing the string theory idea of one-dimensional objects being elementary particles, we get for three different sub-dimensions (now D< 1 !) case:

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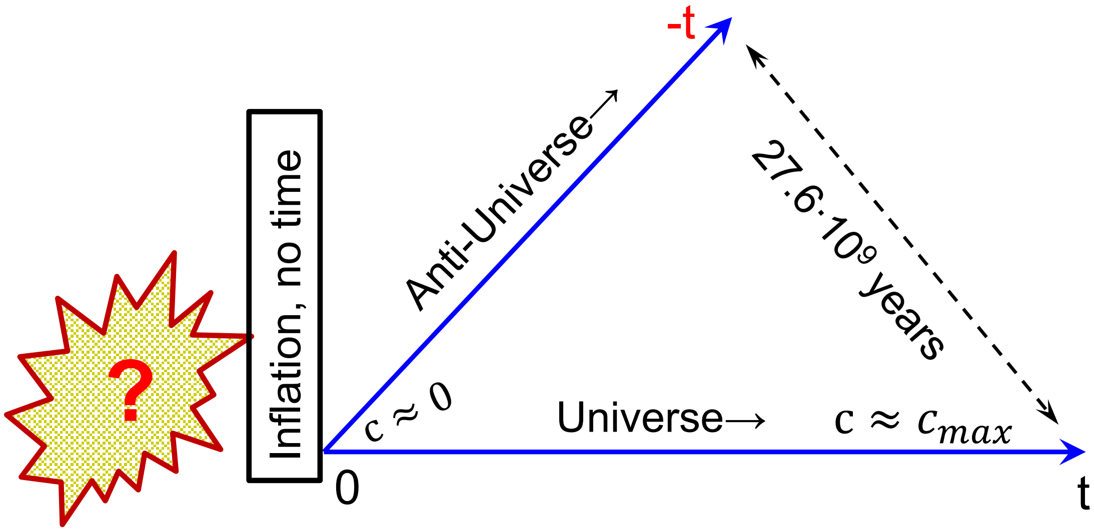
CPT conservation, C, P and T violations

Properties – 7 Cosmology

Inflation at high energy, t=0 at the end of inflation era



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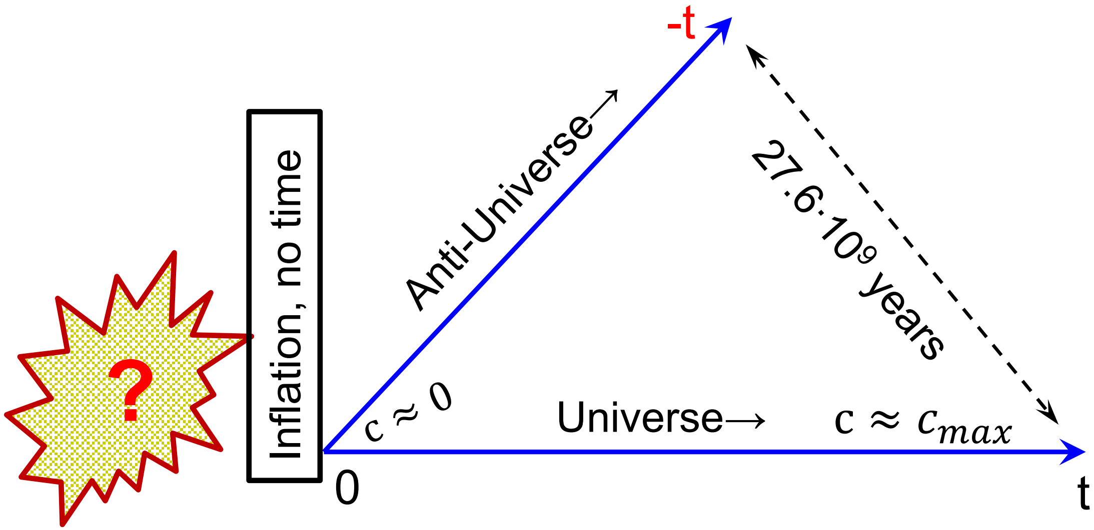

Time fork after t=0, split of the universe due to early stage fluctuations

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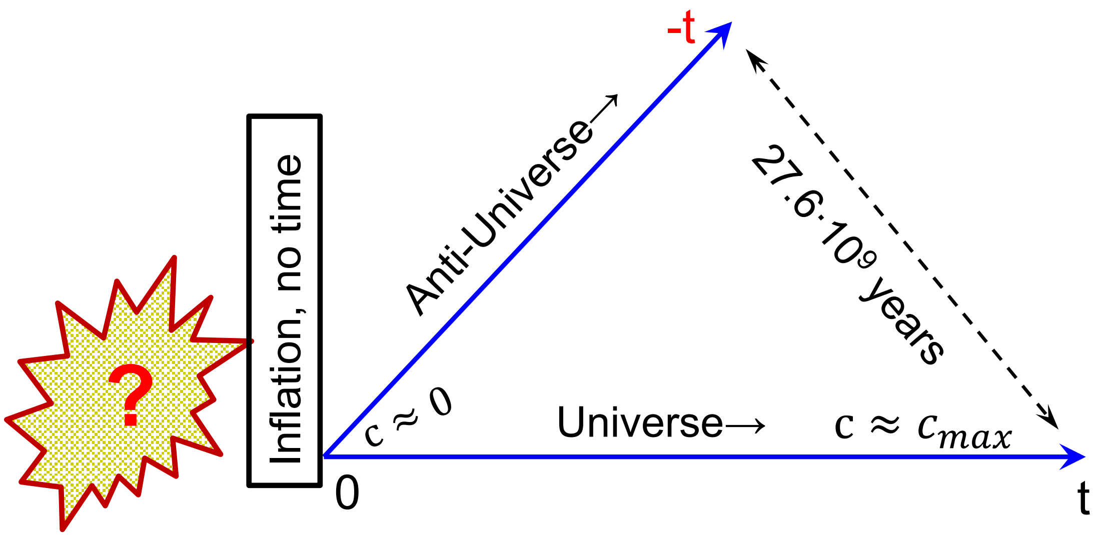

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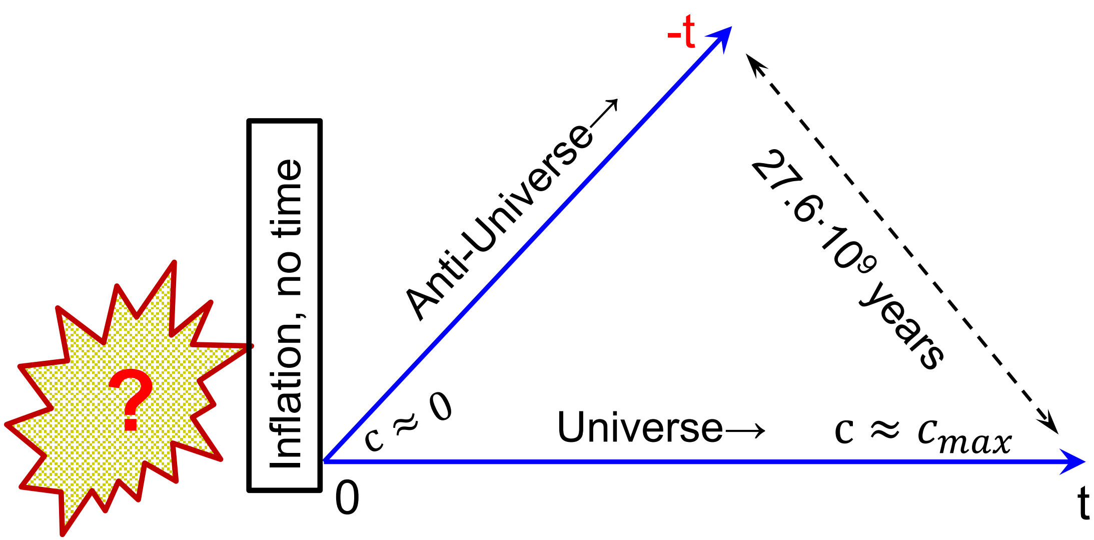

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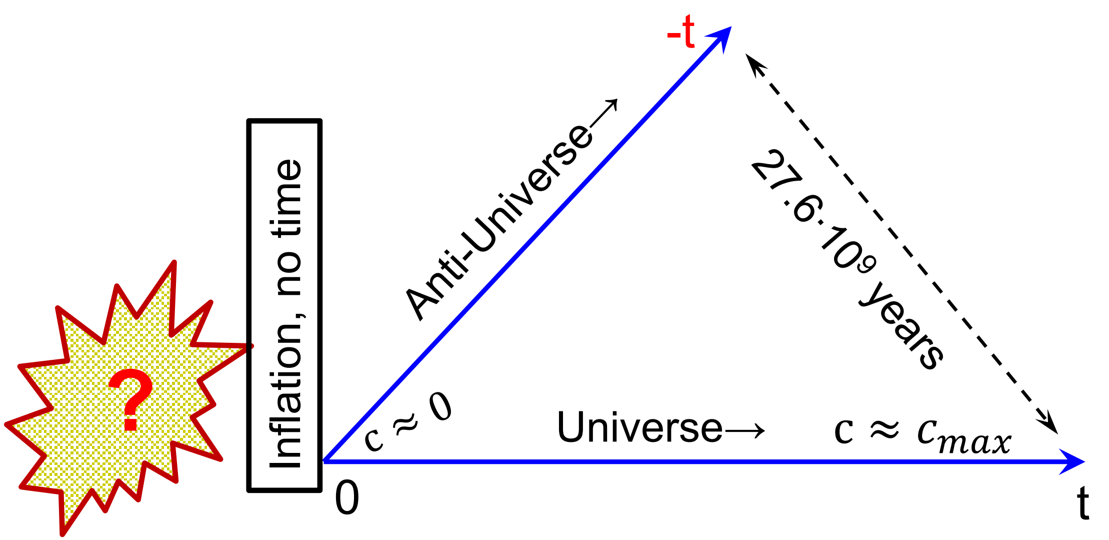

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Accelerating expansion of the universe (time-depending speed of light, delayed potentials from anti-universe)

Open questions (few of many)

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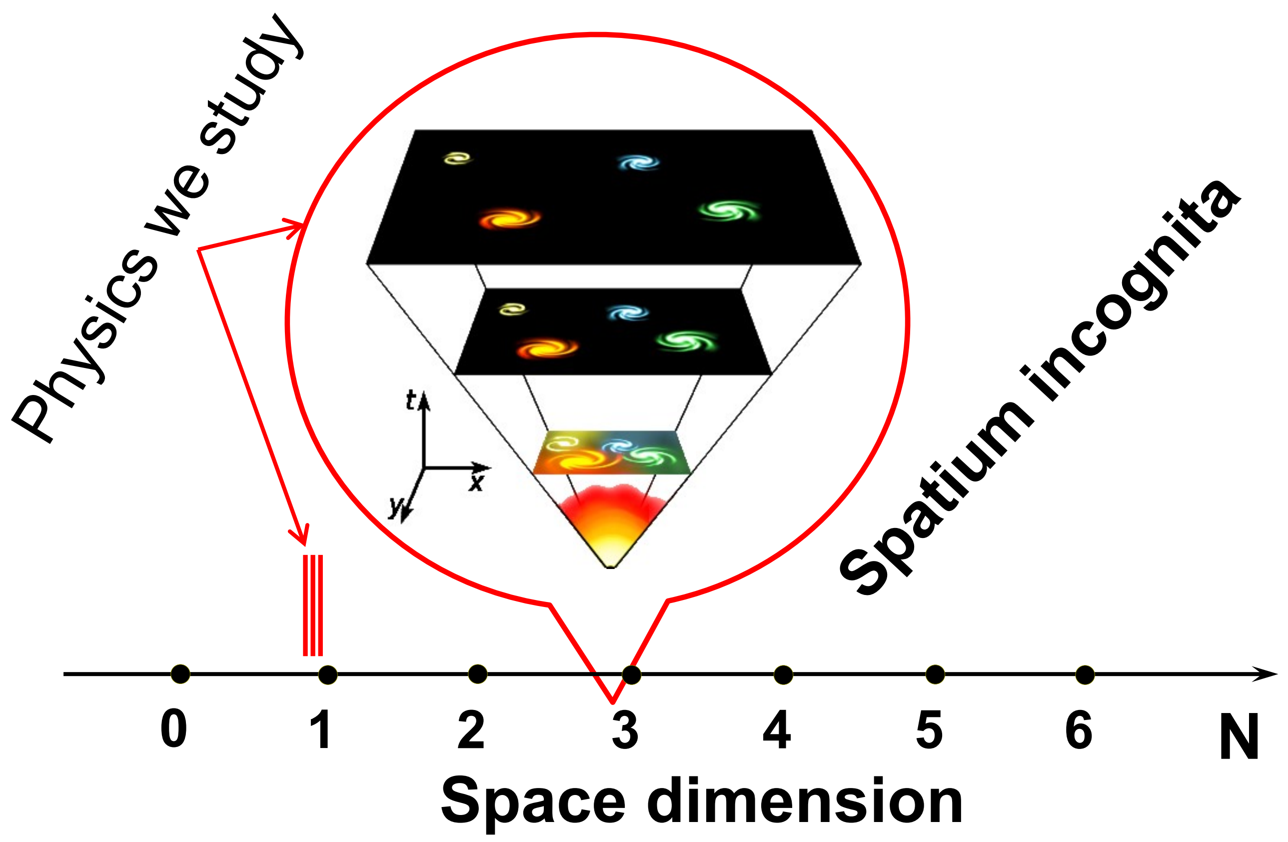
Challenge for the theory: formalism in asymmetric fractal space, especially for e-D case

Conclusions (no free parameters!)

- Starting from the basic (least radix economy) principle, we conclude, that e-dimensional space is the ground state of our universe
- Minimization of long-range field integrals leads to the requirement on the space to be 3-dimensional at large distances
- In addition an extra dimension is required, leading to flat Minkowsky metrics at asymptotically low energy densities, with $c^2 = 3 - e$ being universal constant
- At finite energy densities the space has to have internal curvature, thus requiring gravitation; c^2 becomes space curvature dependent
- Purely spatial *e*-dimensional space at low distances is described by quantum mechanics. Transition between e-D and 3-D spaces is defined from global energy minimization and may be used for Planck constant determination
- Low distance space is asymmetric and has 2 states of opposite chirality. As a consequence, 3 generations of particles with different masses are created at ground state; anti-particles are parity-conjugated states of particles. C, P and T symmetries have geometrical meaning, combined CPT is conserved
- Cosmology: inflation, baryon asymmetry, large scale ‘voids’ and accelerating expansion are natural consequences

Physical space unknowns



Thank you for your attention

See also: Sergej Schuwalow, Low Energy World 1, DESY preprint
[PUBDB-2018-04690] Preprint/Report