On construction of artificial empty space

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Problem list

Problems of modeling vacuum with crystals/lattices

- **Problem 1**: Crystals are anisotropic. The spacetime is isotropic. Therefore, spacetime must not be a crystal.
- **Problem 2**: A 4-dimensional structure cannot be manufactured as a 3D physical object. So the working model cannot be built.
- **Problem 3**: Computers are sequential and deterministic. However, the ambiguity of state is essential part of model with quantum behavior, and it must be kept in the model between measurements/interactions.
- **Problem 4**: What is the time? How the structure becomes dynamic? How should it be evaluated?
- **Problem 5**: The more nodes is considered, the less is the speed of computation. Big models cannot be calculated due to the shortage of computational resources.

Satori structure overview

- The basic structure for our model is the 4D space-filling by **26-cell 'satori' polytopes**. This is the most effective (as it is known) way of space partitioning.
  It can be thought of as a modification of the tesseract grid.
- Each line of nodes along axes is shifted along them on half-edge length:
  Then, Voronoi diagram is produced. It consist of uniform polytopes with 2 dodecahedral and 24 nonahedral 3D-faces.
  Each node in tesseract is considered either Even or Odd. This Parity data is inherited by the Satori structure.

Trigonometrical approximation

The charge density in the 26-cell Satori structure can be approximated by trigonometrical function:

$$\begin{aligned}\rho = -(&\sin x(1-\cos y)(1+\cos z)\\ &+\sin y(1-\cos z)(1+\cos x)\\ &+\sin z(1-\cos x)(1+\cos y))(1+\cos w)\\ -(&\sin x(1-\cos z)(1+\cos y)\\ &+\sin y(1-\cos x)(1+\cos z)\\ &+\sin z(1-\cos y)(1+\cos x)(1-\cos w)\\ &+\sin w(1+\cos x)(1+\cos y)(1+\cos z)\\ &-\sin w(1-\cos x)(1-\cos y)(1-\cos z)\end{aligned} \tag{1}$$

Other approximations

There are several other **representation of grids** that are useful. Namely,

- *Voronoi cells* allow mass/energy estimations;
- Curved *inter-cell walls* can be considered as a brane;
- Approximation by Gaussian kinks alone, or in addition to trigonometrical function, allow implementing analytical methods and produce visualizations and animations.

Compactification

- The grid is compactified (folded) having only one period in one direction.
- The compactification does not change the intrinsic curvature of the lattice
- The structure is CPT-symmetric. The rear side of the 5-cylinder is PT-transformed frontal side. It is equivalent to Charge inversion. So, opposite-charged nodes overlap and mutually compensate, producing zero effective charge density.

No miracles and artifacts

The permanent cutting and folding allows to effectively '*utilize*' all the nodes so no one node is wasted and there is nothing external in respect to the observed Universe. It **explains observed absence of miracles and artifacts** that would appear and disappear in our Universe in case of interacting with 4D or higher-dimensional objects. This restriction does not forbid producing such artifacts intentionally by inventing and applying some advanced technology, for instance unrolling the lattice.

Vacuum domains

The **grid nodes may have physical sense and explainable origin**. It could appear as a self-assembling *vacuum domain structure* in conditions near to critical point of the phase transition. It is analogous to the known **LLPT** (liquid-liquid phase transition) in water-phenol and other similar mixtures. Domains are close to Voronoi cells around nodes, but can have slightly curved walls, according to Plateau's laws.

Electrical Charge

Postulating the changeable Charge of node, and its initial equality to the original Parity, one bit for each node, we can consider the grid as a kind of memory storing the data locally in nodes and having the node-based syntactical freedom.
While the Parity of nodes is fixed by their position in the lattice, the Charge bits can be exchanged, producing a pair of two opposite-charged particle and anti-particle. It reflects the known natural Charge-Parity (CP) symmetry between left-handed particles and right-handed antiparticles, and vice versa. 4

Charge value

The Charge of node can be deferred from the known particle charges statistics, it must be $\frac{1}{6}$ **of the electron charge**. Each defect $\frac{1}{6} \leftrightarrow -\frac{1}{6}$ has charge of $\pm\frac{1}{3}$:

e^-	$\tilde{u}$	d	$\tilde{\nu}$	ν	$\tilde{d}$	u	e^+
-1	$-\frac{2}{3}$	$-\frac{1}{3}$	-0	0	$\frac{1}{3}$	$\frac{2}{3}$	$+1$

The estimated **scale** (domain radius) based on Higgs expectation value **is about** $10^{-21}m$.

Data storage

- The **data in grid is stored both in nodes and edges**.
- The edges are more conservative. They determine the emergent space dimension count, its symmetry, and the rules.
- The node data is more volatile, and it describes individual particles and their behavior. The node data is supposed to be 1 bit per node, or say the node *is* one bit.

Other structures

- **Each geometrical grid type has its special** coordination number determining the dimension count, as well as a set of possible spatial defects arrangements, i.e. the **finite spectrum of particles** and interactions.
- In condition of domain count conservation, the Universe size is reverse-exponential dependent on the coordination number and dimension count.
- If $d > 4$, the Universe is small and casually connected.
- The Big Bang and cosmological inflation probably correspond to decays of high dimensional grid towards low dimensional one.

Polytope vs. hyper-sphere packing

Considering effective space **filling with polytopes is preferable to solid hyper-sphere packing**. It is because of voids between hyper-spheres, that are also bodies. So in fact it is a packing of two kinds of shapes, that is more complicated and less effective (in sense of wall hyper-surface to bodies hyper-volume ratio), that is filling with polytopes that can be all of just one shape.

Example of 8-dimensional structure

Hypothesis that the E8 Gosset polytope is most effective space filling in 8D. There are several known effective space-fillings in 2,3,4 dimensions. All of them can be produced from the corresponding hyper-cubic grid by one or more independent solid-body shifts of some nodes groups. The shift with the most compacting effect is 1D shift, along crystalline axes. The 2D shift of planes is a bit less effective (it produces FCC). All the possible 1D shifts are exhausted in 4D. Supposing 2D, 3D, ... shifts are also exhausted on some dimensions, E8 (that is produced by 7D shift) may be the most effective space-filling in 8D but may be not.

Mutual cancellation of charged domains in case of compactification

The rolling or folding of grid together with Charge-Parity concept can **explain why the observable space is isotropic** while both periodic and quasi-periodic grids, that are supposed to be the background structure of space, are not. In case of folding, there are two mirror-reflected layers in projection, so pairs of CP-symmetric nodes can effectively cancel each other in projection. The Charge (in absence of defects) is exactly 0 everywhere so nodes are not observable, and the projected space appears isotropic and empty. However, all nodes still exist on the rolled space and can participate in time clock movement and cellular-automaton-like evolution. Defects cause de-compensations of charges, that are observable as charged or not charged particles.

Proper time and dynamics concept

- Rear and front sides of the compactified 4D space are mutual mirror worlds
- The oscillation between two mirror worlds is not trivial since the corresponding nodes are of different charges.
- Each node takes different place on each oscillation that looks like virtual movement along the grid with maximal speed determined with the oscillation frequency.
- Single, double, triple defects also participate in the oscillation, that looks like propagation.
- There are dichotomycal forks of paths in the 26-cell filling. Making a choice requires applying extra data.
- In backward direction the fork is a junction that does not require choice to me made.
- Paths of the defect is a composition of forks and junctions with some ratio, that is supposed to be connected with **proper time**. Zero proper time for light-speed movement is caused by no forks of these paths.

Hardware vacuum

The cellular automaton's cells may be equipped with **simple hardware** circuit that performs the evaluating rule. Doing so *simultaneously* and asynchronously may have advances that cannot be achieved by using dedicated CPU that runs simple program rule for all the cells *in turn*.
This approach allows to get rid of computational resources limitations and of lowering performance on big arrays. In asynchronous regime some interesting effects of mutual concurrency may appear, that are suppressed in synchronous computations.

Conclusion

- The concept of vacuum as a tessellation looks rich and promising enough.
- Some experimental research can be conducted further in this framework.