Clifford flat torus as preferred topology for the dynamic tessellation model based on inter-domain wall minimization

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July 7, 2020

Components of the Tessellation approach

Mathematical and logical background

- Self-modelling requirement for Universe model
- Non-linear binary codes offering uncertainty and internal degrees of freedom

Binary code particle models

- Particle and vacuum models based on binary codes (3, 4, 6, 8, 8.1)
- Tessellations of $\pm 1/6$ e -charged domains, equivalent to binary codes
- Higgs field and electrical field unification on scale 10-21m
- 3-dimensional static Weaire-Phelan tessellation model
  - CPT symmetry
  - Polyhedral, Analytical and Double-layer approximations
  - Boson mass calculation based on wall area
  - Mass-based guessing for fermion configurations with odd results

Components of the Tessellation approach (2)

- Dynamics modeling requirements:
  - additional dimension
  - Bresenham's algorithm
  - continuous cellular automaton
- Kelvin's problem and its generalization. Satori structure.
- **Clifford (flat) torus as preferred topology for the tessellation based on inter-domain wall minimization.**
- Uncertainty that emerges from limited information storing ability. Self time as "forward" step count.
- Origin of domains
  - Liquid-liquid second-order phase transition
  - Oriented manifold
  - Bits of fundamental information
- **Model with conserved domain count but free dimension count. Inflation as dimension-changing decay.**

We study the Universe by modeling its structure on a scale of sizes on the order of 10-21 m, trying to ensure that this model conforms to the known theories, observations and experiments.
The basis of our approach is the postulate of the existence of certain regions or domains with a characteristic size of the order of 10-21 m of two types that differ only in sign of electric charge - plus or minus 1/6 of the electron charge. Such a postulate is sufficient to explain the charge-related properties of fundamental particles, considered as clusters of several, of the order of eight, neighboring domains of this kind.

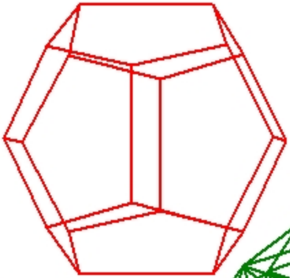
The second postulate is the notion that empty space that does not contain particles is also a bound state from the same domains, representing a periodic repetition of the same pattern in all directions. It can also be thought of as condensate obtained by repeating clusters corresponding to certain background particles.

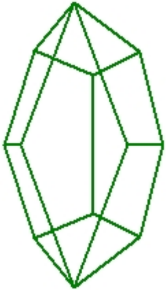
Particles in this case can be considered as anti-structural defects, that are violations of the periodicity of such filling.
In addition to particle defects, other types of excitation can exist in this model, for example, in the form of compression, displacement, and torsion waves, which could be identified as gravitational waves or dark matter.

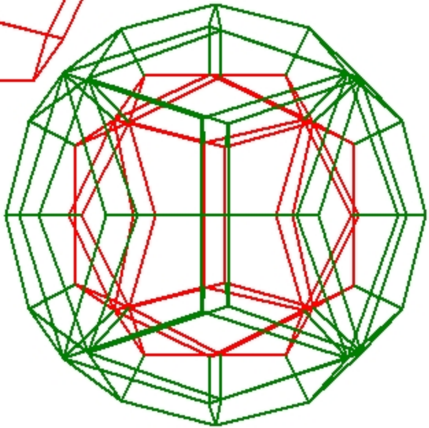
Clifford (flat) torus as preferred topology for the tessellation based on inter-domain wall minimization.

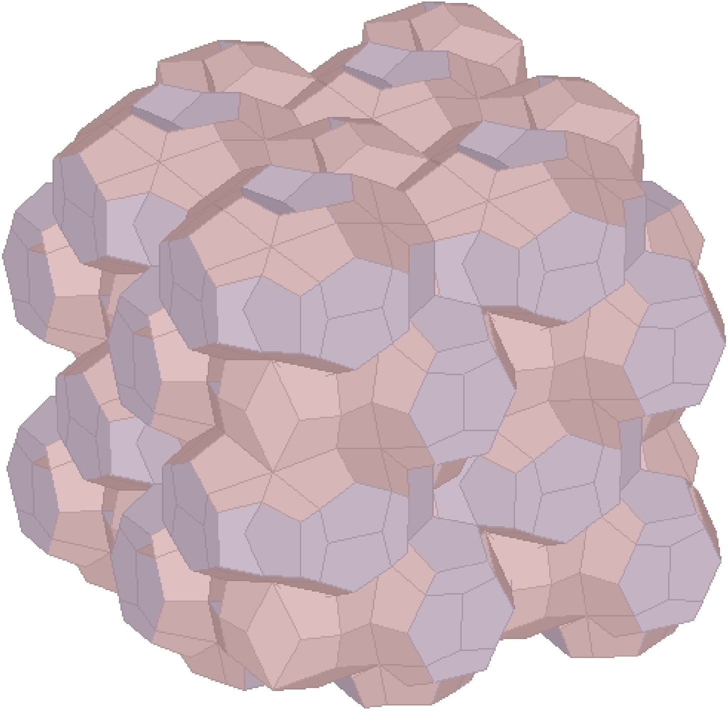
The distribution or alternation of domains is presumably determined by minimizing the energy of their neighboring contact with each other.
Therefore, we mainly consider tessellations that are solutions or candidates for solutions to the Kelvin's problem of optimal packing.
To work with a four-dimensional space, or with spaces of higher dimensions, as well as to get rid of a pre-selected dimension count, we proposed an approach to measuring the economy of filling, which is independent of the dimension count and is based on comparison with the corresponding simple hypercubic lattice.

Thus, we have made possible the generalized formulation of the Kelvin's problem, in which the search for the optimal filling is not limited to three-dimensional space.
Instead, the dimension of space appears along with the solution of the problem, as a characteristic of space, in which this solution can be nested.
The four-dimensional structure that we found and named 'Satori', is a candidate solution for the generalized Kelvin's problem. Like the three-dimensional candidate solution of Weair and Phelan (which offers a bit less economy), the Satori structure is chiral, and it offers CPT symmetry.









Applying the principle of energy minimization to the Satori structure with anti-structural defects, we found out that the favorable topology for the model is the four-dimensional Clifford torus with a period of one translation unit.
The result is 'almost' three-dimensional space, having one additional twisted dimension, the radius of which is emergently fixed. Only in this case it is possible to have defects whose energy is zero, which corresponds to massless particles like photons and neutrinos.

In the absence of twisting or when twisting not in one but in two or more periods, such defects would be massive and the space as a whole would decay by strengthening twisting up to a minimum of one period.
Since the three-dimensional torus is not flat but curved, the same twisting in more than one dimension is likely energetically prohibited due to the curvature energy.
We consider the gluon chain termination with quarks as another way to reduce energy instead of looping the chain.

Considering the structure of Satori in the topology of such a torus, we find that it turns out to be **oriented** along a twisted dimension: all four three-dimensional layers that form the centers of cells or domains are different.

Thus, if we consider these layers as phases of the oscillation of a three-dimensional structure, this oscillation will have the appearance of directional rotation, in which four different phases are ordered in turn, and the two possible directions of sequencing are different.

In this case, the movement of individual domains occurs in such a way that each domain can either rotate in place or move along the remaining three dimensions. However, there is no difference between the two cases due to the fact that the domains are indistinguishable from each other and it is impossible to say which domain is spinning in place and which one is moving. The foregoing relates to the Satori structure with a twisted dimensioin in the absence of defects. In the case of defects existing in it, a difference in the electric charge appears, and such a defect can either move or spin or alternate one both way of moving. A domain cannot remain in place, since at different phases the same place is occupied by domains of different signs.

Thus, when passing from layer to layer, the defect undergoes bifurcation. An exception is when the defect moves along the model with the highest possible speed. In this case, there are no rotational transitions. This behavior of defects allows us to identify it with the motion of particles, for which, with approaching the speed of light, increased half-life is observed, which is usually associated with a slowdown in own time. In our model, the own time of a particle turns out to be a phenomenon associated with branching during the movement of the corresponding defect in a vacuum undergoing directedoscillations: the amount of own time is determined by the fraction of branching at which the choice is not determined.

Model with conserved domain count but free dimension count

Another phenomenon can be considered under the assumption that the number of domains in the model of the universe is fixed or the process of their formation and destruction is not significant compared to other processes.
The dimension count, on the contrary, can be assumed to be free, not fixed, determined only by the average number of nearest neighbors characteristic of this tessellation.
So the space and its dimension count would be one of results of modeling.

In this case, the linear size of the model, counted by the number of jumps from domain to domain, turn out to be related to the number of dimensions by an inverse exponential dependence.
The maximum number of dimensions, equal to the number of domains, is achieved in the model in the form of a multidimensional simplex: each domain is a neighbor of all the others.
But already in the case of a hypercube built from the same number of domains as the number of domains (10^{-21} m in size) in the Universe of about 10^{10} light years, the maximum number of dimensions is only about 468, while such a 468-dimensional universe has a size of about 10^{-20} m.

Rearrangement of domains with a decrease in dimension count leads to an increase in linear sizes, but only at 6 dimensions the universe becomes macroscopic, of the order of 0.1 mm.
A further decrease in dimensions is accompanied by an exponential increase in linear size to about 100 km at $d = 5$ and to about 1000 astronomical units at $d = 4$.
In this step, there happens a loss of correlation between different parts of the universe, which, apparently, has been kept until this time: we have no reason to believe that the speed of oscillations that determines light speed in multidimensional structures should be significantly lower.

The last decay of 4-dimensional space into 3-dimensional, or twisting of one dimension with the formation of a flat torus, leads to the formation of a universe of modern size. Further decay into the usual 3-dimensional, or 2- or 1-dimensional space, most likely, is energetically disadvantageous, since it is the four-dimensional space that offers the best saving of cross-domain walls with 26 neighbors.