No Time for Quarks!

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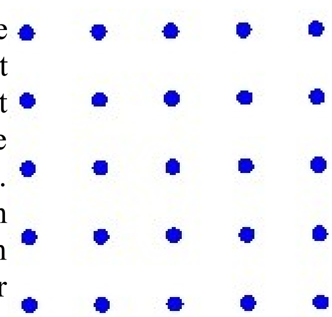
Abstract

An understanding of time from the viewpoint of leptons and quarks moving through a discrete 4-dimensional lattice reveals how we are closely connected to fundamental mathematical concepts. If this brief discussion on the discrete nature of time and space holds true, then the prediction of a new quark called the b' quark will appear at the Large hadron Collider very soon.

We humans experience time and space on a scale that is much larger than atoms and molecules but much smaller than our Solar System and Galaxy. As a physicist, I must consider also what time means on the sub-microscopic scale of the fundamental particles as well as at the super-macroscopic scale of the Universe. Time intervals in seconds covering these extreme limits range over at least 40 powers of ten, from the 10^{-23} seconds for a quark decay to the 13.7 billion year (about 4×10^{17} seconds) history of the Universe. The smallest time interval has yet to be measured, conjectured to be about 10^{-43} seconds, sometimes called the Planck time. The largest time interval could be many times the 13.7 billion years for the present age of the Universe if numerous contractions and expansions have been part of an oscillatory history or if much more 'stuff' exists beyond its known extremities.

The scientific understanding of the nature of time must depend upon a mathematical description followed by the prediction of new experimental evidence. According to Aristotle, any other approach that is not based upon logical or empirical arguments is simply a philosophical description, one that could have been presented before the advent of modern science. Therefore, I present here the mathematical origin of time from the viewpoint of fundamental particles, i.e., the nature of time for leptons and quarks. Then I make the acid-test prediction capable of being answered by planned experiments at the Large hadron Collider (LHC) within the first few years of its operation.

I start by assuming that we live in a 4-dimensional real space R^4 with its four orthogonal coordinate directions (1, i, j, k). Any point in R^4 is located by 4 real numbers (w, x, y, z), so that the point can be represented by the general quaternion $q = w\,1 + x\,i + y\,j + z\,k$. Quaternions have a dual role because they can also represent rotations. For example, the 3-D rendering of objects in video games is done by quaternion rotations. In addition, our familiar 3-dimensional space R^3, the space in which we live, is recognized as the (i, j, k) subspace, and the remaining unused coordinate direction 1 can become the time direction, as I will justify later.

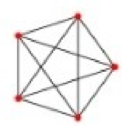
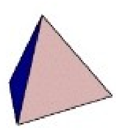
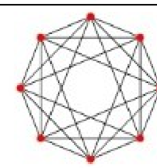
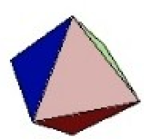
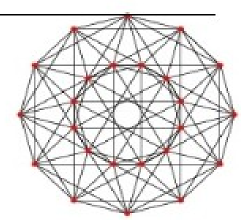
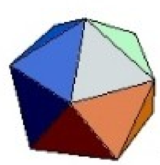
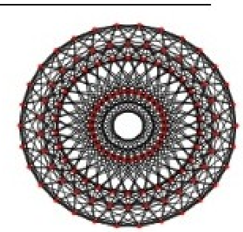


Normally, the four numbers (w, x, y, z) are each assumed to be continuous quantities when they represent our physical world, meaning that there is no minimal spacing between consecutive values. One says that space and time are continuous. However, my physical 4-dimensional space will be discrete, mathematically being a regular lattice of points or nodes. This mathematical lattice of nodes will represent the physical space in which we exist, with a minimal spacing corresponding to the Planck length of about 10^{-35} meters. A visual image of the lattice, but in a smaller number of dimensions than four, would be the regular spacings of atoms in a 3-dimensional crystal or the 2-dimensional slice of the 4-dimensional lattice as shown. At present, experiments have probed down to about 10^{-18} meters, a scale that is considerably larger that the Planck length. So, even though I have a discrete space at 10^{-35} meters, everything "down there" will appear to be continuous when viewed from "up here" with our very limited spatial resolution.

My own previous theoretical research[1,2] has indicated how the leptons and quarks of ordinary matter might behave in this 4-dimensional regular lattice of nodes at the Planck scale. Leptons, such as the electron and its electron neutrino in the first lepton family, are 'a gathering together' of the nodes into 3-dimensional collective entities which have the rotational symmetries of regular polyhedrons. The mathematical groups for these rotational symmetries are the three binary polyhedral groups <3,3,2>, <4,3,2>, and <5,3,2>, as shown. All the symmetry operations in these groups can be represented by the appropriate unit quaternions. Each lepton family with its two orthogonal particle states represents one binary rotation group. As fundamental particles requiring only the subspace of 3 spatial dimensions for their definition, leptons move through the 4-dimensional discrete lattice with the remaining coordinate available to register the passage of time.

This 3-dimensional description of the leptons requires that quarks should be defined in a similar manner. Since the 3-dimensional rotational symmetries are exhausted by the leptons, quarks must be related to 4-dimensional rotational symmetries. Indeed, quarks are 'a gathering together' of the nodes into 4-dimensional collective entities which have the rotational symmetries of the 4-dimensional regular polytopes, analogs to the polyhedrons but one spatial dimension greater. Their mathematical binary polytope groups are <3,3,3>, <4,3,3>, <3,4,3>, and <5,3,3>, as shown. Requiring 4 spatial dimensions for their definitions means that quarks do not have a remaining dimension available for representing time intervals.

This table of leptons and quarks lists the 3 lepton families and 4 quark families, giving the two particle states in each family, their binary rotational symmetry groups, and images of the polyhedrons

Invariant	Leptons		3-D	Quarks		4-D
{1/4}				u d	<3,3,3>	
1	ν_e e	<3,3,2>		c s	<4,3,3>	
108	ν_μ μ	<4,3,2>		t b	<3,4,3>	
1728	ν_τ τ	<5,3,2>		t' b'	<5,3,3>	

and polytopes. The leftmost column contains the mathematical invariant for the horizontal row, revealing that the tau lepton family and the t' quark family are closely related, for example. The ratios of these invariants are the ratios of the particle masses and connect the leptons and quarks to the j-invariant of elliptic modular functions. These additional topics were discussed thoroughly in research articles[1,2] and further development here is inappropriate.

We know that quarks have further restrictions. For example, an isolated quark cannot exist in our 3-dimensional spatial world because a quark 'lives' in 4 dimensions. However, quarks can combine in three special ways to form 3-dimensional entities called hadrons which can move through the lattice with an available remaining coordinate for registering time intervals. Called mathematical intersections, quarks can combine into hadrons with three quarks to make the proton, a quark and an antiquark to make the pion, or three antiquarks make the antiproton. These hadrons move through the lattice just like the leptons do.

Most fundamental particles are 'aware' of the elapsed time because they do not 'live' forever; they decay to other fundamental particles with an average lifetime. However, neither the electron nor the isolated proton is known to decay, meaning that they do not change into other fundamental particles. So, why can the electron and the proton seemingly last forever? I can provide several physical arguments for why they do not decay based upon conserved quantum numbers, but I suspect that these physics reasons are all linked to one mathematical reason.

Mathematicians define a graph as a collection of nodes and connections between some of the nodes. They know that for any mathematical lattice (or graph) chosen to represent our physical world, Kuratowski's Theorem says that every non-planar graph contains either the utility graph $K_{3,3}$ or the complete graph K_5 as a graph minor. Said in a different way, the existence of either one of these two special graphs, one with 6 nodes and the other with 5 nodes, guarantees that the space dimension is greater than two dimensions. Or, if the lattice is 4-dimensional, then it must contain K_5. In still another way, $K_{3,3}$ and K_5 can move through the lattice as invariant entities that cannot be broken down into smaller ones, i.e., they exist forever.

The regular K_5 graph with its 5 nodes equally spaced in a 4-dimensional lattice has the symmetry group <3,3,3> of our first family of quarks containing the up and down quarks. Its representation on the 2-dimensional page is shown above. This mathematical connection dictates that isolated up and down quarks do not decay. A proton is composed of up and down quarks. The up and down quark immortality helps keep the proton from decaying.

The electron of the first lepton family is a representation of the binary rotational symmetry group <3,3,2> for the regular tetrahedron with its 4 nodes and corresponds to the symmetric 3-dimensional substructure of the K_5 graph. Apparently, this 3-dimensional substructure falls under the aegis of K_5 immortality also, i.e., never loses its geometric connection to the K_5 graph in 4-dimensional space, because the electron does not decay. One could deduce that 3-dimensional space and 1-dimensional time form a union that will “preserve an independent reality”.

Time seems to have a direction, for we can recall the past but not the future. However, this 'arrow of time' sensation is not a human failing. The unique time direction is actually built into the fundamental rotational symmetry groups for the leptons and quarks and their interactions that determine our existence[3]. In addition to the particles in our 4-dimensional lattice we know that antiparticles exist in the conjugate 4-dimensional lattice. An area of mathematics called Clifford algebra tells us that both spaces are available. But there is no requirement that we exist in both spaces simultaneously! These two spaces are not equivalent to leptons and quarks. Instead, the quaternions in one lattice and their conjugate quaternions in the other lattice are gauge equivalent, meaning that a particle and its antiparticle have opposite quantum numbers but have the same positive mass-energy. This gauge equivalence implies that antiparticles experience the same time direction as do particles. So I'm sorry to say that backwards time travel for us lives only in our imaginations and in science fiction.

I promised a prediction for the LHC. If time is truly the remaining 4^{th} coordinate for the 3-dimensional leptons and the hadrons, then the prediction of 4 quark families (one more than presently detected) means that the two additional quarks b' and t' must appear at the collider. The theory predicts the b' quark mass to be about 70 to 80 GeV and the t' quark mass at a whopping 2600 GeV. Surely, when the b' quark shows up, we will know then that the nature of time is being experienced by leptons and hadrons in our bodies moving through the 4-dimensional lattice of nodes that permeates the Universe.

REFERENCES

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3. S. L. Altmann, Rotations, Quaternions, and Double Groups, 1986 (Clarendon Press, Oxford), pp. 117-123.