The day of pi

by Jim Adams

On March 14th 2013 Doly Garcia and I went on the ‘Brighton Wheel’, with a panoramic view from it of Brighton & Hove. We were on the Wheel after 3 o’clock, the time represented by the number $\pi = 3.14159$ ...

During a conversation at Donatello’s Restaurant afterwards also with Tim Gibbs, I was asked to provide details of what I had said on my physics research programme, which is not due to begin until 2016. Here, including a little addition on why I think there might be 3 families of leptons, is the extended content of what I said.

Is the content of theories of physics secure? Perhaps not. It is not only that the contents of the philosophy of physics, close to logical positivism, are I think false, it may also be the case that theories today accepted as true, despite their many experimental confirmations to enormous accuracy in quantum mechanics, may indeed be only approximations to the correct description of nature.

Many theoretical physicists are adept at fitting a mathematical model to experimental data, and may be able to do this in a large number of ways. However, such curve fitting techniques do not of themselves provide insight.

If we look back in the past over 2,000 years, to the work of Aristotle, in some ways a theoretical physicist of his day, providing theories of logical deduction as well as of physical processes like the laws of motion and the motion of celestial bodies, and despite his obvious erudition, we see a salutary lesson. Any scientifically educated reader of today is immediately able to detect gross errors in Aristotle’s description of the physical world, and yet in medieval times and later, the work of Aristotle was revered as the high point in thinking in a logical way about the laws of nature, and that is indeed the case, for its time. Philosophers took the work of Aristotle as text, without submitting what he said to experimental confirmation. The scientific revolution initiated by Galileo and others was a reaction to this state of affairs. Many scientific theories of today had their genesis as a critique of Aristotelian logic or physics. In that sense, Aristotle was extremely important.

If the human race survives 2,000 more years, would a physicist of that time be able to look back on the physics of today and immediately spot its errors? I think so.

Quaternions, a type of ‘four dimensional complex number’ discovered by the Irish mathematician William Rowan Hamilton, in which the real component of the quaternion describes a timelike dimension, and the three noncommuting variables, i, j and k represent space, are used in a highly efficient method for interpreting the motion of gyroscopes. They are also a representation, as mentioned by the mathematician Eli Cartan in his book ‘The theory of spinors’ of the Dirac relativistic equation of the electron.

The algebra is described as follows, for a quarternion H

$H = a1 + bi + cj + dk$
$H^* = a1 - bi - cj - dk$
HH^* is a scalar: $a^2 + b^2 + c^2 + d^2$
$1.i = i = i.1$, $1.j = j = j.1$, $1.k = k = k.1$
$1^2 = 1$, $i^2 = -1$, $j^2 = -1$, $k^2 = -1$
$i.j = k = -j.i$, $j.k = i = -k.j$, $k.i = j = -i.k$.

Quaternions describe exactly the special relativistic Lorentz transformations in physics. This is what I call the *space* point of view. We can represent a scalar by

$HH^* = (a1.a1) - (bi.bi) - (cj.cj) - (dk.dk)$

and this form is the scalar line element of special relativity, measured with respect to an observer in space described by the 3-dimensional basis element set (i, j, k). Note the minus signs in this representation. This form describes the Lorentz transformations, as is done in a section 7 of my work ‘Vector Calculus’ on my website www.jimhadams.com.

Not only does HH* represent a space invariant, it also represents a time invariant, of the form

$HH^* = (a^2 + b^2 + c^2 + d^2)1$.

We will interpret this as the quaternionic representation of the wave function now not given by a complex number, but by its quaternionic extension, multiplied by its quaternionic conjugate. In conventional physics, this represents the probability of the wave function.

The quaternions may be embedded in the octonions, a nonassociative algebra. This is described in the website as item 1Ba, which is an overview article on hyperintricate numbers, in chapter IV on division algebras. It is then possible to accommodate further aspects of the particle spectrum in such a theory. Further, by this means the quaternions can be embedded as part of a curved space-time within a flat octonionic space, useful in considering general relativity.

Doly is interested in why there exist finite states. To develop this theme – why should the universe be described by complex numbers, quaternions or octonions, from my own point of view? An answer might be that other algebras are possible – as is mentioned in chapter IV on division algebras in 1Ba, but only in the above three cases is division possible except division by zero. It is an interesting speculation that those other algebras have existed, but the allowance of states within them that are equivalent to division by zero has meant that singularities have formed. It is my point of view that division by zero can be accommodated, and the result is not a number, but a set, the set of all numbers. Thus in this instance number is not conserved. It is also possible that number has not been conserved in the creation of the universe, and this corresponds to the situation of a singularity, and division by zero.

There are three families of leptons, all described by the Dirac equation which I have stated is represented by a quaternion. If you look at the division algebra chapter in 1Ba, you will see that three main representations of the quaternions are given. It is an idea that these matrix representations are actually present in nature, and correspond to the electron, muon or tau particles, or their neutrinos. A complication is that the multiplication of quaternions in different representations may not result in a quaternion, and this may have implications in say electron-muon interactions which renders this approach unviable, particularly since singularities would then be present, implying the possibility of the non-conservation of number.

In more detail, the three representations of quaternions are of type 1: $a1_1 + bi_1 + c1_\alpha + d1_\phi$, type 2: $a1_1 + b1_i + c\alpha_1 + d\phi_1$, or (and I have been slightly lying here), type 3, which can be of two ostensibly equivalent forms, type 3a: $a1_{11} + bi_{\alpha\phi} + c\alpha_{\phi i} + d\phi_{i\alpha}$ and type 3b, which is the alternative cyclic permutation: $a1_{11} + bi_{\phi\alpha} + c\phi_{\alpha i} + d\alpha_{i\phi}$.

What is interesting is that type 1 and 2 when multiplied together don't in general produce a quaternion, but if say a = b = c = d, then they produce a scalar, which is another way of saying this is timelike, and this would usually be positive, but if say type 1 was positive in a, b, c and d in this way and type 2 was negative in the same coefficients, then this would be a negative timelike result, that is, going backwards in time.

I add in parenthesis that at the initial singularity of the universe (zero), it is possible for one portion to go forwards in time and the other backwards, and this allows asymmetries, for example in having non-zero mass for particles.

The situation for multiplication (interaction?) of these two types with types 3, and type 3a with type 3b is again never a quaternion. In fact, we must assume that say type 2 is of the form $a1_{11} + b1_{i1} + c\alpha_{11} + d\phi_{11}$ in order to multiply with type 3a or 3b.

The work of the physicist John Bell, given in the book 'Speakable and unspeakable in quantum mechanics', CUP, 1987, who was responsible for the 'Bell inequality' in quantum theory, is highly important. Bell speaks (I have introduced a hyphen) of be-ables, rather than observables. Basically, a physical should describe what *exists*, rather than be based on what is *observed*. Observations then come out as a consequence of a theory rather than its basis.

According to Bell, it is possible to introduce into relativity a fixed frame of reference, as was pointed out by Lorentz, thereby reintroducing the idea of simultaneity into physics. The relativistic equations do not change, from this point of view.

Bell also speaks of hidden variable (de Broglie Bohm) theory in quantum mechanics. It is well understood that these are viable, and sidestep the von Neumann 'no-go' theorem on the inadmissibility of such theories, since they do not conform to its assumptions. It does, after all, satisfy the Schrödinger equation!

The idea of 'entanglement' in which in a thought experiment a box containing an electron is sealed in London, a partition is inserted to divide the box and one half is sent to Tokyo and the other to New York, so that on opening the box in Tokyo and finding an electron present collapses the wave function in New York so that it is no longer present there, is now unnecessary when a global simultaneity operates. The de Broglie Bohm interpretation, in which the electron already exists in one side of the box or the other, but is accompanied by a pilot wave, can now jettison entanglement in the relativistic case, but I think this was not the opinion of Bohm.

A further idea is that spin states may be represented by global Möbius bands within a quaternionic or octonionic space which is flat. This introduces a new aspect to theories of supersymmetry, which jettison the Dirac equation in favour of a complex Schrödinger picture together with relativity, in order to accommodate spin states. This theory is predictive. I do not think it is needed.

What I have described so far is Theory I – the attempt at an octonionic theory of everything. I will now move on to mainly the quark description of the strong interactions, which I believe require a different type of description not included in the octonionic theory.

John Bell points out that quantum mechanics also applies to macroscopic states – states in the large. However, there appears to be a contradiction here – quantum mechanics requires the linear superposition of states, as is necessary to describe the line spectra of transitions within electron orbitals in the atom, measured by emission of photons, but it is not possible to linearly superpose a fork and a glass of coffee in a macroscopic environment. The explanation given by most physicists is that the wave function has collapsed – that is, the Schrödinger equation no longer operates. The question then raised is *where* does the wave function collapse, but it does not seem to matter!

The objective of the next section is to state why I believe the wave function collapses just beyond the quark level, or its equivalent. This is Theory II, and involves branched spaces, which I describe in 5A and 5B in the website as the subject of chromotopical algebra. 5B is currently an uncompleted work.

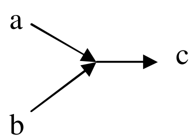
It follows that since quarks interact in a chromotopical space, and the characterisation of such a space differs from a space described by a division algebra, that the quark particle spectrum does not have to be described by an octonionic theory or a subalgebra of this. Supersymmetry was invented in order to accommodate particle states with relativity. I am now claiming this is unnecessary.

Topologies of unbounded spaces can be described by a dimension, n, and to each number 1, ... n we can describe a line. Uniquely, the line *globalises*, that is two lines can connect, each line has two end points, and the globalised amalgamation again has two end points. A variation is that the two end points can connect, forming a circle. Topologically, this is all you can do with a line.

It is my contention that this structure is available with division algebras or an algebra with vectors, which define the electroweak interactions, but it fails for branched spaces of which I provide some description next, and branched spaces are what we have for quarks. The detailed description of branched spaces and chromotopical algebra is given in the references already mentioned. I will not repeat it here.

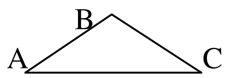
The consequence of the non-unique branched space globalisation is that states which do globalise uniquely measure a superposition of states for the branched space. This is precisely the linear superposition of states in quantum theory. Quarks interact in threes, and that is why the algebra is branched. It also implies that leptons have an interior structure which is branched.

An additional comment is that group structures may be described by opposite chromotopy to a type of branch



The combination of a and b results in c.

Doly Garcia raised the question of whether the world is described finitely by cellular automata. I stated that a distance between objects could be defined by the number of times they interchange information, and that non-standard topologies are possible. This can define a metric space if the distance function obeys the triangle inequality,



where the distance AB + BC > AC. In order that the objects recognise the distance between them, the system must have memory, that is, it is a Markov process. The cellular automaton model if it is to succeed, needs to be able to describe the dimensionality of a space, but this is best done by assuming the objects are embedded in a space, which is not an all-encompassing cellular automata approach.

However, the cellular automaton model has some merits. In particular information passed from A to B does not have to exist in equal measure to information passed from B to A. Whilst this does not conform to a single distance function idea, it does allow the possibility of a dynamical theory which inherently promotes motion of the objects described within it.