Construction of the 2nd and 3rd Generation of Quark Particles in the Standard Model

Christopher C. O'Neill
University College Dublin (UCD), Belfield, Dublin, Ireland
email: chris.ozneill@gmail.com
22 December 2020

Abstract

A method for the construction of 2nd and 3rd generations quarks using DGO Quaternion Multiplication is outlined in full. This work builds on previous work involving quark and gluon construction and extends it out to its logical conclusions.

Flock of Birds

We know that gluons are 4-dimensional rhombi-dodecahedrons (the analogue vertex-first perspective projection of a hyper-cube) and that *u* and *d* quarks are both hypercubes and rhombicuboctahedron prisms, respectively.[1] We also know that the gluons are the !Δ (XNOR) and Δ (XOR) sums of the ^U (AND UP) and/or !VD (OR DOWN) logic inherent in the quaternions.[2] XNOR is the rule set that governs imaginary numbers and XOR rules the real numbers.[3] We can add, subtract, multiply and divide — or do any other kind of arithmetic — with the imaginary and real numbers, if we first privilege the XNOR (!Δ) values over the XOR (Δ) values and then the reverse:

$$!\Delta(x)*\Delta(y) = !\Delta(z) \tag{1}$$

$$\Delta(x)*!\Delta(y) = \Delta(z) \tag{2}$$

Finally, we sum both values in XOR:

$$!\Delta(z)+\Delta(z) = (\Delta)w \tag{3}$$

Since, !Δ and Δ are non-commutative (Δ)w must equal 0. And we can do the same with addition:

$$!\Delta(x)+\Delta(y) = !\Delta(z) \tag{4}$$

$$\Delta(x)+!\Delta(y) = \Delta(z) \tag{5}$$

Finally, we sum in XOR, and we have our result:

$$!\Delta(z)+\Delta(z) = (\Delta)w \tag{6}$$

But now we notice something strange and seemingly inconsistent. Why can't we simply continue the process of seen in equation (4) and (5) with equation (6)? If we did the process would be neverending. We are going to make use of this feature to create our 2nd and 3rd generations of quarks, so let's try it. Here, we have a graph showing repeated multiplication of !Δ and Δ polynomials (Fig. 1-4).

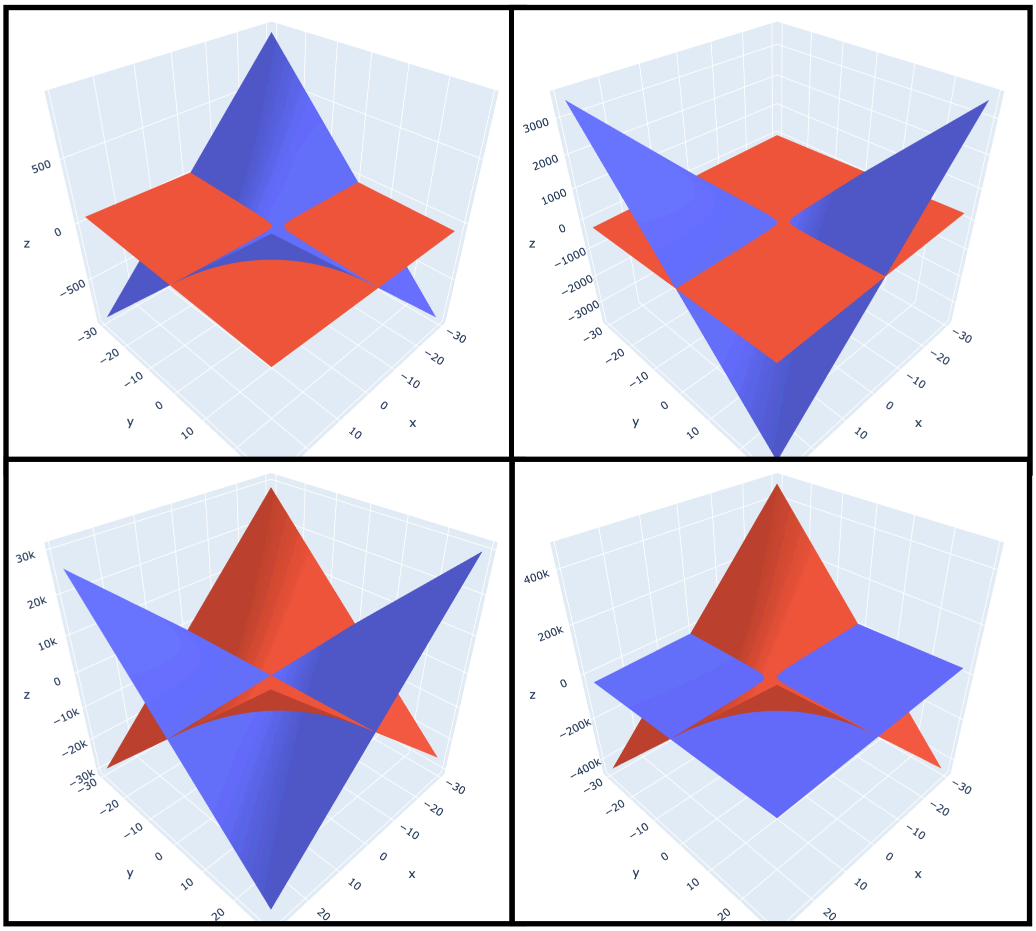

Fig 1 to 4 (Crosswise from top-left): The result of continuous !Δ and Δ multiplication over a range of -30 to 30.

Notice how the values on the z-axis begin to expand upward. This occurs after only a few iterations. By the time 20 of these are achieved the results reach seven digits. But this operation is obviously unreasonable. Notice how the two planes oscillate past one another like a bird flapping its wings. When the wings are flat, this is when the non-commutative aspect of XNOR and XOR comes into play and all the values cancel each other out. We should naturally stop there, but we don't. And this is why we see such an unreasonable result.

A similar natural stopping point occurs with addition. Once both sums have been given the treatment in the !Δ and Δ dimensions, they are now fully reconciled and can be treated like any normal sum in Δ. Therefore, just as 3 + 2 = 5 and nothing else, our sum has nowhere left to go.

So, why is this such an obvious choice for quark generation?

The answer comes from what we said at the beginning: “gluons are the !Δ (XNOR) and Δ (XOR) sums of the ^U (AND UP) and/or !VD (OR DOWN) logic inherent in the quaternions.” There is also another curious feature about !Δ and Δ operations in the realm of quaternions, which contributes to this and which we will discuss now in greater detail. If we take the !Δ product of two four-vectors in quaternion space (Here, I’m using ‘•’ as the matrix multiplication operator):

$$(a1 + bi + cj + dk) \bullet (e1 + fi + gj + hk)$$

we get:

$$-ae - af(i) - ag(j) - ah(k)$$
$$-be(i) + bf - bg(k) + bh(j)$$
$$-ce(j) + cf(k) + cg - ch(i)$$
$$-de(k) - df(j) + dg(i) + dh$$

Next, we take the Hamilton product of the same vectors, which is just multiplication in XOR. Then we sum these two together in XNOR and XOR gives us two matrices. First XOR:

[[0, 1, 1, 1],
[1, 0, 1, -1],
[1, -1, 0, 1],
[1, 1, -1, 0]]

and then XNOR;

[[1, 0, 0, 0],
[0, -1, 0, 0],
[0, 0, -1, 0],
[0, 0, 0, -1]]

Notice how the trace of the XOR matrix is zero, giving marked confirmation that it is real. This means that our second matrix is almost certainly not real. The fact that they are both different, means that we can — without fear of them resulting in all zeroes — add them together in both XNOR and XOR. In fact, we can go on adding them together indefinitely. And each time, the result will be similar to one or other of the matrices in Fig 5.

Δ	**1**	**i**	**j**	**k**
1	1	i	j	k
i	i	-1	k	-j
j	j	-k	-1	i
k	k	j	-i	-1

!Δ	**1**	**i**	**j**	**k**
1	-1	-i	-j	-k
i	-i	1	-k	j
j	-j	k	1	-i
k	-k	-j	i	1

Fig 5: The ordinary XOR Quaternion matrix (left) and the XNOR Quaternion matrix (right)

The pattern that we will see emerge will be very similar to the flocking birds in Fig. 1-4. But instead of wings or planes oscillating, this time, it will be 3-dimensional polyhedra. And not just any polyhedra, but the ones that make up our gluons and quarks.

The 1st Generation

We start small. This is a gluon. It has 113 unique points; 256 data-points, and a range of (-1, 2). It is the first of the polyhedra and the first generator of the quarks.

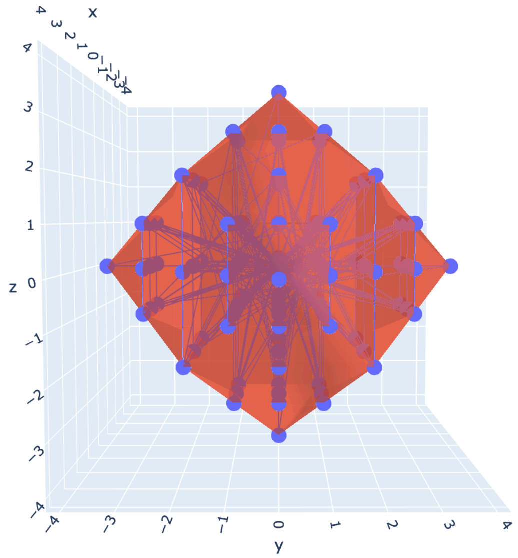

Fig 6: A scatter plot gluon.

When we sum the gluon to itself in XNOR, we get the first of our quarks, the u quark. It has 27 unique points, 256 data points and a similar range.

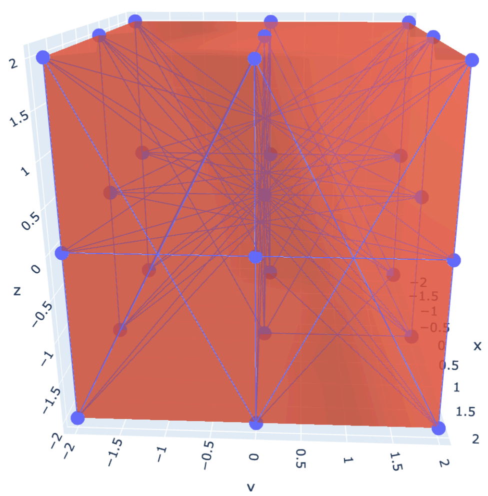

Fig. 7: Up quark

Summing the gluon to itself in XOR, gives us the *d* quark with 171 unique points and 6561 data points. This one is slightly larger than the others. This may reflect the fact that down quarks are slightly more massive than up quarks.

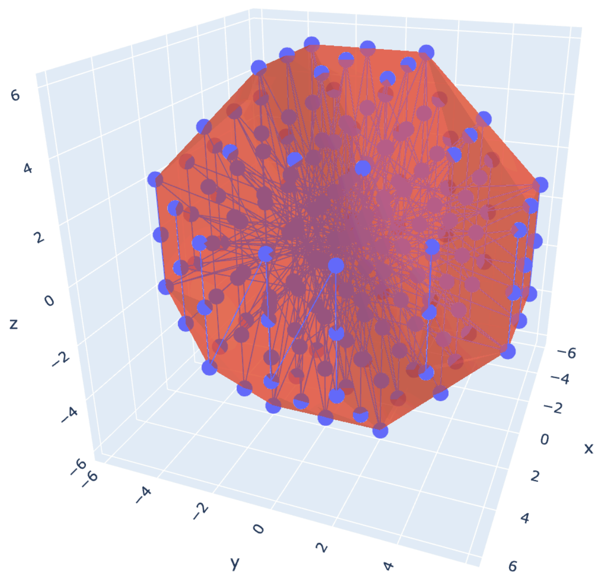

Fig 8: The Down Quark

When we sum the up and down quark in XNOR or XOR, we get the first particle of our new generation. This is just the same gluon we saw at the start. It is slightly bigger, because we are using a slightly bigger range now. This increase in size suggests that this '2nd generation' gluon has lower energy than the last gluon. Then again, it could also be an, as yet, undiscovered particle. So, we will label this 'unknown', for now.

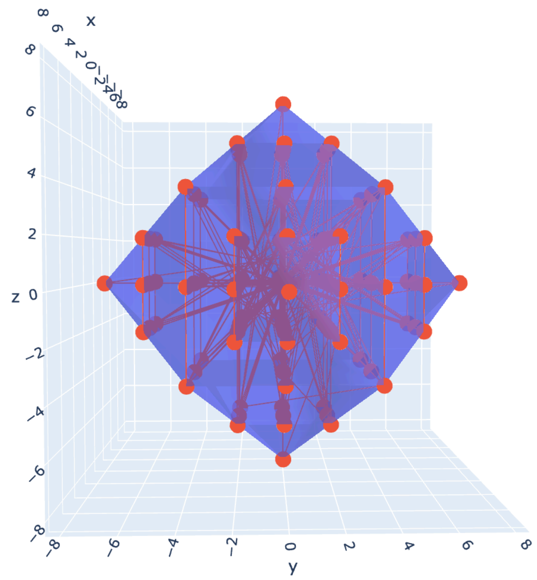

Fig 9: Unknown

The 2nd Generation

Continuing the process, we sum the 2nd gen unknown to itself (in both XNOR and XOR) to produce our truly 2nd generation quarks — the strange and charm quarks.

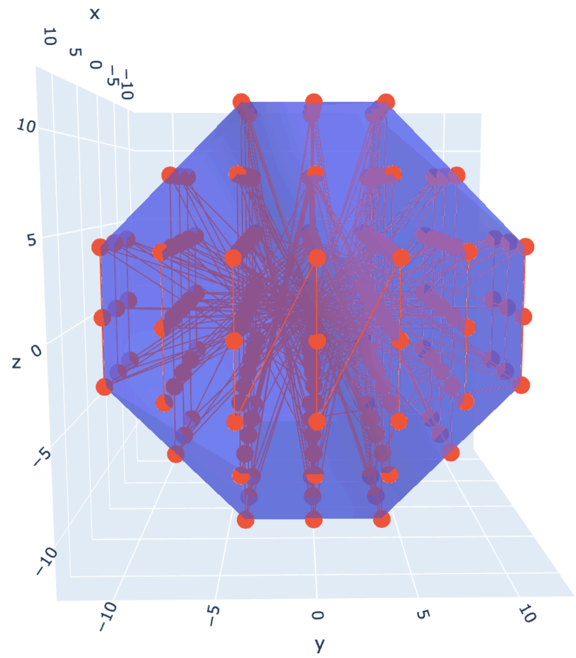

Fig 10: Charm Quark; charge ±2/3

But at this point in the Standard Model something strange happens. The masses of the particles appears to 'switch places'. Now it is the charge 1/3 particles that are heavier. To counteract this, we must switch the operation as well. Now, the cubes are charge ±1/3 and the rhombi-cuboctahedrons are ±2/3.

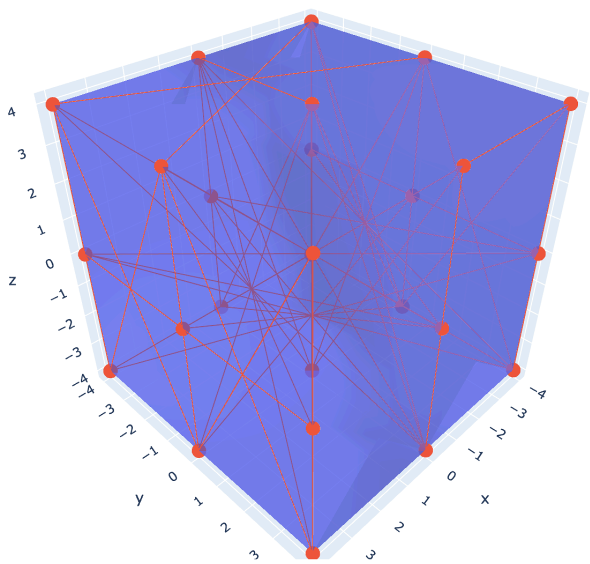

Fig 11: Strange Quark; charge ±1/3

This tells us something about our model. The number of data points, unique or not, seem to be irrelevant to the energy, masses and charges of the particle. Even the shape has no real significance. Only the area seems to be of some relevance.

At this, you might object — if you haven't done already. Particles don't have area. They are point masses. This is true and I don't deny it — despite even the strange implications it has for renormalisation. But remember, we are dealing with 4-dimensional objects here. From a 3-dimensional perspective, 4-dimensional objects have infinite areas. Rotate these areas by 180º and they shrink down to virtually nothing. Therefore, whatever the elementary particles are, they exist at the centre of each of the hyper-dimensional polyhedra and their masses are determined by the area of the said polyhedra. But this is only part of the story.

The other part is hinted at in another research paper, entitled; 'Heisenberg Uncertainty and DGO'.[5] I have yet to fully examine that area of research and it is outside the scope of this paper, so I will leave it to another time.

The 3rd Generation

At the commencement of the third generation, we once again encounter an unknown particle. Is this yet another higher energy gluon? Or could it be something else? I believe that these are the W and Z bosons, for reasons I will divulge now.

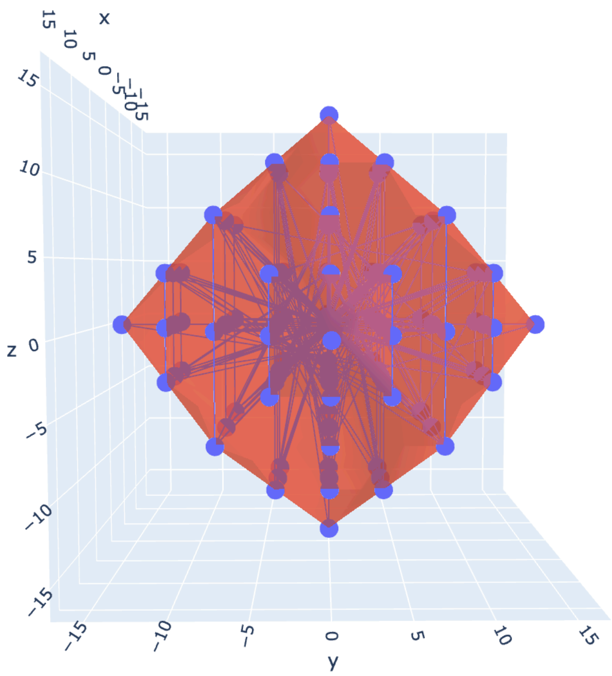

Fig 12: 3rd Generation Z boson

At this point in the process, we have reached the quarks whose mass energy ranges from 4.18 GeV/c^2 (for the bottom quark) all the way up to 173.1 GeV/c^2 for the top quark. The mass ranges for the W and Z bosons lie somewhere between that range, as does the volume of our 3rd Generation rhombic-dodecahedron (See Fig 12).

Therefore, it is obvious that the 3rd Generation RD equals the W and Z bosons. The reason it can be both is because W and Z bosons are self interacting and can create one another.

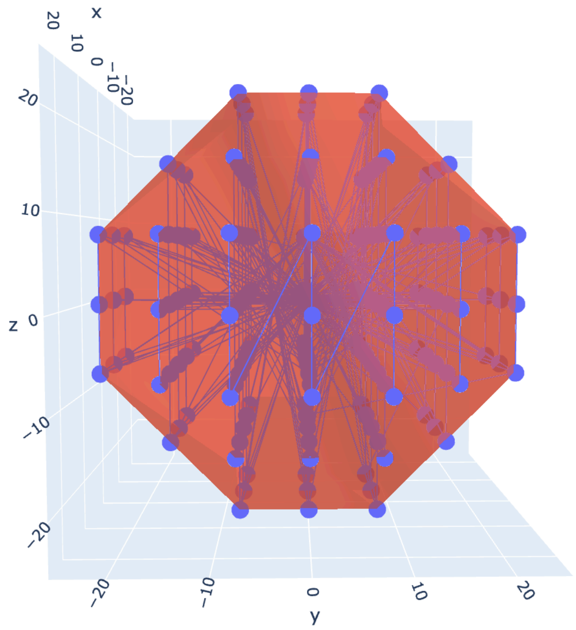

Fig 13: Top Quark

Furthermore, we can now determine that the previously unknown 2nd particle is a lighter version of the W and Z bosons. The existence of these particles was theorised in a paper from 1980, and they were labelled One W and One Z bosons. [6] While no experimental study has proven the existence of these particles, the interest in this paper has grown in the last number of years, suggesting that there may be some necessity for them in the literature.

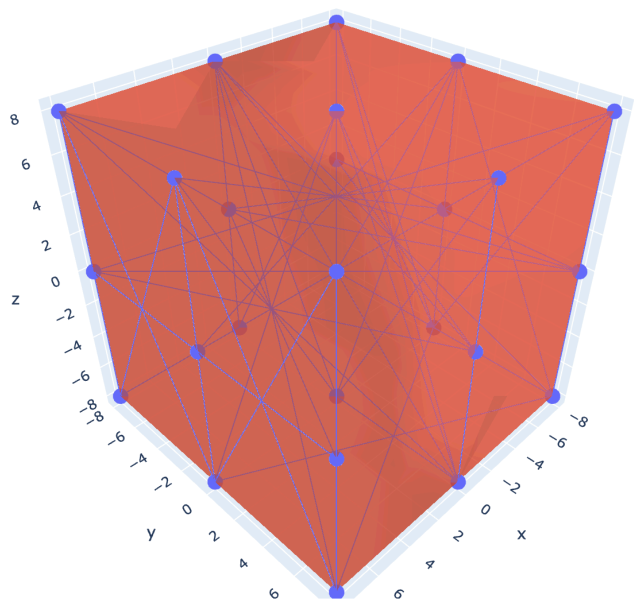

Fig 14: Bottom Quark

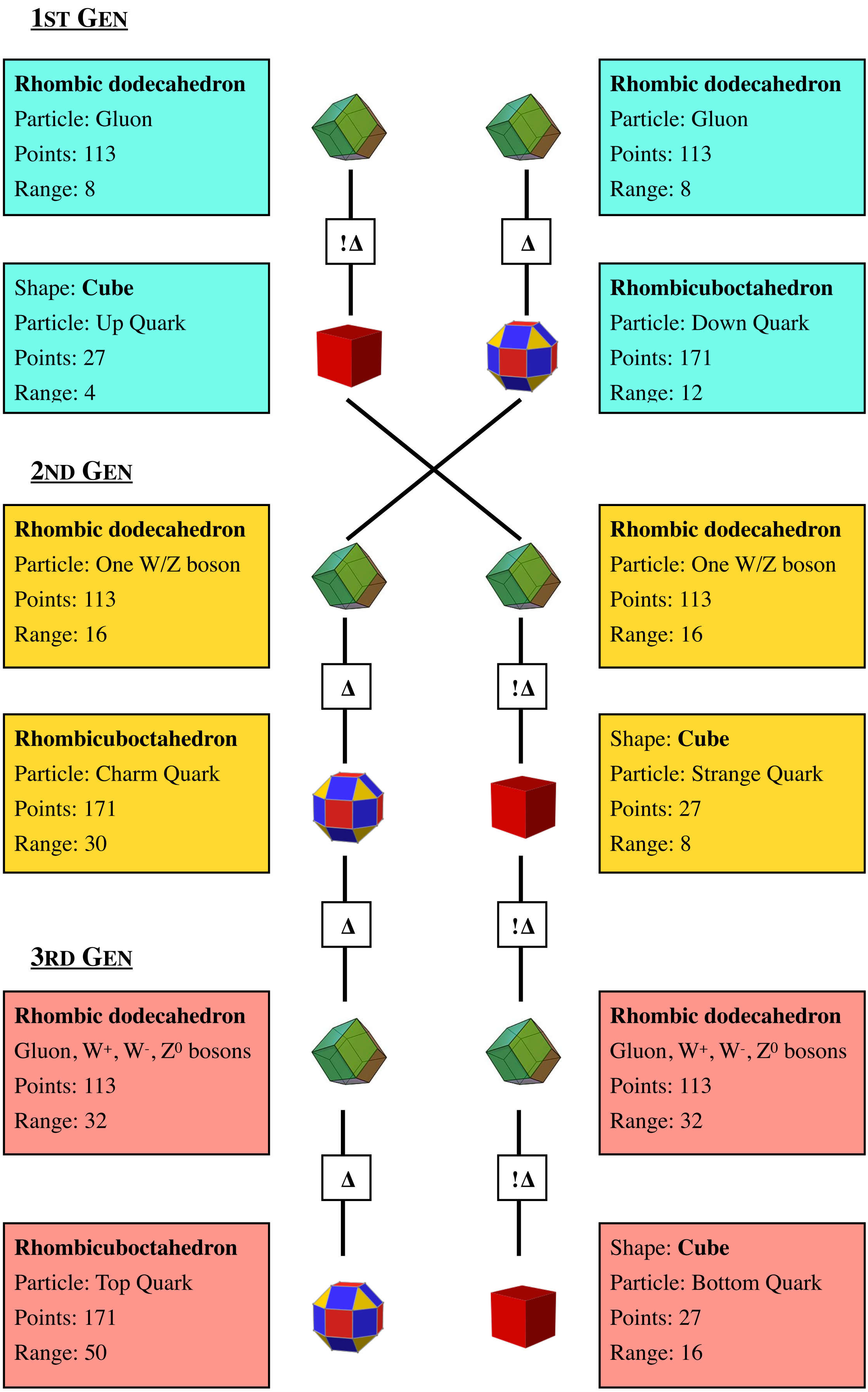

Fig 15: Diagram showing the complete set of generations in order. Notice the twist or 'braid' before the beginning of the 2nd generation.

The Ghosts & the Gluons

When I first encountered the larger, so-called ‘heavier gluons’, I dubbed them ‘ghost particles’, as they appeared like echoes or *ghosts* of the original gluon. Later, I attributed their larger size to a decrease in energy. But then I realised that they may also serve another purpose.

In the section ‘A Flock of Birds’, we recall that the quaternions are based on ^U logic. But this is only part of the story, as they also contain Δ, !Δ and !VD logic. In fact, every single one of the 16 logic gates shown in ‘Logic Arithmetic and Quaternions’ can be shown to be applied to the quaternions.[4] This tells us that no further gates can find application in the Hyper-complex spaces above the quaternions, because — simply put — there aren’t any more.

For this reason, when we multiply and sum the ^U logic with our !Δ and Δ operators, we can view the result to be either in Δ, !Δ or ^U or any other combination of the 16 logic gates without difficulty. This provides us with tremendous freedom, but as we shall see; only four operators are truly useful; Δ, !Δ, ^U, !VD.

1	i	j	k
i	-1	k	-j
j	-k	-1	i
k	j	-i	-1

(^U•)

-1	-1	-1	-1
-1	-1	-1	-1
-1	-1	-1	-1
-1	-1	-1	-1

=

1	i	j	k
i	-1	k	-j
j	-k	-1	i
k	j	-i	-1

Fig 16: ^U matrix multiplication of the Quaternions by -1 matrix equals the Quaternions

In ‘DGO Quaternion Multiplication & Gluon Structure’, we were able to explain many of the properties of gluons. Included in this was an explanation of the fact that gluons appear as their own anti-particles.

In Fig. 16, we see a quaternionic matrix. When we left multiply this (using ^U logic), by an equal sized matrix filled with -1s, we see that it results in the same matrix. This is why gluons are their own antiparticle. Even when you multiply the entire rhombic dodecahedron by -1, it is still the same matrix.

This however is not true of the W bosons. The W^+ boson is the antiparticle of the W^- boson. They are the only gauge bosons that have this property. This is a very strange fact. And what can account for it?

The answer lies in something that was noted in ‘A Flock of Birds’. Remember that when two systems using Δ and !Δ logic are cross-multiplied together, they collapse down into a single logic. What that logic is is really up to the mathematician’s discretion, but it is usually either Δ or !Δ (in the case of the Imaginary Numbers). Similarly, when the quaternionic ^U matrices are multiplied together using Δ and !Δ logic, they too can be said to have collapsed down into a single logic; either Δ or !Δ. One feature of these two types of logic is that multiplying a matrix of either of them by -1 *will absolutely not result in the same matrix*. It will always be its conjugate.

$$!\Delta(-1) * -1 = 1$$
$$\Delta(1) * -1 = -1$$

Therefore, we can say with confidence that W^+ and W^- bosons operate under Δ or !Δ, and it doesn't much matter which.

Where it does matter, in at least one sense, is when we get to Z-bosons. Z-bosons are their own anti-particles, but — for reasons that I can't get into right now— they also do have mass. This makes them at least as strange as the W-bosons, but for markedly different reasons. It is clear that Z-bosons need to avail of some form of logic like ^U, but one that distinguishes them from the gluons. !VD is the obvious choice. The only difference being that you need to right multiply the RD by -1, when using !VD to achieve the same results. Once again, I'm using '•' as the matrix multiplier:

$$\begin{matrix} -1 & -1 & -1 & -1 \\ -1 & -1 & -1 & -1 \\ -1 & -1 & -1 & -1 \\ -1 & -1 & -1 & -1 \end{matrix} \quad (!VD\bullet) \quad \begin{matrix} 1 & i & j & k \\ i & -1 & k & -j \\ j & -k & -1 & i \\ k & j & -i & -1 \end{matrix} \quad = \quad \begin{matrix} 1 & i & j & k \\ i & -1 & k & -j \\ j & -k & -1 & i \\ k & j & -i & -1 \end{matrix}$$

Fig 17: !VD matrix multiplication of the Quaternions by -1 matrix also equals the Quaternions

Once you've done this, of course, you never have to do it again. But the reason for doing so will become more apparent in subsequent papers that look more in depth into particle interactions and decay, and offer up an entirely new way of algebraically representing particle reactions that is both more simple than the current method and more informative than the Feynman diagrams. This is not to say that this method is any better than either of the originals, it simply occupies a sort of middle-ground, between the two extremities.

In precisely, the same way that we have generated the antiparticles of the W^+ and W^- bosons, we can generate the antiparticles of the other quarks, giving us a complete set of quarks and two thirds of the bosons.

Inconsistencies

There is structure to the theory, but some of it feels arbitrary and messy. For instance, why does the geometry of the gluon switch to the W and Z bosons at the commencement of the 2nd generation? The answer for this could come from the twist or braid seen in Fig. 15. In order for the masses of the quarks to remain consistent, the logic operators need to be switched. Initially I had this switch take place between the second generation gauge particles and the *c* and *s* quarks. However, if the switch were to take place before the generation of the gauge particles, this might explain the shift from gluons to W and Z bosons. It also might explain why none of the subsequent quarks or bosons above the switch are stable in any sense.

Another way to fix this problem is to say that there are three separate varieties of quark sets;

Δ, !Δ					
g	u	w/z	s	w/z	b
g	d	w/z	c	w/z	t

^U					
g	u	g	s	g	b
g	d	g	c	g	t

!VD					
w/z	u	w/z	s	w/z	b
w/z	d	w/z	c	w/z	t

The first one is the one that we have just arrived at. The second ignores the W and Z bosons and just focuses on the gluons and the third does the reverse. We could distinguish between these three variations in the manner described above. Namely, each variation is described by the logic used to produce it, either: Δ, !Δ, ^U or !VD.

This distinction will help us when writing the program, which will generate all of the particle transformations.

Conclusion

Using a very basic set of assumptions, we have been able to create a model for all three generations of quarks and their anti-particles, as well as the gluons, W and Z bosons. On top of this, we have demonstrated some of the logic that explains why particles can be their own antiparticles or not, within the framework of the model. At present the model may appear a bit messy, arbitrary or incomplete. I assure you that once the other parts are put into place, it will begin to look more ordered and more comprehensible.

Citations

[1] DGO Quaternion Multiplication & Gluon Structure, Christopher C. O'Neill https://www.researchgate.net/publication/347522261_DGO_Quaternion_Multiplication_Gluon_Structure

[2] DGO Quaternion Multiplication, Quarks & Polyhedra, Christopher C. O'Neill https://www.researchgate.net/publication/347495967_DGO_Quaternion_Multiplication_Quarks_Polyhedra

[3] Reimagining Complex Numbers, Christopher C. O'Neill www.researchgate.net/publication/346527686_REIMAGINING_COMPLEX_NUMBERS

[4] Logic Arithmetic and Quaternions, Christopher C. O'Neill https://www.researchgate.net/publication/347435053_Logic_Gate_Arithmetic_and_Quaternions

[5] Heisenberg Uncertainty Principle and DGO, Christopher C. O'Neill https://www.researchgate.net/publication/346528123_Heisenberg_Uncertainty_Principle_and_DGO

[6] A Gauge Model With Light W and Z Bosons, Vernon D. Barger, Wai-Yee Keung, Ernest Ma; https://inspirehep.net/literature/152417