The Hierarchy Problem

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Abstract

The Hierarchy Problem encompasses a number of varying concerns, including; gross difference between the strength of the gravity and the Weak Force and why the Higgs Field has the mass value it has. The DGO Standard Model is a surprisingly simple and powerful tool for understanding the world of Quantum Physics. Here we apply it to the Hierarchy Problem in an attempt to find the answers to this long sought after problem. We also learn how to create the symmetry to protect the mass of the Higgs.

Keywords

Hierarchy Problem, Gravity, Weak Force, DGO, Dimensional Gate Operators, pentonions, Higgs Field, Higgs mass, W and Z bosons.

Appear Weak When You Are Strong?

There are many different versions of the hierarchy problem in Quantum Physics. For instance, there is the question of why there are 3 distinct flavours of matter, why the top quark is so heavy, and the discrepancy between the forces — in particular the weak force and gravity. The 3 flavours of matter was explained by creating each of the bosons and fermions from scratch using either quaternions, trionions or pentonions and then relating all of them to the Octonions and Sedenions in a grid like pattern which also encompasses all of the matter and Dark Matter particle and anti-particle copies (See Fig. 1).

Surprisingly, the same method and research also provides explanation of the relationship between the top quark and the Higgs, as it shows that the t quark literally being swamped by the Higgs causing a kind of asymmetry in the graph.[1]

Having explained both of these problems, on this occasion, I would like to turn our attention to the discrepancy between the weak force and gravity.

Usually when physicists and cosmologists discuss this and related subjects, they talk about how gravity appears so weak when compared to the other fundamental forces. One way to explain the discrepancy is to have gravity leaking into some unseen dimension. I always liked this idea and will return to it later on. However, in doing research for this preprint, I discovered an alternative way of viewing this subject matter. The source for this interesting piece of information is — surprisingly enough — a Wikipedia article. [2]

	e0	e1	e2	e3	e4	e5	e6	e7	e8	e9	e10	e11	e12	e13	e14	e15
e0	g	d	1W	c	WZ	t	H^3	G_8	g	d	1W	c	WZ	t	H^3	G_8
e1	u	y	ve	μ	H^1	H^2	H^4	H^3	u	y	ve	μ	H^1	H^2	H^4	H^3
e2	1W	e	y	vτ	G_1	H^4	H^2	t	1W	e	y	vτ	G_1	H^4	H^2	t
e3	s	vμ	τ	G_4	G_5	G_1	H^1	WZ	s	vμ	τ	G_4	G_5	G_1	H^1	WZ
e4	WZ	H^1	y	G_3	G_4	vτ	μ	c	WZ	H^1	y	G_3	G_4	vτ	μ	c
e5	b	G_6	G_7	y	τ	y	ve	1W	b	G_6	G_7	y	τ	y	ve	1W
e6	G_2	H^2	G_6	H^1	vμ	e	y	d	G_2	H^2	G_6	H^1	vμ	e	y	d
e7	H^3	G_2	b	WZ	s	1W	u	g	H^3	G_2	b	WZ	s	1W	u	g
e8	g	d	1W	c	WZ	t	H^3	G_8	g	d	1W	c	WZ	t	H^3	G_8
e9	u	y	ve	μ	H^1	H^2	H^4	H^3	u	y	ve	μ	H^1	H^2	H^4	H^3
e10	1W	e	y	vτ	G_1	H^4	H^2	t	1W	e	y	vτ	G_1	H^4	H^2	t
e11	s	vμ	τ	G_4	G_5	G_1	H^1	WZ	s	vμ	τ	G_4	G_5	G_1	H^1	WZ
e12	WZ	H^1	y	G_3	G_4	vτ	μ	c	WZ	H^1	y	G_3	G_4	vτ	μ	c
e13	b	G_6	G_7	y	τ	y	ve	1W	b	G_6	G_7	y	τ	y	ve	1W
e14	G_2	H^2	G_6	H^1	vμ	e	y	d	G_2	H^2	G_6	H^1	vμ	e	y	d
e15	H^3	G_2	b	WZ	s	1W	u	g	H^3	G_2	b	WZ	s	1W	u	g

Fig 1: Eight copies of the Standard Model corresponding to the Sedenions

To begin with the article restates what we already know; “There is no scientific consensus on why… the weak force is 10^{24} times stronger than gravity.” But, further on down the article, it explains the relationship between several hypothetical forces. I’ve altered the quote slightly (bold text), so that it relates directly to the question on the weak force:

> “We might wonder, if one force is so much weaker than the others that it needs a factor of **10^{24}** to allow it to be related to them in terms of effects, how did our universe come to be so exactly balanced when its forces emerged?” [2]

This is an entirely new way of looking at this concept for me. Usually, when I hear of electromagnetism, for example, being stronger than gravity, I believe it that it means just that. But this quote turns everything on its head.

It states that *gravity* is stronger than the weak force, because the weak force needs to be turned up so high to counteract its effects and to hold the world in balance. Whether this is true or not is in some ways immaterial, but I thought it was such a novel way of looking at the issue, I simply had to make reference to it and it might also be useful later on.

The Higgs Mass

A better way of look at the Hierarchy Problem overall comes from Matt Strassler's very interesting and insightful website. [3] The problem boils down to two related quantities that is; non-zero Vacuum Expectation Value (VEV) of the Higgs field, which in turn determines the mass of the W and Z particles. "The non-zero Higgs field has a size of about 250 GeV, and that gives us the W and Z particles with masses of about 100 GeV."

The question (or at least one way to phrase the question) is; Why is the Higgs Field small (250 GeV) but not zero?

Unfortunately, DGO does not help with this particular way of phrasing the problem. This is because DGO is not really a field theory (or at least, I don't think it is). It doesn't expressly deal with the Higgs Field or its "size". Instead it deals with the hierarchical aspects of particles and some of their intrinsic properties.

One of the intrinsic properties it does appear to deal with is the mass of the Higgs particle. The mass of the Higgs is 125-7 GeV. If we look at the XORed 5-dimensional Higgs boson, we see that it has: 59049 data-points. However, if we convert these into unique data points over 3 dimensions (which makes sense, because of the Pauli Exclusion principle), we arrive at only 126 points, which is dead centre on the mass of the Higgs. If we then minus the central point, just as we did on our very first occasion of mapping the RD (rhombic dodecahedron) to the elementary particles, all the way back in [4], we get 125, which is the most quoted value for the GeV mass of the Higgs. It is interesting to note that this method does not produce the masses of any of the other particles, but it does produce the mass of the Higgs, whose associated field produces the masses of the other particles.

This is interesting because (warning; imperfect analogy ahead, as Strassler would say), it is almost as if we have found the compiler that compiles the machine code of the Higgs mass into a readable mass, which in turn makes all the masses of the universe ‘readable’.

Initially, some people were suggesting a link between the value of the Higgs Field and the mass of the Higgs, because 250 GeV is twice that of 125 GeV. [3] Unfortunately, this doesn’t help us with our main objective (trying to solve the Hierarchy Problem), because—as Strassler points out— the Higgs field actually has a value of 246 GeV and therefore, there is no reason to think that it has anything to do with the mass of the Higgs. This seems to be rather counter-intuitive, as you would expect there to be a clear relationship between the mass of the particle and the field. Strassler calls this seeming relationship a ‘coincidence’, but it is not much of a coincidence, if the 250 GeV measurement was flat out wrong to begin with.

If we look at 59049, which is the total value of the data-points in the DGO Higgs Model, we see $\sqrt{59049} = 243$, and this is very close to value of the Higgs Field at 246 GeV. Could the Higgs Field value also be an approximation? It could. The equation for the Higgs VEV is:

$$v = 1/\sqrt{\sqrt{2}G_F^0} = 2M_W/g \approx 246.22\,\mathrm{GeV},$$

where M_W is the mass of the W boson. The boson mass is also an approximation, but it is only a few MeV and too small to account for the larger error of 3 GeV. Perhaps the closeness of 243 and 246 is merely another coincidence.

Although, this leaves me perplexed, as how can the mass of the W boson be used to determine the Higgs Field value, if the Higgs value is being used to determine the W and Z bosons? It turns out that the mass value of the W boson is used to ascertain the Higgs Field VEV, not that the value actually goes into ‘making’ the VEV, in the sense that the DGO make the bosons and fermions. And that is an important distinction to be aware of.

Elsewhere, Strassler talks about how “the top quark mass is closed to sqrt(2) * the Higgs mass, the Z particle mass is close to the Higgs mass / sqrt(2).” However, his point is that this is like ‘numerology’, rather than science. He goes on to say, “when you try to calculate these things in real theories, such simple ratios do not generally emerge for particle masses; quantum corrections move things around a lot.” [3]

I don’t have a lot of experience ‘calculating things in real theories’, because I’m dealing not with the perturbations of particles in the real world with respect to motion and derivatives, or even probability, which is such a staple of Quantum Mechanics (QM). Instead, I’m focusing on the abstract forms, which underpin the bosons and fermions themselves. This method is, in fact, very beneficial, because as we know the √2 makes regular appearances on the 4th-dimensional Rhombic Dodecahedron (4DRD) which represents the W and Z boson and also goes into forming the top quark through a process of addition. [5 , 6]

Mass Protection

Another curious and unique property of the Higgs is that its mass isn't protected by symmetry like the other gauge bosons and fermions. Gauge bosons, like the massless photon and gluon, have symmetry restricting them from gaining new mass. The Higgs is a scalar boson, which cannot avail of this, because it can paradoxically give mass to itself. Fermions have chiral symmetry, which prevent them from gaining mass arbitrarily from the VEV or anywhere else, for that matter. Therefore, to protect the Higgs mass it may be necessary to give it Fermion symmetry. There are several ways to accomplish this, including; Supersymmetry, Large Extra-dimensions, or possibly a Composite Higgs. [7]

5D	
G	H
G	H

(Δ, !Δ) 4D					
g	u	W/Z	s	W/Z	b
g	d	W/Z	c	W/Z	t

3D					
W/Z	*e*	W/Z	μ	W/Z	τ
W/Z	*ve*	W/Z	*vμ*	W/Z	*vτ*

(^U) 3D (Photons)					
y	*e*	y	μ	y	τ
y	$a^{\dagger}$	y	$a^{\dagger}$	y	$a^{\dagger}$

2D (Anyons)					
y	*e*	y	μ	y	τ
y	$a^{\dagger}$	y	$a^{\dagger}$	y	$a^{\dagger}$

Fig 2: Table of elementary particles

The DGO Standard Model naturally contains extra dimensions, as part of its structure. It also places the Higgs boson into firmly the Fermion category, from the outset. [8, 9] In order to construct the Higgs, we simply create the multiplication and then internally add a Graviton to another Graviton:

$$G + G = H$$

Alternatively, we could have 5D set mimic the first set, with its creation and destruction type operators, where G acts as the creation operator:

5D	
G	H
G	$a^\dagger$

Either way, the result is the same.

In each other set, when a boson is added to second boson of the same kind (during the matrix multiplication phase) it results in a fermion. As such, by adding two gravitons together and arriving at a Higgs particle means that our Higgs scalar boson is now being treated as a fermion. [8]

This eliminates the need for SuperSymmetry and extra Higgs particles like the Higgsino, which causes its own problems. [7] Super Symmetry appears to be ruled out anyway based on the configuration in Fig. 1. [1]

Hierarchy Problem & Multiple Dimensions

We've seen how the mass of the Higgs and potentially how the strength of the Higgs Field is constructed. And we've also seen how the mass of the Higgs is protected from symmetry breaking in the DGO Model. Now, let's examine the discrepancy between the Weak Force and the Higgs Field, from the perspective of the DGO Standard Model. Returning to Fig. 2, then, we note that the weak force occupies dimensions 3 and 4 and is spread out over 6 to 24 individual particles, ranging from rhombicuboctahedra and rhombic dodecahedra, to cubes and rhombicuboctahedra in both 3 and 4D space. In contrast, the other bosons are constrained to a much smaller habitat. In particular, the Higgs and Graviton, of which is our focus, are constrained to one higher-order dimension and to one (or at most two) particles.

In the same way that physicists pontificated over the gravitational force leaking into extra-dimensions and thereby greatly weakening it, we can pontificate that the Higgs force is equally spread out over this extended range of dimensions and particles. This implies that the W bosons are working over a much greater surface or domain than that of the other bosons, and this is why it appears so much weaker than the Higgs and gravitational force.* It is clear that the W and Z bosons that govern the weak force are much more thinly spread and also share their space with the strong force interaction, which may distort or interfere with its strength in some, as yet, undetermined way. *By 'weaker' of course, we mean from the point of view of all forces in the universes being balanced (see the section on "Appear Weak When You Are Strong?" for more on this). [2]

This, as you can see, is the exact inverse of having Gravity spread more thinly over a greater number of dimensions. It also has the benefit of having an actual physical framework to pin the number of particles and dimensions onto. This framework is naturally applied to the DGO Standard Model. Whether or not this model can explain everything, or even operate as a viable model in all instances, remains to be seen. But the harshest and most rigorous of tests still lay ahead, so time will certainly tell us that.

If the weak force is 10^{24} times weaker/stronger than gravity and also has 6 particles times 2 dimensions, then that's a factor of 12, so each particle must represent a reduction/increase factor of $10^{2.}$ That is assuming the increase is linear and not logarithmic, which I suspect it isn't, but it makes sense to keep the model simple, at this early stage.

Then again, the weak force also extends over all of the leptons and quarks. There are 6 of each of these—not including the anti-particles—which means that the the Weak Force is actually extending over 24 particles. Each particle, therefore, lends a factor of 10 to the strength of the weak force to create 10^{24}. The reason why antiparticles aren't included is because we can generate particles and antiparticles easily by simply switching the sign operation inside of the matrix multiplication, therefore particles and antiparticles are looked at from an absolute sense, much like they are in the 4D-RD-SM. [10]

Another way to think of the Weak Force operating over 24 particles is to examine its relationship to the quarks. We can make a down quark by simply adding two W bosons together in the vector multiplication space. To make an up quark, we simply subtract:

$$W + W = d, \quad W - W = u$$

Furthermore, we can make a more energetic/heavier W boson by adding the *d* and *u* quark together. We can call this new W boson the 1W boson. Since this boson is a virtual particle it need not obey the laws of conservation of energy and can be used to generate particles that may be much heavier than it, for example the top quark:

$$d + u = 1W$$

But since d = W + W and u = W - W, we can say that:

$$(W+W) + (W-W) = 1W$$

By adding and subtracting 1W with itself, we can create the next generation of quarks; the strange and charm quarks. Therefore, we write the following:

$$((W+W) + (W-W) + (W+W) + (W-W)) = c$$

or,

$$((W+W) + (W-W) - (W+W) + (W-W)) = s$$

The next set of W bosons, which we will call 2W, are actually the W boson that appears in the SM, and a mass of around 100 GeV, are generated in the following manner:

$$((W+W) + (W-W) + (W+W) + (W-W)) + ((W+W) + (W-W) + (W+W) + (W-W)) = 2W$$
$$((W+W) + (W-W) + (W+W) + (W-W)) - ((W+W) + (W-W) + (W+W) + (W-W)) = 2W$$

Therefore, by the time we reach the top and bottom quarks, we find that this is already 16 W bosons of varying strengths and sizes.

Strassler concludes his article with the following statement, meant to clear up any confusion (bold face additions to the text are my own):

> *By the way, you will often read the hierarchy problem stated as a problem with the Higgs particle mass. This is incorrect. The problem is with how big the non-zero Higgs field is. (For experts — quantum mechanics corrects not the Higgs particle mass* ***but the Higgs mass-squared parameter****, changing the Higgs field potential energy and thus the field's value, making it zero or immense. That's a disaster because the W and Z masses are known. The* ***Higgs mass is unknown****, and therefore it could be very large — if the W and Z*

masses were very large too. So it is the W and Z masses — and the size of the non-zero Higgs field — that are the problem, both logically and scientifically.)

As he states, "the Higgs mass is unknown". The "mass" referred to here, as I understand it, is "the Higgs mass-squared parameter", which relates to the Higgs field potential energy and not the mass of the Higgs particle itself.

It is "unknown", because it could and should be either "zero or immense". Since the strength of the Higgs Field is based off the masses of the W and Z bosons, the field "could be very large". But in order for that to happen, the W and Z bosons would also have to be very large. Since we know the mass of the W and Z bosons to be only around 100 GeV, this severely limits the Higgs Boson size without making it zero. So, the problem stems as much from the W and Z masses, as much as it does from the Higgs field strength. [3]

By looking at the Higgs force and Gravity as being the 'stronger forces', we have been able to show that it is actually the weak force that is leaking around the place. In this sense, each dimension and particle that the weak force encounters behaves like a force magnifier increasing the strength of the weak force up to the level of Gravity and the Higgs. The fact that there are 6 such particles times the two dimensions (or alternatively 24 particles) explains the field strength ratio of 10^{24} and therefore, I believe, gets to the root of this hierarchy problem.

The W and Z bosons that govern the weak force are much more thinly spread and also share their space with the strong force interaction, which may distort or interfere with its strength in some, as yet, undetermined way (See Fig. 2 Table: (Δ, !Δ) 4D).

Conclusion

The DGO Standard Model reliably predicts and explains how the Higgs mass is protected via the Fermion chiral symmetry without recourse to Super Symmetric particles, or composite Higgs particles. The extra-dimensions of the DGO can be used to explain why the Weak Force gains so much strength over that of the Higgs and gravity and in the specific ratio of 10^{24} that it does. Furthermore, the square root of the maximum number of data-points for the Higgs gives a corrected value of 243 GeV for the Higgs field mass and the unique points gives the approximate value of the Higgs mass at 126 GeV. The interaction of these two values with the other particles in the Standard Model generates their respective masses thereby explaining why the data-points of these particles don’t have any bearing on their experimentally obtained mass values.

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