Chapter 4: Back to Revolution

For almost 2000 years after his death, the thought of Aristotle dominated the discourse of philosophy and science in the Western world. The Greek philosophers thought that all matter consisted of four elements: earth, fire, air and water. They knew that these could be converted each into the other through the action of weather and life. However, they did not have measurement technologies that would allow them to calculate the relationships between the elements.

The Greek philosophers also knew that matter was finely divisible, and posited an ultimate endpoint to that division, which they called the atom.

The strange point is that metallurgists clearly had a working knowledge of the common metals well before the time of Aristotle. The Torah, in its tract on accidental murder, says that the murderer is always to be forgiven unless the implement of death was iron. Then, the blood price must be paid.

Apart from the Torah, however, the Greeks generally had a monopoly on the institution of the European library. Their works were meticulously copied by the scribes of the Catholic Church, and so passed from generation to generation.

It was really the printing press that spelled the end of Aristotle’s dominance. Reproduction of printed knowledge became cheap. The undocumented knowledge of the tradesman and craftsman was captured, organized, and studied to reveal patterns that had escaped notice before. Once it was recognized that the variety of substances could not be satisfactorily explained by variations in the percentages of the four elements, the race was on to enumerate the atoms.

This story illustrates a general historical tendency. Physics has always progressed through long periods of stasis enforced by institutions of learning, followed by rapid change when it became obvious that the old system of thought was unsuitable. If we follow the progression, a glaring deviation becomes clear in the modern age.

Particles and Fields

The behavior of the cosmos was the first mystery to be tackled by modern physicists. The work of Copernicus, Brae, Galileo and Newton was unified by the theory of the first field, gravitation. Gravity was thought of as a force that mediated interactions “at a distance” between two or more massive particles.

After enumerating many types of materials, scientists experimented with the transformations among them. As the elements (various types of atoms) of material composition were isolated, it became clear that they could be collected in groups corresponding to how they reacted with other elements. For example, carbon and silicon combine with the same number of oxygen atoms. Through the analysis of such patterns, Mendeleev’s Periodic Table was constructed.

As the number of elements grew apace, physicists began to question whether the atoms were themselves fundamental. At the beginning of the 20th century, positive proof became available
that atoms were a composition of the particles we know as the electron, proton and neutron. The electron and proton were held together by the force of electromagnetism. Once these components were isolated, physicists (around 1950) began bashing them together to see if anything more was inside. This time patterns in the mass of the produced particles led to the hypothesis that the neutron and proton were a composition of something smaller dubbed “quarks”. These are held together by a field that has three “colors”, but fundamentally the same strength as electromagnetism.

At this point in time, the theoretical physicists adopted a novel perspective. They decided that quarks and electrons were absolutely fundamental. In fact, they decided that their theories should be founded upon the principle that all particles were equivalent and interchangeable. This principle was supported by the characteristics of the weak interaction, through which matter composed of quarks was observed to change into electrons and their uncharged partners, neutrinos.

It would be nice to say that the proposition of interchangeability was thoroughly justified by empirical evidence, but it was actually an outgrowth of a fascination with a type of mathematics called group theory. Group theory describes the transformation of mathematical objects. One of the exciting properties of group theory is that mathematical groups can be composed into larger groups. Therefore, after casting one kind of interaction into the formalism of group theory, physicists could hope to bring it into a larger theory involving other interactions. This promised a way forward to the Grand Unified Theory that had eluded Einstein. It also gave the theorists something amusing to do as the interval between the commissioning of new experimental facilities grew from months to years to decades.

Now, you might wonder how they can just arbitrarily make the universe more and more complicated. Wouldn’t they run afoul of experiment if they decided that electrons had sister particles with twice as much charge? Well, that’s the magic of particle physics: by making the mass of that sister particle high enough, we could be certain that it would have been transformed a long, long time ago into lighter particles through the mechanism of the weak interaction.

The alert reader will recall that the revolution has returned to its start in at least one way. As described in Chapter 2, physicists are once again looking to the cosmos to test their theories. As our survey there concluded, the results haven’t been exactly discouraging, but they are certainly far from satisfying.

Whenever physicists hit a road block, the way forward has always come from revisiting the fundamental assumptions that underlie the theory. Let’s start by putting interchangeability on the chopping block, and seeing if we can identify patterns that might guide us into a new layer of composition.

**The Preponderance of Three**

As particle physicists organize their understanding of matter, there are three generations of particles. Each generation is similar to the prior, except all the particle masses are larger.

Let’s look at the first generation. Each particle has four properties: mass, charge, color and spin.
The particles in the first generation are called the neutrino (\( \nu \)), up quark (u), down quark (d) and the electron (e). The table shows the relationship between their properties.

<table>
<thead>
<tr>
<th>Particle</th>
<th>Mass (MeV)</th>
<th>Charge</th>
<th>Color</th>
<th>Spin</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \nu )</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>( \frac{1}{2} )</td>
</tr>
<tr>
<td>u</td>
<td>138</td>
<td>-1/3</td>
<td>1</td>
<td>( \frac{1}{2} )</td>
</tr>
<tr>
<td>d</td>
<td>140</td>
<td>2/3</td>
<td>1</td>
<td>( \frac{1}{2} )</td>
</tr>
<tr>
<td>e</td>
<td>0.5</td>
<td>-1</td>
<td>0</td>
<td>( \frac{1}{2} )</td>
</tr>
</tbody>
</table>

This table tells us that fractionally charge particles tend to resist motion. If we factor out the 1/3, the sizes of the charges are zero, one, two, three. The fractionally charged particles also have color, and since the color and charge interactions have the same strength, we might presume that the two are related.

What do we observe about space? Well, it has three dimensions. And the mathematical complexity of the electromagnetic, weak and color interactions follows the pattern: 1, 2, 3, respectively.

In fact, in what we observe of the universe around us, it appears only time is singular.

Hmm. Can you see the future coming, anyone?

Let’s start with the proposition that we should be able to construct a physics where all of the numbers highlighted above are one or two, progressing to three, and maybe to higher numbers if that seems to make sense. This means exploring the possibility of physics on a line, in a plane, and in four or more spatial dimensions.

**The Physics of I**

So let’s start in one spatial dimension. Let’s construct a mental model of a dynamic (ever-changing) universe with one dimension. You can construct one model fairly easily: get a bunch of squishy springs, some magnets, and a thin metal rod. Drill a through-hole for the rod in each of the magnets. Put magnets on either end of each spring, but make certain that each spring has a oppositely polarized ends (north on one, south on the other – in Illustration 1, take the north pole to be the end with the ball). Now put the springs, in random orientation, on the metal rod. Jiggle the rod and see what happens. Move one spring, and see what happens. See if you can cause vibrations on the line.
We know what should happen: adjacent springs with north and south poles together will stick together – unless shaken too hard. If north poles or south poles face together, the springs will repel each other. We also know that oscillation will stop in our universe, because the magnets and springs will rub against the rod and each other, and heat up due to electrical currents in the metal parts. However, let’s look beyond that for now, and imagine the world is free of friction and eddy currents (sorry for the jargon: currents caused by time variation in the strength of a magnetic field at the surface of a conductor). Motion would continue indefinitely.

Still, not terribly interesting, ennit? The springs can’t move through each other, so we can’t break up the sequence of bound and repelled pairs.

That changes in two dimensions. Take your springs, and roll them onto a tray. Now start shaking them. Many of them will end up in a one-dimensional configuration, with head to tail of their partner. But some will end up in more complex configurations. The simplest is the triangle, but you might see rectangles as well, and even the rare pentagon. Of course, the triangle is the only stable shape. Push on one corner, and the unit will move as a whole. For every other shape, the configuration will collapse to some combination of lines and triangles. The stability of the triangle is an important principle in mechanical engineering.

Now things are more interesting, for once we get a bunch of triangles together (Illustration 2), we can start wrapping larger chains around them. We now have an “inside” and an “outside”, reminiscent of a cell boundary.
Let’s imagine that we keep on adding triangles to our tray. Eventually, the tray will be filled with hexagonal pattern of triangles. Let’s imagine that we keep on adding triangles, forcing them in. The triangles will lift off the tray and jut into the air (Illustration 3). Now imagine adding layers of such trays. Illustration 4 shows a model of how triangles might be packed to fill three-dimensional space with a homogeneous array.

What we have is a stack of cubes, but the sides of the cubes are only partially covered by triangles. Let’s imagine we keep on adding springs. These might connect into linear “fibers”. Some of them will go through the triangles, and some will go through the empty area on the side of the cube (Illustration 5).

Look at the corner of the matrix, and you’ll see a “unit cell”, the fundamental building block of the array. It is a set of three triangles, each one facing along a different axis. If we assume this is a stable unit (held together by Van der Waals forces, for the technically inclined), then it has three holes to fill, corresponding to the fractional charges of the particles in our table above.

**Matter and Spirit**

My first proposition is that matter is composed of any unit containing a triangle with a fiber through it. Units with no or three holes filled look the same in all directions, and so might be presumed to move more easily through the matrix. If only one or two holes are filled, the tendency may be for the unit to tumble as it moves, suggesting a possible explanation for the larger mass of fractionally charged particles (there are other explanations, of course, which also account for the mass of the electron, but the discourse is more labored).

Open fibers will tend to flail around in the lattice until they close themselves. These loops would be expected to twist around in the lattice, absorbing and emitting freely propagating loops. Certain configurations of the free loops are what we recognize as “light”. In most cases, the lattice would be likely to squeeze the free loops back onto the originating particle. This would
explain Newton's first law: a particle loses very little energy as it propagates through free space.

The four forces result from the interaction between the bound fibers and the distortions created in the lattice by freely propagating fibers. It is possible that the charge sign (look back at the table) has something to do with whether the sum of the bound fibers is even or odd (odd-odd and even-even couplings are repulsive, odd-even couplings are attractive). To understand the behavior of the proton as it interacts with an electron, we obviously have to break it down into its constituents.

How to explain the three particle generations? Imagine that one of the cell's triangles is turned outwards. That would obviously be a configuration far more disruptive to the matrix as it moved. The third, most massive generation would have all triangles turned out.

As in the two dimensional case, the matrix can support more complex constructions. Let’s say, for example, that the fibers are woven into sheets. These could be wrapped over a collection of cells, and be stabilized and supported by the enclosed units (imagine wrapping the construction in the photo in a piece of cloth). In the model I would suggest, these constructions are what has here-to-fore been termed “spirit”. The weave could serve to stabilize the fibers, suppressing the emission of light.

Obviously, in empty space, the spirit’s opportunities to grow are severely impoverished. Spirit therefore has an interest in staying attached to matter. In fact, matter properly organized can serve as a machine to organize fibers and sheets into more complex assemblies, allowing the spirit to grow.

**The Structure of Time**

The greatest defect of our picture of the spatial matrix is the lack of motion. Rather, as with water molecules, the triangles should be vibrating, and slight spaces should exist at the corners. If you imagine the spaces, you can see that between every layer of cells, an entire two-dimensional reality could be found.

Remember the density of the hexagonal layout of the spatial matrix in two dimensions. It is tightly packed, and therefore fibers would have more difficulty propagating than they would in the three-dimensional lattice. In consequence, information could possibly move at different speeds in the two environments. For purposes of discussion, we assume information propagates more rapidly through the lattice, but the picture that follows holds equally well if the opposite is true.

Imagine that a fiber under great pressure pops out of a plane, and propagates energy through the lattice. The signal would move faster than signals that stayed in the plane. Now suppose the line in the lattice merged back on the originating matter at a distance far from the point of its origination. Then it would seem as though it was interacting with a “future” dominated by slow signals moving through the plane. By analogy, if our reality is embedded in the spaces between the layers of a four-dimensional matrix, we might observe interactions between the past and the future.
In this picture, the future and the past all participate simultaneously in an event. However, the future cannot alter the events of the past, because it was part of their creation!

**Enriching the Physics**

The picture we have developed cannot be called a model. It lacks the mathematical detail that would allow us to calculate the behavior of the system, and therefore to determine how accurately it corresponds to reality.

But, similar to the richness of group theory, there is great room for exploration. Our picture is a one-component model (composed only of sticky springs). Multi-component models might add additional richness. We might imagine models where the lines of spirit are composed of flexible s, rather than chains of the elements that make up the lattice. The springs could also be far more interesting objects, for example tubes that are linked by strings.

In the 19th century, Einstein’s predecessor at the peak of physics was the Scottsman James Clerk Maxwell. Maxwell developed a unified theory of electromagnetism, combining the description of charge, electric fields, current and magnetic fields, achieving thereby an explanation of the nature of light. When he was trained, however, only the theory of the motion of solid objects was on a stable footing. Maxwell therefore spent several years of his life building a mechanical model of the “luminiferous ether”. My proposal is that it might be useful to return to this line of inquiry.

The important point, however, is that this picture, with its free and enclosed paths through the lattice, seems to naturally explain the existence of spirit. We’ll also see that it has some satisfying correspondences with what we know about the history of the early universe.

**A New Universe**

In the beginning, there was – nothing!

Well, maybe there was an empty box surrounding a void.

Then a bodiless somewho threw sticky springs into the box. The springs began to organize themselves into one-dimensional lines, two-dimensional sheets and lattices in three and more dimensions. Because the sticks were thrown in without plan, the structures grew up at random locations with arbitrary orientations. As they grew, they eventually began to collide with each other.
Free springs fled the interiors of the expanding lattices, seeking partners to form more structures. Eventually, they were pushed into crowded voids between the lattices. When the pressure grew too great, they bounced off of each other, rushing through the gaps in the lattice, forming fibers and loops, some of which attached to the lattice as particles, but many of which broke off and propagated as light (Illustration 6).

The earliest objects that we can see in the universe are enormously bright quasars. This picture seems to account for their formation. It also explains why they would appear on the surface of extremely large voids, at the interfaces where the self-assembling lattices come into contact.

Astronomers now tell us that the universe is full of “dark energy”. This would appear to be natural, as our lattice of springs has many of the characteristics of foam. Unless the distribution of springs was perfectly uniform at the start, we would expect the density of the lattice to vary from point to point. The compression of the springs in the denser areas would correspond to “dark energy”.

Light might be expected to interact weakly with the lattice, causing it to lose energy as it traversed the enormous gaps between galaxies. This might explain the cosmic microwave background, and Hubble’s observations that light seems to lose energy as it travels to Earth from ever more distant galaxies.

Now consider the fundamental forces: the electromagnetic and color interactions are shown to be the same force. The weak interaction, involving the exchange of charge between particles, would appear to involve transferring a loop from one triangle to another. It is therefore suppressed by the energy that holds the triangles and loops together. This would explain the large “mass” of the fields in the standard model (the W and Z) that mediate the weak force.

Given these correspondences, you might expect that I would encourage physicists to run out and start elaborating this framework with mathematical models. Actually, I think that is a truly terrible idea. We’re talking about figuring out how to contain and dismantle spirit. I’m pretty certain that the powers that be wouldn’t tolerate our attempts to propagate our destructive immaturity into that space of existence.