A 2020 VISION FOR A NEW THEORY OF PHYSICS

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Abstract. I offer a vision for a possible unified model of fundamental physics, based on a rigorous examination of the underlying assumptions. Where the assumptions on which current theories are based are contradictory, I offer revised assumptions that are not. Much of this is necessarily speculative, but much is supported by the experimental evidence. I omit the detailed technical and mathematical arguments, that can be found elsewhere.

1. The fundamental problems

1.1. **The status quo.** The physical theory of the very small is based on quantum mechanics, which is a very successful theory that underpins almost all of modern technology. The physical theory of the very big is based on general relativity, which is a very successful theory that underpins our understanding of the universe and our place within it, and is also an essential ingredient in modern technology such as GPS. There is only one problem—these two theories are incompatible with each other. This problem has been known since the 1930s but we seem to be nowhere near a solution yet. A full discussion can be found in [1].

Part of the reason for this is that the two theories have been almost too successful. By the 1970s, quantum mechanics had developed into the 'standard model of particle physics' which explains almost everything about the elementary particles of which the universe is made. Almost every experiment has confirmed the model in almost every detail, culminating in the discovery of the Higgs boson in 2012.

1.2. **The neutrino mass problem.** There is perhaps just one irritating gap, and that is that we do not understand the masses of the elementary particles. A particular case of this is the neutrino mass problem. Neutrinos are produced in the interior of stars, in radioactive decays and in nuclear reactors. They are very hard to detect, as most of them pass right through the Earth without hitting anything on the way. The question is whether neutrinos have mass, or whether, like the photons that constitute light (and X-rays, and microwaves, and radio waves, and so on), they are massless.

The standard model requires them to have non-zero mass in order to explain their experimentally observed properties. But no experiment has been able to measure this mass directly, and it must be very small—no more than about one-millionth of the mass of the electron, which is the next lightest particle. Therefore this (hypothetical) non-zero mass is a prediction of the standard model that has not yet been confirmed by experiment. While most physicists regard this prediction as a solid fact, I do not. There is simply not enough physical evidence to support this hypothesis, in my opinion.

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1.3. **The dark matter problem.** Similarly, general relativity has developed into the 'concordance model of cosmology' which explains almost everything about the structure of the universe on a large scale. But again there is a fly in the ointment, and again it is a problem of mass. According to our current understanding of normal matter, there is simply not enough mass inside galaxies for them to behave in the way that they obviously do. The structure of galaxies can only be explained by general relativity if there is a large amount of 'dark matter', making up nearly 85% of the total matter in the universe. There is no direct evidence of this dark matter, and therefore its existence must be regarded as a prediction of general relativity that has not been confirmed by experiment. While most cosmologists regard this prediction as solid fact, I do not. I am not alone in this, but my opinion is definitely a minority opinion.

1.4. **A possible way forward?** In the light of these problems, I have been working on developing a mathematical model for fundamental physics in which

- neutrinos have zero mass, and
- there is no dark matter.

If such a model can be built, then there is some possibility that it might eventually replace the existing models. Mathematical details are presented in [2].

2. The basic assumptions

2.1. **Lessons from history.** There is a close analogy here with Einstein's development of the theory of special relativity in 1905. In the late 19th century explorations of the properties of light, electricity and magnetism had developed to the point where serious contradictions started to appear. There were experimental results that could not be reconciled with any commonsense view of the universe. The Michelson–Morley experiment produced the apparently absurd result that the speed of light in a vacuum is always the same, independently of how fast you are moving when you measure it. Einstein cut the Gordian knot by taking this result at face value, and making it his basic assumption. He was then able to develop a theory which not only explained the phenomena which had been seen, but also made predictions about new phenomena. These predictions, such as the one that moving clocks run slow, have been very well tested, and found to be correct.

Now it turns out that, just as Einstein had to abandon the most basic assumptions about the nature of space and time, so we have to abandon the most basic assumptions about the nature of mass and spin.

2.2. **The concept of spin.** Ordinary spinning objects return to their original state after rotating through 360°. Quantum mechanics is based on the idea that certain fundamental particles, including the electron, proton and neutron that make up all of ordinary matter, 'spin' in a different way: they have to rotate through two whole revolutions, that is 720°, before they return to their original state.

This is not as mysterious as it sounds, and can be visualised with an ordinary coffee mug: if you rotate it through 360° on a table it comes back to where it started. Now try to keep hold of the mug as you rotate it in the air in front of you: after 360° you will find your arm is uncomfortably twisted, but if you keep going through another 360° in the same direction, you will find your arm has somehow magically untwisted itself.

That image provides a model for how electrons, protons and neutrons 'spin'—something is 'holding on' to them. That something, I maintain, is the rest of the universe, and the way it is holding on is by the various forces of nature, most importantly electromagnetism, but also including gravity. This means that ordinary space and time are sufficient to explain this initially surprising property of electrons, protons and neutrons. In quantum mechanics, for mainly historical reasons, an abstract space of 'spinors' is used instead—but is not necessary, as this discussion proves. Occam's razor, that is the principle that the simplest explanation is the best, should therefore force us to remove the concept of a spinor from quantum mechanics altogether. Everything that can be explained with spinors can be explained with spacetime instead. In fact I have shown elsewhere that it is the concept of a spinor that is itself responsible for the contradiction between quantum mechanics and general relativity. Thus it is not only desirable, but almost certainly essential, to abandon the concept of a spinor altogether.

A further benefit of avoiding spinors is that we avoid at least some of the problems of interpretation of quantum mechanics, which bedevil the subject. The basic question is 'What *is* a spinor?' which is unanswerable, although many people have tried to answer it. A weaker version of the question is 'How should we think about a spinor?' to which the traditional answer is 'Shut up and calculate.' Questions of this type go away when spinors are replaced by spacetime. There are however other questions of interpretation that do not necessarily go away, which I will come back to later.

2.3. **The concept of mass.** A similar problem affects the concept of mass, in the foundations of general relativity. Einstein originally took as his starting point the 'general principle of relativity', that is, the principle that the laws of physics are the same for all observers. But in the end his theory of general relativity was based instead on the 'equivalence principle', that gravitational mass and inertial mass are the same thing. Gravitational mass measures how hard gravity pulls an object, and determines how heavy an object is. Inertial mass measures how difficult it is to move the object, and does this by seeing how hard the electromagnetic forces between atoms push and pull. The equivalence principle therefore states that the relative strength of gravity and electromagnetic forces is always the same.

This principle has been tested to high accuracy both on the Earth and in satellites orbiting the Earth, and no discrepancy has yet been found. But it is known that the relative strengths of electromagnetism and the nuclear forces are *not* always the same, so why should gravity be any different? Cosmological evidence from the shapes and sizes of galaxies also casts doubt on the equivalence principle on very large scales. It is therefore desirable, if possible, to devise a more general theory that does not assume the equivalence principle.

2.4. **Up the creek without a paddle.** To summarise the conclusions at this point, we have found it necessary to abandon the basic assumptions of both quantum mechanics and general relativity, namely

- the existence of spinors, and
- the equivalence of gravity and inertia.

But we cannot just abandon the two theories, which work extremely well in their respective domains. We must give them new foundations so that they can continue to work in practical situations.

3. New foundations

3.1. **The four forces.** In the case of quantum mechanics, I have already suggested that the space of spinors can be replaced by ordinary 4-dimensional spacetime. But this begs the question of how spacetime on the scale of elementary particles relates to spacetime on the human scale. This is a mathematical question of some technicality, but it turns out (see [2]) that there are exactly four ways in which spacetimes on different scales could in principle be related to each other. Therefore a theory based only on spacetime, without spinors or any of the other abstract concepts that are contained in the standard model, can in principle model physical forces on exactly four distinct scales.

Modern physics does in fact describe the universe in exactly these terms. There are four recognised forces of nature, namely gravity, electromagnetism, the weak nuclear force (responsible for radioactivity) and the strong nuclear force (responsible for holding the nucleus of an atom together), in order from large to small scale. As the scale changes, the relative importance of the different forces changes. There are two ways the scale-change can be measured. One way is directly in terms of distance and time, and the other way is indirectly in terms of speed and energy. These two ways of measuring are 'dual' to each other in the mathematical sense that the greater the energy, the smaller the distances that can be resolved.

3.2. **The human perspective.** The interesting thing about the human scale is that both gravity and electromagnetism are very significant for us in our everyday lives, whereas the weak and strong nuclear forces are of marginal concern (except in certain parts of modern technology). The particular mix of gravity and electromagnetism that we experience is something particular to our scale, and our place in the universe. But there is nothing in modern physics that measures this mixing. This is a gap in the theory that needs to be filled.

Mixing of forces is described in the technical language of particle physics via a 'mixing angle', which can in principle vary from 0° when one of the forces dominates, to 90° when the other force dominates. For example, the mixing angle between electromagnetism and the weak nuclear force is measured at around 28.5° in experiments on Earth, though it varies slightly as the energy scale varies. We need a similar mixing angle between the forces of gravity and electromagnetism, appropriate to our scale. It must be an angle that is clearly important on the scale of the whole Earth, but which goes to 0° or 90° on much larger scales, say on galactic scales. Since we have replaced the spinor by spacetime, this angle is probably one that is visible in spacetime on a gravitational scale. The only angle of this type that I can see is the tilt of the Earth's axis, at around 23.44°. This is surely the only plausible mixing angle between electromagnetism and a quantum theory of gravity. Such a quantum gravity does not yet exist, but this seems to be a property that any such theory must satisfy if it is to be credible.

If there is indeed a mixing angle of this type between electromagnetism and quantum gravity, then its effect in everyday terms is to measure a ratio between inertial mass and gravitational mass. As long as this ratio is constant, we will never notice the difference. This certainly seems to be the case on Earth, where the angle of tilt is the same for all experiments. But it seems to me that in principle the ratio of inertial to gravitational mass could be anything, and that on Earth it is likely to be $\sin(23.44^\circ) \approx .3978$, or fractionally less than $2/5$.

3.3. **A new perspective on dark matter?** By using inertial mass instead of gravitational mass in Newton's law of gravity, we are potentially under-estimating the strength of the gravitational force on a large scale, by a factor of approximately $(5/2)^2 = 6\frac{1}{4}$. This number matches closely to the estimated ratio of all matter (including dark matter) to ordinary matter in the universe. Indeed, the dark matter estimates produce an estimate for the inertial/gravitational mass ratio of $\sqrt{.155} \approx .394$, about 1% smaller than my prediction. Therefore a quantum theory of gravity based on the principles I have put forward could potentially explain the large-scale structure of the universe without having to include any hypothetical dark matter in the model. All that is required is a mixing angle between gravity and electromagnetism, as measured on Earth, of approximately $23.44°$.

3.4. **A new perspective on quantum gravity?** At the same time we need to propose a physical mechanism for quantum gravity. It is usually assumed that the particle that 'causes' gravity is a spin 2 graviton. Here spin 2 means it has $180°$ symmetry, and the requirement for a spin 2 graviton comes from the formalism of general relativity, under the assumption that there is a direct translation from the force to a particle. However, there is no direct evidence for a spin 2 graviton, and there is no theoretical reason why the spin 2 effects (essentially tides, but on a very small scale) cannot be obtained from a combination of other particles, such as two particles of spin 1 or four particles of spin 1/2.

It is therefore theoretically possible to base a model of quantum gravity on neutrinos, which are spin 1/2 particles that, as far as direct experiment shows, could have zero mass and travel at the speed of light. Since the choice is between basing a theory on particles that are known and reasonably well studied experimentally, or basing it on hypothetical particles, Occam's razor strongly favours the former approach. It is certainly known that neutrinos are associated with large-scale gravitational events in the universe, and can carry huge amounts of energy away from star systems that are rotating very fast or colliding. The association of neutrinos with smaller scale gravity is only conjectural at this stage, and it is a challenge to devise appropriate experimental tests of this conjecture. All that can be said with certainty is that neutrinos interact very weakly with matter, and therefore cause a very weak force between large bodies of matter. In particle physics terms, gravity is a very weak force indeed. So if the force that is caused by neutrinos is not gravity, what is it? Again Occam's razor comes to our aid.

If neutrinos are indeed responsible for gravity, in the sense that they are the 'messengers' sent out by massive objects to attract other objects to them, then we finally have a solution to Newton's 'action at a distance' problem. Newton was disturbed by the fact that his theory of gravity did not contain any mechanism by which bodies could attract each other from a distance. If they send out neutrino rays, analogous to light rays but much harder to detect, then this problem is solved.

4. Neutrinos and electrons

4.1. **Neutrino oscillations.** More importantly, this hypothesis implies that experiments involving neutrinos cannot be considered independently of gravity. Every experiment involving neutrinos must be considered in the context of the local gravitational field, and it must be expected that the results of neutrino experiments will in general depend on the gravitational field. These results may depend not only on the strength of the gravitational field, but also on its direction.

In fact, there is no direct evidence of dependence on the strength of the gravitational field, but there is significant experimental evidence of a dependence on the direction of the gravitational field. To explain this evidence, note first that the neutrinos produced in nuclear reactors, and in radioactive decays on Earth, are always electron neutrinos. There are two other kinds of neutrinos, called muon neutrinos and tau neutrinos. The experimental evidence is clear that an electron neutrino produced in one location can be detected as a muon neutrino or tau neutrino in another location. Conventional wisdom is that the neutrino itself has changed, but this requires the neutrinos to have non-zero mass, that has not been independently detected.

An alternative is to consider the possibility that it is instead the environment that has changed. If a neutrino produced in a nuclear reactor travels through the Earth and is detected in another location, then the one thing that is significantly different between the two locations is the direction of the gravitational field. As well as the local directions of up and down defined by the gravitational field, we must also take account of the directions East and West defined by the rotation of the Earth. Then the directions North and South are also fixed, as the unique directions perpendicular to both up/down and East/West. When the neutrino is detected, it suddenly has to replace its original idea of the gravitational field with a new one, and is more likely to choose one which involves a small change in the coordinate axes, even if this involves relabelling the x, y, z axes as y, z, x or z, x, y. There is a simple mathematical formula that relates the various directions, and which therefore predicts the probability that an electron neutrino produced in one location is detected as an electron neutrino in another location.

A similar phenomenon occurs with neutrinos produced in the Sun. These neutrinos are produced as electron neutrinos with respect to the local direction of the gravitational field. But as far as we can tell, this direction is equally likely to be any direction at all, so from our point of view it is completely random. Therefore neutrinos from the Sun should be equally likely to be of any of the three types. In the original experiments, only electron neutrinos could be detected, and the fact that only about one-third of the expected number were detected was a puzzle. More recent experiments [3] can detect all neutrinos, and have confirmed that the proportion of electron neutrinos is, to within experimental uncertainty, exactly $1/3$.

In particular, a gravitational role for neutrinos is capable of explaining why neutrinos appear to 'oscillate' between the three types. This explanation does not require neutrinos to have non-zero mass, and is therefore in better agreement with experimental evidence than is the standard explanation. Moreover, this gravitational model explains why there are exactly three types (called 'generations') of neutrinos—it is because there are exactly three perpendicular directions in space.

4.2. **Three generations of electrons.** It is not only the neutrinos that come in three generations, but also the electrons. The other two generations of electron are called the muon and the tau particle. They differ from the electron in that they are much heavier, by about 200 times and 3500 times respectively. One of the challenges for modern physics is to explain these three differing masses. There seems to be no reason for these values, and the standard model does not explain them. I too have been unable to find a convincing explanation, but the fact that the electron, muon and tau particle are each associated with their own neutrino suggests that the gravitational field has a lot to do with it.

There must then be some relationship between the three generations of electron and the three directions in space, defined locally in the region of the experiment. The particle masses, however, must depend on global properties, since they do not depend on where on Earth the experiments are carried out. Just as neutrinos arise equally in all three generations, the same must be true on a global scale for electrons. But this is certainly not true on a local scale, where only ordinary electrons are normally seen. Muons arise from cosmic rays, and the tau particles are even more elusive. Nevertheless, there must be a large-scale gravitational sense in which electrons, muons and tau particles 'occur' (whatever that means) in equal numbers.

This must surely mean that the sum of the three masses has some global gravitational meaning. All three of these particles are negatively charged, so to get rid of electromagnetic effects we need three positively charged particles as well. The only positively charged particle in ordinary matter is the proton, which is not associated with a particular neutrino, and therefore does not come in three generations. The simplest approach is then to add three protons to the list, and add up the masses of all six particles. The total mass should be a gravitational mass carried by neutral (uncharged) particles.

It turns out to be equal to 5 neutron masses, to well within experimental uncertainty. In the usual units used in particle physics, the total of the six particles comes to $4697.805 \pm .16$, where .16 measures the experimental uncertainty in the mass of the tau particle, while the mass of five neutrons comes to 4697.825. It is practically inconceivable that such accuracy could be achieved by chance. Moreover, this equation provides a prediction which can be tested by measuring the mass of the tau particle more accurately than is currently known. The mathematical details of the model [2] also explain why we get five neutrons, and not some other number.

5. Fundamental masses

5.1. **Speculations.** One of the fundamental processes of radioactivity is the decay of a neutron into a proton and an electron. This process releases energy, and is the basis of the nuclear power industry, but it was discovered early on that up to 60% of the energy goes missing. This missing energy is taken away by a neutrino (technically, an anti-neutrino). The energy that is left behind is represented partly by heat, which we can use, and partly by the mass of the electron, which is only about 2/5 of the mass difference between the neutron and the proton. More precisely, the proportion is about .3952.

So the question is, is there a good reason for this number .3952 to be so close to both .394 (obtained from consideration of dark matter) and .3978 (obtained from the tilt of the Earth's axis)? Or is it just a coincidence? The conventional answer is certainly that they are all coincidences, but I have argued that all three of them are essentially just different ways of measuring the ratio of inertial mass to gravitational mass, and that therefore there is more to this coincidence than conventional physics recognises.

Even if some of the three exhibited numbers that are around 2/5 do turn out to be closely related, it does not necessarily imply that changing one of them automatically changes the others. Much more likely, they all depend on something deeper that we should try to understand.

5.2. **The motion of the laboratory.** The general hint is that there may be some unrecognised dependence of some parameters on the motion of the Earth. This could be a huge problem for particle physics if it turns out that some experimental results depend on the fact that the experiment is rotating along with the Earth. It is generally assumed that the effects of gravity and rotation on particle physics are too small to be noticeable. This may be true, but it really needs to be tested experimentally, rather than being assumed without real evidence.

Unfortunately, it is not practical to build a particle accelerator anywhere except on the Earth, so that direct experiments are impossible. We must be more inventive, and look for cheaper experiments. My model implies, contrary to general assumption, that the effects of gravity and rotation are not negligible. My model cannot be refuted by simply asserting that my conclusions are wrong. These conclusions only contradict a (dubious) assumption, and do not contradict experiments.

By throwing away the spinor and using spacetime instead, my model implies that almost everything in quantum mechanics depends on the motion of the experiment, and therefore depends not only on the tilt of the Earth's axis, but also on the relative lengths of the day and the year. Moreover, the Moon has a significant influence on the motion of the Earth, and therefore the length of the month is also important, as is the inclination of the Moon's orbit to the ecliptic. As before, I am saying nothing about what causes what—I am only pointing out relationships. Of necessity, I am leaving out a certain amount of detail, such as the eccentricities of the orbits, variation in angles of inclination, and so on.

5.3. **Proton and neutron.** It is not possible to explain all the relationships I have found without some technical detail. Most of these are relationships between masses of elementary particles, which by Einstein's equation $E = mc^2$ means a relationship between different energies. Scaling the energy upwards corresponds to slowing time down. For example the scaling of mass between proton and neutron is small, numerically $m(n)/m(p) \approx 1 + 1/726.5$, and corresponds to a scaling of time. Because protons and neutrons need to rotate through 720° to return to their original state, we need a scaling of time corresponding to a 720° rotation. The obvious conjecture is a scaling by adding one day every two years, corresponding to a ratio of 1/730.5. The small difference between 726.5 and 730.5 is in the region we should expect, given the effects that I have ignored in making this calculation.

5.4. **Chirality.** The process by which a neutron decays into a proton and an electron, plus an anti-neutrino, is called beta decay, and is governed by the weak nuclear force. This process is the mechanism for most (but not all) radioactive decay. The weak force is chiral in the sense that it comes in a left-handed form and not in a right-handed form. This was demonstrated by the famous Wu experiment [4] that involved magnetising radioactive cobalt 60 at a temperature a whisker above absolute zero: the direction of motion of the ejected electron turned out to be strongly correlated with the direction of magnetisation. The ejected neutrino travels in the opposite direction to the electron. At the time, neutrinos were assumed to be massless, and the conclusion was drawn that all neutrinos are inherently left-handed.

The analysis of this experiment, like all others, assumes that the laboratory is essentially 'at rest' (whatever that means), or at worst travelling at constant speed in a fixed direction. This assumption is clearly false, given the rotation of the Earth, so the question is, does it matter?

I have argued that it does matter, and that until there are definitive experiments to test it, it is not safe to use this assumption in the theory. In fact, the motion of the laboratory is strongly chiral, due to the influence of the Moon. Chirality requires three axes of rotation, so that if you try to use your thumb and first two fingers to point in the direction from the South Pole to the North Pole for each rotation, in a particular order, only one of your hands will be able to do it.

The rotation of the Moon around the Earth is really a rotation of both around an axis that passes through the Earth about 4600 km from the centre. It therefore contributes significantly to the motion of the laboratory, and creates a significant chirality in this motion. It is therefore possible that this chirality is responsible for the observed chirality of the weak force. The standard model attributes the chirality to the neutrino, while my model attributes the chirality to the atom that ejected it. More importantly, my model explains where the chirality comes from, and the standard model does not. As far as I am aware, no experiment has been done to test this proposal. It should be possible to devise a suitable rotating experiment to distinguish between the two predictions. In the meantime, I suggest that Occam's razor favours the assumption of one source of chirality rather than two.

6. Inside the atomic nucleus

6.1. **Quarks.** Let us move now to the smallest possible scale, that is the domain of the strong force, which is responsible for holding the nucleus of an atom together, and for the internal structure of protons and neutrons. In the standard model, protons and neutrons are made of up and down quarks, but the masses of the quarks account for only about 1% of the total mass of the proton or neutron. The rest of the mass arises in some way from the action of the strong force.

Four more quarks have been discovered in high-energy collisions in particle accelerators, so that altogether there are three generations of quarks with charge $-1/3$, called down, strange and bottom, and three generations of quarks with charge $2/3$, called up, charm and top. One peculiarity of the generations of quarks is that they do not match up with the three generations of neutrinos and electrons. We have already seen this in the equation that relates all three generations of electrons to the proton and neutron, which contain only up and down quarks. My model suggests mathematically that it is better to divide the 6 quarks into two triples on the basis of mass rather than on the basis of electric charge. Thus we get three light quarks (up, down and strange) and three heavy quarks (charm, bottom and top).

6.2. **Pions.** The strong force acts in the atomic nucleus by moving the up and down quarks between the protons and the neutrons. The combination of one quark moving in each direction can be imagined as a very short-lived particle consisting of one quark and one 'anti-quark', each being of up or down type. Such particles are called pions, and they can also be observed as independent particles, and their properties, such as mass, can be measured. There are only three different pions, rather than the four that you might expect. One moves a positive charge from a proton to a neutron, one moves a negative charge the other way, and one is neutral. The charged pions are very slightly heavier than the neutral pions, with a mass ratio $m(\pi^+)/m(\pi^0) \approx 1 + 1/29.39$. Comparing this with the ratio of proton to neutron mass given earlier, we may not be surprised to see the number of days in a month appearing in this formula. Of course, this may just be a coincidence, but the more such coincidences we find, the harder it is to explain them away.

6.3. **Kaons.** If we now extend from two quarks (up and down) to three (up, down and strange) we should expect the number of particles to increase from $3 = 2\times2-1$ pions to $8 = 3 \times 3 - 1$, and hence find five more particles that are similar to pions but are heavier. In the standard model these are identified as four kaons and one eta meson. My model predicts something slightly different, and identifies all five as kaons, putting the eta meson somewhere else in the theory. There is a conflict here: is the true number of kaons four or five?

Surely this should be easy to determine experimentally? Indeed it is, and the number of clearly distinct kaons that are detected experimentally is in fact five. There are two charged kaons K^+ and K^-, about which there can be no argument. The standard model then contains two neutral kaons called K_0 and $\bar{K}_0$, that cannot in practice be distinguished experimentally. It also contains two 'quantum superpositions' of K_0 and $\bar{K}_0$, called K_1 and K_2, that can be clearly distinguished experimentally both from K_0 and from each other. In other words, the standard model is trying to force five experimentally observed kaons into a theory which only has room for four. While conventional wisdom is that this procedure succeeds, my view is that it does not. In my view, the kaons must occupy all five of the available spaces, and the eta meson must go somewhere else. The standard model does not have anywhere else to put the eta meson, but my model counts 10 particles rather than 9, so has exactly the right amount of room for the extra kaon.

6.4. **Kaon oscillations.** There is another property of kaons that is something of a puzzle for the standard model. The K_1 particles decay very rapidly into two pions, while the K_2 particles decay much more slowly either into three pions or into one pion plus some other particle(s). Hence it is possible by careful timing to produce a pure beam of K_2 particles. The puzzle is that this pure beam then exhibits some decays into two pions, suggesting that some of the K_2 particles have converted into K_1 particles. This is rather reminiscent of the way that neutrinos appear to convert from one generation to another as they travel through the Earth. Just as in that case, I suggest the mechanism is more likely to be the change in the environment, and in particular the change in the direction of the gravitational field. Here, the length of the beam was only 57 feet, and calculating the angle of rotation around the Earth that this corresponds to suggests that approximately 3 in every million K_2 particles should appear as K_1 particles over this distance. This predicted proportion is consistent with the experimental results. Just as in the case of the neutrinos, it is not the particles that have changed, it is the environment.

If there are five kaons rather than four, then there is a mathematical sense in which they belong to a 'square' of 3-dimensional space, which seems to imply that their masses relate to squares of distances. Hence the ratio of the charged kaon mass to the neutral kaon mass should be a ratio of squares of distances. My model suggests this ratio should be $\cos^2(5.14^\circ)$, where 5.14° represents the inclination of the Moon's orbit, that is the angle between the Moon's orbit around the Earth and the Earth's orbit around the Sun. This value is correct to within experimental uncertainty, but there is one puzzle remaining. The angle of inclination varies from about 4.99° to about 5.30° on a 347-day cycle. Does this variation imply a variation in the kaon mass ratio, or is it cancelled out by some other variation somewhere else? It is not entirely clear, but this experiment can be done, and I suggest it therefore should be done. There is a Nobel prize waiting for the first person to detect such a variation consistent with my model.

7. Interpretation of quantum mechanics

7.1. **The measurement problem.** I have argued that the experimentally observed 'oscillation' of neutrinos and kaons between three different types can best be explained by a change in the environment, rather than a change in the particle itself. This leads to a much more general principle that many properties of elementary particles that are generally assumed to be intrinsic may in fact be properties of the relationship of a particle to its environment. In the two cases already discussed, it is the gravitational environment that is most relevant. In other cases, on a smaller scale, it may be the electromagnetic environment that is important. In all cases, when an interaction takes place, the particle is in a definite one of the different forms, but in between interactions, it is not. The 'measurement problem' is the problem of understanding how a particle decides which of the available forms it is going to take.

The standard model does not contain any solution to the measurement problem. Some of the alleged solutions are worse than the disease, such as the 'many worlds interpretation' whereby at every moment the universe splits into infinitely many different universes. But in my opinion the entire problem arises because the particular property that is being measured is assumed to be intrinsic to the particle. The experimental evidence of neutrino and kaon oscillations unequivocally supports the hypothesis that, on the contrary, many of these properties are extrinsic.

7.2. **Entanglement of spins.** The example that is usually discussed is that of electron spin, which can be either 'up' or 'down'. One of these, say 'down' corresponds in the coffee-mug analogy to your arm being straight, and the other, say 'up', to your arm being twisted. There is no meaningful sense in which the mug itself is either 'up' or 'down'—this is a property of the relationship of the mug to its environment. As long as the electron does not interact with anything, its spin remains 'entangled' with the spin of the last particle it interacted with. As soon as it interacts with something else (or someone else takes the coffee mug from you) its spin changes and it becomes entangled with a new particle. All the mysterious properties of quantum entanglement can be easily understood in terms of the coffee-mug analogy. There is nothing mysterious about it at all. Richard Feynman famously said 'Nobody understands quantum mechanics'. If you have followed my argument this far, then *you* understand quantum mechanics.

8. Summary

The problem of reconciling quantum mechanics with general relativity goes back to the 1930s. Attempted solutions since then have mostly taken the form of throwing more and more mathematics at the problem. The lesson of history is that this approach will not work. Fancy mathematics is useless unless is it based on valid assumptions. The correct mathematical assumptions can only be obtained from correct physical principles. The correct physical principles can only be obtained from analysis of the crucial experiments.

The detection of neutrino oscillations suggests that the 'generation' property of a neutrino, and therefore also of an electron, is not intrinsic, but is a property of the relationship of the particle to its environment. The detection of the chirality of the weak force suggests that the 'spin' of a particle is not intrinsic, but is a property of the relationship of the particles to their environment.

Cosmological studies of the rotation speeds of stars in galaxies have led some people to conjecture similarly that mass is not an intrinsic property of a star, but is a property of its relationship to its environment. Hence we have the following important physical principle.

Mass and spin are not intrinsic properties of a particle, but are properties of the relationship of a particle to its environment.

There are two types of environment that need to be considered, the electromagnetic and the gravitational. There are two ways that a particle can communicate with its environment, using either photons or neutrinos. Photons communicate with the electromagnetic environment, which suggests that neutrinos communicate with the gravitational environment. Thus we have another important physical principle.

Neutrinos are the means by which the gravitational force operates.

These two physical principles are sufficient to show us what the correct mathematical assumptions are, on which we can try to build a new theory that generalises the old theories. There is now, for the first time, a real prospect of a unification of the theories of fundamental physics into a Theory of Everything.

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