Flying on the Wings of Genius

A Chronicle of Modern Physics

Book 2

If I have seen farther, it is by standing on the shoulders of giants.

Isaac Newton (1676)

Dr. Andrew Worsley

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Dedicated to:

The Elegance and Symmetry of Nature

The study of Nature is intercourse with the Highest Mind.

Jean Louis Agassiz (1807-1873)

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Forward

We stand on the shores of a great ocean of truth examining pebbles on the beach………while the whole sea of unfound knowledge lies before us.

Isaac Newton

Newton's original laws of motion held sway in the scientific world for over 250 years and some still apply today. What is scientifically now known is certainly more advanced than it was in the time of Newton. Yes we have invented computers, aeroplanes, space travel and the electric kettle. But if we are to be honest, the fundamental knowledge of the workings of the Universe still eludes modern physics. Some believe that they are on the brink of having a comprehensive theory of everything in the Universe. That theory is known as string theory. Nevertheless, there are many problems with string theory and it seems to predict very little from first principles. In truth the ocean of knowledge is vast and we have not even set sail upon the sea that lies before us. Until we do so, it cannot be said that humankind has found the full wisdom or maturity to progress its knowledge.

What knowledge we do have today on the workings of the Universe seems like a leaky boat. It is made from ill-fitting pieces and when it is put in the water it merely starts sinking. Without a proper ship modern science is confined to exist upon our island of knowledge, without ever knowing what lies beyond. Science does not know, what it does not know. It was the great physicist John Wheeler who once said:

We live on an island surrounded by ignorance. As our island of knowledge grows so does the shore of our ignorance.

Additionally, it would appear that our wisdom to use the knowledge that we do have has not advanced. Indeed the present use of our knowledge, such as nuclear technology, merely imperils our own existence. Many challenges lie ahead and at the current time it is clear that the very survival of humankind may rest upon advancing our knowledge and our ability then to use it wisely, in this new millennium.

To assist in this end, Book 1, of this series of three books, entitled "On The Wings of Genius" was written. That book was written to help gain an insight into the aesthetic structure of Universe and to give a far greater understanding of the true beauty in which Nature is designed. It contained the knowledge to build the ship to sail the oceans, so that we can discover more knowledge and perchance begin to use it wisely.

This second book, sets sail on a course, which is destined to reveal some of the most elegant secrets of the Universe. One of the most mysterious aspects of Nature is the way in which the fundamental materials (subatomic particles) of the Universe are so aesthetically constructed. This second book lifts the shrouds of mystery, which surround this subject. It does so in a way, which accurately agrees almost completely with currently held experimental evidence about the physical characteristics of these fundamental materials from textbook physics [1-3]

In it we also find that some of the fundamental constants of nature may be derived from first principles. This can be done without recourse to the simple contention that these are just fundamental constants, whose veracity cannot be questioned, but shows logically how these may be derived. It does so in a way that not only agrees with modern physics, but also explains the elegance and symmetry of Nature. It builds on the knowledge laid out in the previous book and does so in a way that strengthens enormously the truth of those findings. It opens a new window onto the physical Universe.

As with the previous book these findings have also been published in a scientific fashion and I again refer the reader to the first two references of the book.[4,5] This second book is comprehensive in itself, nevertheless it is highly recommended that the reader read Book 1 of the series in order to achieve an overall perspective of the power of this approach to physics. The previous book not only clarified many of the mysteries of quantum physics, but clarified the nature of energy.

This 2nd book further clarifies the nature of energy and overall brings an even greater understanding of the magnificent symmetry of the physical Universe and the unified nature and exquisite elegance of its design.

Andrew Worsley, February 2006

Chapter 1

Introduction

The more one chases quanta, the better they hide themselves.

Albert Einstein

It is now over 100 years ago that a physicist named Max Planck discovered the fundamental constant of quantum physics. [6,7] Planck's constant, as it is still known today appears in virtually every quantum formula. These formulae for quantum physics have over these past hundred years been built up to form an entirely new picture of the world. That is a world where everything, on a small enough scale, comes in discreet packages or quanta. Nevertheless, even today the true nature of the quantum has evaded science. The quanta that have been sought for so long are indeed incredibly important.

In present day physics we are very good at measuring things and examining the pebbles of knowledge we do have in great detail. The problem is in doing so we can miss the overall picture of what is quantum physics. The fundamental question, which is not answered is, Why? Take for instance the electron, which is the particle, which is best known for the transmission of electricity down an electric wire. We *do* know the exact value of the mass and electrical charge of the electron particle. But present day physics has not got a single clue as to why the mass and charge of the electron is what it is. Similarly with many aspects of physics, there are constants of nature to which we have measured the value down to an accuracy of 12 decimal places, that is like measuring the distance between here and New York down to the thickness of a single atom. But we still have no idea whatsoever why that value is the value that it is.

In truth the claims to this tremendous accuracy regarding these constants of nature may not be that well founded. Yes we have measured the constants on this planet to that degree of accuracy, but what of confounding factors, that we are aware of, or even more likely unaware of. One of the biggest surprises of modern physics (although some still contend it) is that one of the important constants of nature, the fine structure constant, does not appear to measure the same everywhere we look. Some distant galaxies seem to have a fine structure constant which is slightly different. This difference is only some 1 in 100,000 but this is still significant. Furthermore the fine structure constant is dependant on other constants, such as the charge of the electron amongst others. So we really do not know, which if not all of these component constants are accurate. Moreover, the fine structure constant is just about the only constant we can measure on distant galaxies, by examining the light that comes from them. We cannot for instance go to these distant galaxies and measure the charge of the electron, so it is quite possible that other constants could be a little bit different elsewhere. There is another parameter that scientists *can* measure in distant galaxies, that is the ratio of the mass of the proton to the mass of the electron. Indeed recently scientists have noted that there also appears to be difference in the ratio of these masses, on distant galaxies, by about the same amount as with the fine structure constant. Until this mystery is solved this means we can realistically only be certain of values down to about five decimal places.† This still represents a considerable degree of accuracy. There is a model of the particle world called the Standard Model, this does not predict the fundamental constants or the masses of the fundamental constituent particles. The predictions it does make about subatomic particle masses, such as the proton are accurate only to 2 decimal places. The magnificent strength of this new approach, over the Standard model, is that it is possible to define these constants and particles from first principles to a much greater degree of accuracy. In doing so we can also solve the mystery of why the constants and fundamental particle masses are what they are.

This can be done, by finding the true ephemeral nature of the quantum. In the first book of the series we *were* able to find such a fundamental quantum and indeed this enabled the introduction of a unified description of the Universe. In that book we were also able to clarify some of the mysteries about the nature of the quantum formulae and derive them on an entirely logical basis. This led us closer to an understanding of the truer nature of energy and matter. This second book goes farther than this, it enables an even more comprehensive understanding of energy and in particular matter at a much more elegant level.

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† In this book therefore we will operate on the basis of 5 decimal place accuracy.

What then of string theory, which has been the major contender for a comprehensive physical theory, over the past twenty-five years.[8-10] In the previous book we solved many of the problems associated with string theory. Another major problem of string theory is that it also fails to predict any of the fundamental constants or particles. So much so, that physicists are beginning to be concerned by its lack of predictive power. This has resulted in one eminent physicist in string theory saying:

"people in string theory are very frustrated as am I by our inability to be more predictive after all these years."

David Gross (2006).

Yet another problem is that string theory *does* modify the established equations for quantum physics. [11,12]

The truth is, that only certain elements of string theory are correct, and the fundamental quantum mass that is used in string theory is incorrect. Once we find the one true elusive quantum mass, we are open to deriving not only the equations for quantum physics from first principles but also the fundamental constants and the masses of the particles in an entirely harmonious way.

Chapter 2

The Standard Model

How can it be that writing down a few simple and elegant formulae, like short poems governed by strict rules such as those of the sonnet…..can predict universal regularities of Nature

Murray Gell-Mann

In this book it will be possible to demonstrate that a few direct rules are all that are needed to explain the ocean of knowledge that lies before us. However, before we embark on a journey across this ocean of knowledge we should recap on the history of particle physics. The first evidence of a subatomic world came with the discovery of the electron by J.J. Thomson in 1897. He first described what was thought of as a particle with a negative charge and a tiny mass. His discovery was made, using a cathode ray tube, which in fact is pretty much the same as an old-fashioned cathode ray TV tube. The discovery was incredibly important, the applications of electricity and electronics or the understanding of chemistry is unthinkable without the discovery of electron. Moreover some radioactive decays which are crucial in the understanding of particle physics, called beta decay, is actually the release of an electron from the inside of an actual atom . But as with many truly crucial discoveries the great importance was not recognised at the time.

Of the electron he said:

"Could anything at first sight seem more impractical than a body which is so small that its mass is an insignificant fraction of the mass of an atom of hydrogen."

J.J. Thomson.

About the same time as J.J. Thomson was working on the electron a famous Polish scientist, Marie Curie Skłodowska, was working in collaboration with her Husband Pierre Curie, on radioactivity. She showed as early as 1897 that certain naturally occurring atoms, such as Uranium, would decay by giving off small particles, which were themselves the constituents of the larger atom. The achievements of Marie Curie Skłodowska are made even more remarkable in that she was largely a self-taught woman in a field, which was almost exclusively dominated by men. Nevertheless, her discoveries were so important that she is one of the few scientists, and the only woman to date, to have won two Nobel Prizes. Moreover, what knowledge she had gained on splitting the atom she used for good purposes and she was able to set up an institute for the treatment of cancer with the very radioactivity that she had discovered.

What she had in fact discovered, from a physics perspective, were the decay products of the centre of the atom. This centre or nucleus was later found to be made up of small particles known as protons and neutrons. As early as 1900 she wrote a paper on the release of alpha particles, "Les Rayon Alpha" as she called them. [13] It was not for some time after this that it was realised that an alpha particle was actually two protons and two neutrons bound together, and was an important part of the decay of the nucleus of an atom.

Indeed it was not till 1918, that Ernest Rutherford actually discovered the proton itself. The proton in contrast to the electron had a positive charge, which was the exact but opposite charge of the electron. By 1919 a picture of the atom was emerging of a small central nucleus, orbited by electrons. So in the case of hydrogen, the smallest atom, we have a picture of a single proton orbited by a single electron. The nucleus of the atom was so small that if the orbit of the electron is the size of the dome of St. Paul's Cathedral, then the nucleus would be about the size of a marble. The nucleus is effectively 100,000 times smaller than the atom itself.

When the neutron, a neutral particle with no net charge, was later discovered by Chadwick in 1932 the picture of the atom seemed complete. Each atom had a central nucleus, which was composed of protons, with neutrons to stabilize the nucleus. The nucleus was itself surrounded by a cloud of electrons, which orbited around the nucleus. Differing atoms would have increasing numbers of protons and in turn electrons and these in turn would determine the characteristics of an atom.

This gives the wonderful diversity of atoms, which enables the world to be built up. For instance if we take two atoms of hydrogen (each having one proton and electron) and add one atom of oxygen (having eight protons, eight neutrons and eight electrons), these atoms go to form the molecule H_2O; that substance which is so essential to life - water.

Similarly if we take six protons and six neutrons and six electrons, we get the carbon atom, the principle atom from which all life on this planet is based. In this way with differing numbers of protons and neutrons we can build up all the atomic elements. Additionally, if we combine these atoms together, as with water, we can account for all the molecules we see in the Universe

Everything appeared so neat and tidy. But almost as soon as scientists had confirmed the presence of these three fundamental particles, the proton the neutron and the electron, then in 1936 came along another particle called the muon. To most physicists of the time this was an unexpected and unwanted surprise.

Certainly what was to happen next, came as an even more uncomfortable surprise, soon more and more particles started to appear. These came from the study of cosmic rays, specifically rays that are coming from outer space. Something coming from outer space was telling us that our simplistic model of the Universe was actually wrong. It was almost as if the Universe was hinting to us that that we were missing something very important. After their experiments with cosmic rays, scientists of the 1950's went on to built particle accelerators, these effectively accelerated protons (or electrons) and smashed them together at great speeds. Soon a whole plethora of particles were being revealed. These came in pairs, which seemed to mirror each other. So in the case of the electron with a negative charge they later discovered it's opposite called the positron, with a positive charge. This plethora of subatomic particles thus became known colloquially among physicists as the "particle zoo".

Particle physics was in deep trouble, if all the members of the particle zoo were indeed fundamental particles then the Universe was awash with these apparently fundamental particles. The picture of nature was looking far too messy. The particle physics ship was sinking and fast.

Along to the rescue came the eminent physicist Murray Gell-Mann. He surmised that the fundamental particles like the proton must be composed of even more fundamental particles, which were termed quarks. In the first instance *three* quarks were postulated. In the case of the proton, for instance three of these quarks were to combine to from the proton particle. But then as the number of new particle discovered grew, the number of quarks grew to six. With these six fundamental particles physicists were able to devise a system, which apparently explained all the particles that were proton and neutron like.

The history of science can however be strange. In fact it was two people that postulated the theory that there may be very fundamental particles at the core of particle physics, virtually at the same time. Murray Gell-Mann and George Zweig almost simultaneously, in 1964, described these fundamental objects. George called them "aces" and postulated that there were four such particles. Murray called them quarks and postulated that there were three of these. Indeed he called them quarks form a line in James Joyce's poem, Finnegan's wake "three quarks for Muster Mark". Murray Gell-Mann was theoretically nearer the mark at the time with three quarks, and won the Nobel Prize in 1969. George Zweig for his pains was not rewarded and left physics to become a neurobiologist.

The genius of Murray's theory is that it predicted the existence of three quarks called: up, down and strange and at the same time was able to predict the existence of new particles. When such a predicted new particle containing three strange quarks actually turned up in experiments later in 1964, Murray's theory was vindicated. Moreover the theory of quarks has been built up to produce an enormously successful model of particle physics called the Standard Model, which predicted the existence of a further three quarks

The next set of three quarks to be later discovered were originally called: charm, beauty and truth. Sadly the latter two have since been renamed, bottom and top – leading to various papers which have titles that for instance refer to: "the discovery of the bottom". There are some who plea for their names to be returned to their original, beauty and truth.

Nevertheless the Standard Model has been remarkably good at predicting certain aspects of physics. But as time goes by there is a realisation that this model does suffer from some drawbacks. Of the masses of fundamental particles, in one of the latest books on "Particle Physics", by Abraham Seiden,[14] it is said that

"There is no fundamental understanding of the mass pattern."

and

"The large variation in masses is an unsolved puzzle."

But not only are the masses of the fundamental particles like the electron and quarks not understood, the calculations which result in the masses of the known particles resultant from the current quark model are not quite perfect.

"The agreement is, however, not perfect and typical of a phenomenologically motivated model; we do not know how to improve the agreement systematically."

The time has come to investigate new models of nature, one that can offer us a window into why the fundamental particle masses are what they are and can explain why the fundamental constants of nature such as the fine structure constant and charge of the electron are what they are. A predictive theory is required which can completely unify the whole of physics.