# THE FOURTH SOURCE

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## Effects of Natural Nuclear Reactors

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Back cover: Image of M51, the Whirlpool nebula, and its companion, by the Canada-France-Hawaii Telescope (© 2002); photo of author (by the author), December 2007.

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# PROLOGUE

Science progresses by making mistakes. Sometimes abruptly, these mistakes are corrected, and science proceeds on. Understanding the history of science is essential if we are to understand what we understand. The corrected errors may start with a flat Earth, as the center of the Universe, with the stars being distant campfires in the sky. That fit the earliest observations of our ancient predecessors and was consistent with the earliest theories. Observation and theory continued to evolve, each correcting the other. Now, do we know everything, except the smallest details, the insignificant fringes, or is it only what is beyond the fringes that we don't know? Like every generation prior, are we muddling along, burdened unknowingly by an abundance of unseen errors? What are those errors, what will the next big corrections be? This book makes an attempt to answer some of those questions. I hope the answers will be as exciting for you as they have been for me, and raise as many more new questions.

Some of this must remain as an exploration. There are problems I have not been able to resolve but that I think are important enough for further consideration.

**for**
**Zoey and Ian,**

**because of**
**June**

*The real voyage of discovery consists*
*not in seeking new landscapes*
*but in having new eyes.*

Marcel Proust

*This is the greatest adventure of mankind:*
*To find something that was never known before,*
*or understood.*

Irving Stone

*And the end of all our exploring*
*Will be to arrive where we started*
*And know the place for the first time.*

T. S. Eliot

# Table of Contents

# List of Figures

# Preface

In ancient times, when people looked at the skies and wondered about their world, the high priests told them stories to explain what they saw. We call those stories myths and legends. In modern times, when people look at the skies and wonder about their world, scientists tell them stories to explain what they see. We call those stories theories and models.

As myths and legends are questioned, and as both the questioners and the answerers gain knowledge, the stories become more clearly based on facts, and approach more closely to the reality that they try to explain. But sometimes, because an effect is overlooked or misinterpreted, the stories go off-course and the people are led astray. That seems to be so for our current stories of the Universe, from the Earth and its fellow planets, to our Solar System neighborhood, to the most distant reaches we can imagine.

Our Universe has been described in myths and legends invoking many mysterious forces, but we now explain it by theories and models using just three major sources of energy: gravity, nuclear fusion, and electromagnetism. Because of our limitation to these three energy sources, our explanations are often incomplete and confused, sometimes overwhelmingly complex, and we must invent phenomena never seen.

Our theories have become increasingly creative and ingenious, calling on unobservable objects and processes, such as black holes, neutron stars, and inflationary cosmology, to explain our Universe. We struggle with inconsistencies and confusion in the stories of our world. While our concepts of reality are shaped by our perceptions, our perceptions are directed by our concepts. In some cases, the currently accepted models have become so firmly entrenched as to constitute "paralytic paradigms". These concepts are so strongly held and so severely control our thoughts, that contrary or alternate theories cannot be considered, and contradictory observations are not recognized.

Three sources of energy have long been known: gravity, that controls the motions of all bodies, heavenly, Earthly, and human; nuclear fusion, that provides the power to light the stars; and electromagnetism, that carries energy throughout the Universe and holds the atoms together. Our current explanations of the Universe are based on these three sources.

Things could be simpler... Something was missed along the way that can clarify much of the current confusion. That something is nuclear fission. We have been trying to explain effects that are caused by nuclear fission without including the process of nuclear fission in the explanations. Including nuclear fission as the fourth source of energy brings unity and clarity to our stories of the world, from the planets of the Solar System to the galaxies of the Universe. This book provides some new solutions to old, solved problems.

The omission of nuclear fission from our understanding of the Universe is an interesting philosophical question. You probably know very little about nuclear fission, other than that it is a very energetic process, used in weapons and power plants, and you probably know little about nuclear weapons and nuclear power plants. We have a concept that nuclear reactors must be very complicated, because those that we make are complicated, but Nature ran reactors in the bottom of a river delta for 600,000 years, 2 billion years before we discovered nuclear fission. So, how hard can it be, with the right stuff, and enough time?

Excluded from academia by anti-war sentiment, hidden from curiosity by extreme governmental secrecy, nuclear fission has languished in an intellectual limbo. It is well known, well understood, by its practitioners, but it is a will-o-the-wisp to outsiders.

My research, leading to a new understanding of the Universe by including the effects of nuclear fission, began in 1989 as a simple personal search for a better understanding of the impact of natural radioactivity on our world and our lives. It became a self-guiding tour, with a life of its own, in 1993, as I began to discover possible effects due to nuclear fission, and how poorly many of these observations were explained by present theories. Each discovery led naturally to more. At times, I was startled by the weakness of arguments that decided fundamental questions of reality, and how those decisions have not been re-examined as our knowledge and our observational techniques have improved. On the other hand, it is impressive that the fundamental observations were made so well, reported so honestly, and kept so accessible, that a stranger to the specialists' worlds can still glimpse reality clearly. The results of this research have been quite contrary to many of our current models, but provide the key to understanding our knowledge more completely.

The reader of this book will be faced with a pair of basic questions:

1. If what I propose is true,
   is it likely to be important?

and

2. If what I propose is important,
   is it likely to be true?

Each reader's answer to these questions will prove whatever worth this book may have.

As I came to an understanding of the presence and probable source of excess energy in the early eons of Earth, my search for its source took me into space, into our Solar System and far beyond. And then, surprisingly, I was brought back to Earth, with a clearer understanding of the puzzle of evolution, and how and when we became us. What was expected to be, and intended to be, a short article in a technical journal grew to be something that was too large, too broad, too interdisciplinary to fit into any journal. Instead it has become a book, for the curious members of *Homo sapiens sapiens* to discover their world.

This is not so much a science book as it is a book about gaining knowledge and understanding. That knowledge and understanding is the right of every citizen of this planet, and should not be restricted to an elite of scientists, by virtue of being written in an arcane language. Here, there are few equations (except in a special Appendix), no integrals, no calculus. There are graphs and plots. These are like maps to help you see where we are, and where we might be headed. This book is filled with observations and ideas, with the hope that you will gain knowledge and understanding. The math and the science are there, but behind the scenes, available if you wish to discover them, but not demanding your attention. The equations are embedded in the physics. If you need the equations, you probably already know them. If you don't already know them, you probably don't need them. You can find them in the references, if you want. In the references, I have tried to provide readily available publications that are acceptable to the specialist and others that are more accessible to the novice. We are all novices in most fields. While the artists of the Renaissance ground their own pigments and formulated their own paints, fabricated their own brushes and canvasses, you do not need to do that to appreciate a Rembrandt or a Reubens or a Titian. The Universe is a beautiful masterpiece and I want you to enjoy this book about it.

Since this is not a science book, I have tried wherever possible to write in ordinary English, translating and interpreting as much of the official technical language and jargon as I can. The experts will not approve, and will use this as evidence that I don't even know what I'm writing about. I'm sorry. I think it is more important for more people to understand what they are reading about, than to present the information in an officially satisfactory but obfuscated way. By avoiding technical terminology, interpreting and explaining in ordinary language, I hope to gain in accuracy of understanding what may be lost in precision and correctness. Perhaps this book can be read without a dictionary in your lap.

This book is an exploration, rather than a declaration, and in some cases the reader must be left to choose the best answers.

To offer a solution from a foreign field often appears to be an appeal to magic, or more bluntly, to be crackpot science. If the foundation for an explanation is not known, recognized, or understood, that explanation may appear to be nonsense. Nuclear fission and radiation physics are foreign fields to most researchers, just as their fields are foreign to me. In those foreign fields I can only offer the insight of an outsider, glimpses of ideas that are based on knowledge that is unknown to the resident experts. Every expert in every field that this book addresses knows more about his field than I do. My only advantage is that I haven't known so much that is wrong.

Until you have read this book, you may not be familiar with many of these problems, which leads to my quip that "those who understand the solution don't know the problems, and those who know the problems don't understand the solution." The purpose of this book is to get those two populations, each understanding part of the situation, together.

To a large extent, this book is a story of catastrophe. In the all-too-often either/or world of science, Catastrophism lost out to Uniformitarianism. Most of the Earth has certainly been formed and shaped by the slow, steady progress of processes that can be seen in action somewhere on the Earth at the present time. Still, some catastrophes can be recognized and accepted, rare as they have been. In our current view, large volcanic eruptions are local catastrophes. Recent eruptions are insignificant compared to major eruptions in the distant past, which were truly global catastrophes. The mass extinctions, in which nearly all life on Earth was terminated, or at least altered irreversibly, must be viewed as catastrophes, whatever the cause. Impacts by asteroids or comets are now accepted as one possible catastrophic cause.

Natural physical processes are proposed here to explain, by catastrophe, what has not been explainable by uniformity.

The basic framework for studying the structure and form of the Earth was established on the assumption that the Earth is cooling and contracting (shrinking). The contraction led to the formation of the mountains of the continents as "wrinkles". In spite of evidence to the contrary, for example, the expansion of the ocean floor at mid-ocean ridges, contraction has continued to be an underlying concept. Mountain-building has been transferred to the contraction caused by collision and subduction of crustal plates. The apparent success of this Plate Tectonic Theory has blocked consideration of alternatives.

Some of the ideas in this book are soft and speculative. I must overwork the word "suggest" to convey the sense of possibilities worth exploring, rather than dogmatic facts to be accepted. I take that as my privilege as a visitor, an intruder, an explorer in fields where I lack the specialists' knowledge and authority. Lacking the authority to establish ideas as facts, I shirk the responsibility to present these ideas in a fully rigorous manner. I hope that there is enough rigor where it is appropriate that the promise of the soft ideas will be recognized.

One of the symptoms of crackpot science is the solution of problems in widely unrelated fields, often by the use of strange and obscure techniques. At first glance, that criticism might be very easily applied to this book. But it is important to recognize that this book does not try to explain all things as the result of nuclear fission. Many (in fact, most, by far) of our observations are well explained by fully developed theories and need no help, from fission or anything else. And there are other problems that seem to be beyond the help of nuclear fission, such as the initial origin of life. (We will make occasional detours to examine these.) This book attempts to explain those observations that appear to me to be poorly explained at present, and are clearly related to the effects of nuclear fission. Some of the detours will insist on intruding, but I hope they help rather than hinder our understanding. Moreover, everything in the book is only physics. I have simply applied the methods of physics to problems that became unveiled once the possibility of natural nuclear fission reactors became clear. These methods and knowledge are straightforward and well-founded. I have invented little that is in this book. Mainly, I have interpreted and integrated other researchers' ideas by the use of the methods of physics. What I present here is no more complicated, inherently, than gravity. Things fall. Reactors happen naturally, natural reactors sometimes explode.

In the 1950s, Immanuel Velikovsky wrote some outrageously speculative books, based on what he saw as poorly explained events that were described in myths, legends, and religious writings [Ginenthal 1995]. He invented a mechanism to explain these observations, but the mechanism was judged, quite objectively, to be a crackpot idea. (Unfortunately, his books were rejected much more emotionally and his perceptions were thrown away.)

In the first part of the 20th Century, Alfred Wegener collected observations that showed many of the continental coastlines had at one time been adjacent to each other, but had drifted apart [Wegener 1928]. His mechanism for this "Continental Drift" was also quite unreasonable, physically, and his entire concept was repeatedly rejected. Drifting blocks of continents was scientifically unacceptable, until oceanographers discovered spreading ridges in the middle of the oceans, and invented the theory of Plate Tectonics, where continental and oceanic scum is carried across the globe by giant convection cells in the mantle. Just as the mechanisms invented by Velikovsky, Allan and Delair, Carey, and Van Flandern, were physically implausible for their observations, so Wegener's drifting continents was also crackpot science. Unfortunately, his collection of observations was also rejected as not requiring consideration or explanation. When the scientific establishment came across a surprisingly convincing observation, ocean spreading ridges, Plate Tectonics was developed to accommodate the drift of continents.

Over 400 years ago, Galileo saw mountains on the Moon, spots on the Sun, handles on Saturn, and stars around Jupiter, at a time when these were known to be impossible nonsense. Alfred Wegener proposed that continents drifted through the oceanic crust, to explain the undeniable matching of the continental shelflines and geology. The meaning of his observations was denied for 50 years. Edwin Hubble showed that the spiral nebulae were outside of the Milky Way Galaxy, and therefore were vast Island Universes of stars, just like the Milky Way Galaxy, because Galileo had said the Milky Way was made of innumerable stars. Immanuel Velikovsky said that Venus was extremely hot and that Jupiter had a magnetic field, because Venus had been ejected from Jupiter just thousands of years ago.

Pioneers and crackpots, missionaries and explorers. How can we separate the wheat from the chaff if we can't tell them apart?

Time proved Galileo to be mostly correct. We have had to reinterpret some of his words, but that was done so gently it is hardly noticed. His use of the telescope for direct observation of the heavens is the foundation of modern astronomy. Wegener had to propose a physically unrealistic process for Continental Drift, that the continental plates moved through the surface of the oceanic crust. His fundamental observations finally won acceptance, and it was decided that oceanic plates dived beneath the continental crust. Velikovsky built his ideas on religious writings and invented mechanisms that were thoroughly impossible to explain the observations. He may have seen some truths, but the fallacies of his explanations drew such vehement attacks, it was not acceptable to explore what he had found. Just as the mechanisms that were invented to explain the observations of Wegener and Velikovsky and others, such as Carey, Allan and Delair, and Van Flandern, were physically implausible, their work became crackpot science. Scientists tend to reject an observation if a reasonable explanation for its cause cannot be provided. "If we can't imagine how it happens, it must not happen." That is bad science, but it happens over and over. That puts great pressure on an observer to provide an explanation of the process. Often, the observations have great merit, but the forced explanation is so artificial that the entire story fails to convince. In this book I present a mechanism, the formation and action of natural nuclear fission reactors, that has been omitted from consideration in our exploration of the Universe, and I show that this mechanism can explain many existing observations better than our present stories. I hope that I have also shown that this mechanism is physically reasonable and plausible.

Part of this voyage of discovery was a stumbling attempt to find out what had gone wrong in astronomy and cosmology, for we have certainly gone astray. Some of these paths have been clearer than others: remarkably, as I was struggling to prepare a decent sketch of the Milky Way Galaxy and the Solar System, for I am a poor artist, I found that one had already been done, by Cornelius Easton, in 1900. Other signposts and way-markers required more careful reading.

Many of our most important astronomical explanations invoke monsters that have never been seen, and worse yet, can never be seen. In some of these cases, I can only act as a tour guide, pointing out where nuclear fission has had effect, and saying "Isn't that interesting, probably the result of ..." and leave the detailed exploration of the sidetrack as an exercise for the reader. Hopefully, someone who has greater resources to investigate these possibilities will become interested in exploring these suggestions. More detailed developments of the application of the fission process in explanations of observations are welcomed, sought, encouraged, and requested.

The result of this research has been to produce a revised view of the Universe, and our place in it, that rather resembles a fisherman's net in terms of intellectual structure. It is a mixture of evidence for the effects of natural nuclear fission reactors and suggestions as to how these natural reactors explain various observations. Facts are connected and cross-connected in a somewhat untidy manner at present, and that makes an orderly presentation difficult. The distinction between evidence and a suggestive explanation may at times be somewhat fuzzy. Turns must be taken and backtracks made in order to cover the territory fully. This voyage has been a search for patterns in the observations, searching for and trying to understand what causes underlie similarities and differences. The reader's patience in dealing with such an exploration is sincerely requested. But science itself is a net, with weak meshes and strong meshes holding the structure together. Sometimes these meshes get distorted, unknowingly disconnected from reality, but representing a reasonable consistency of their own.

It should be clear from the start that this book is barely a beginning and that much more work still needs to be done. But it opens doors to a view of a new Universe, which you are welcome to visit and study; after all, you live here, too. Many details have been left as exercises for the reader. I hope that you will welcome the challenge.

In science, we have to name something before we can understand it, but naming by itself does not guarantee understanding. "Quasars" and "gamma-ray bursters" are clear examples. These names describe the observations, but do not explain what the underlying objects are. This book will describe several objects from a new viewpoint, from an understanding of nuclear fission. I will try to give them names that provide a new understanding.

The basic concept used in this research is that if the results of a process provide an explanation for observations, then the observations provide evidence for the existence of the process.

Science appears to progress by a combination of the two opposing theories of science. Francis Bacon proposed that science observes and formulates a theory to explain the observations, while Karl Popper considers that science formulates a theory and observes to test the predictions. For example, we are assured of the existence of gravity, even though no specimen of gravity has ever been isolated, inspected, weighed, measured, or its color determined. It is observed that things fall to the ground, and gravity explains this, and how things fall to the ground, and more. The process of gravity is not perfectly understood, and current theories do not perfectly explain all the observations. Yet the principle of the process of gravity is deeply ingrained in our theories of the Universe. Its explanations are essential to our understanding of a multitude of observations. So too, for electromagnetism and nuclear fusion. This book presents evidence that nuclear fission must also be included with these other three sources in order to prepare a correct model of our Universe.

There are several ways in which science uses knowledge to understand our world. We may know how something can happen, such as why icebergs float in the ocean: ice is less dense than water, and gravity forces the lighter to float on the heavier. We may know how something cannot happen, so that airline pilots never need keep watch for icebergs at 37,000 feet, even over the North Atlantic in the winter. Sometimes, however, we simply don't know how something could happen, and presumptuously claim that therefore it can't happen. If we don't know how something cannot happen, we may at least be more open to the possibility that it could happen.

Development of this book progressed by two considerations:

1. If nuclear-fission chain-reactions could cause a certain effect, have the consequences of that effect been observed, and particularly, are they poorly explained at present?
2. If an observation is poorly explained at present, could it have been caused by the effects of nuclear-fission chain-reactions?

Some of what is presented here is clearly speculation. That speculation is intended to show directions in which good research should be able to make good observations, and either confirm or refute the proposed possibilities. Our existing paradigms, an expanding Universe, Plate Tectonics, stellar galaxies, gradual evolution, are so deeply embedded in our science that it may only be from some sweet accidents that the ideas in this book are recognized, proven, and accepted.

This book reexamines several concepts in modern science that most of us, certainly this author, thought had been clearly settled long ago, if I was aware of them at all. I found that the settlement was often not that clear, and was determined more by the personal strength of ego of the participants than by factual reasoning. There are many things in our science that are well founded, well considered, and well settled. Those successes have led on to the remarkable success that science has shown in explaining most of our world. However, to insist that long-settled concepts should not be reexamined, as some critics will, is to pretend that science is thoroughly correct, at this moment at least. History proves this wrong.

A mistake often made in scientific controversies, is to structure them as though they were debates in logic, with pre-established choices for conclusions, argued much as a flamboyant trial lawyer might, with victory won by the loudest voices. Specious arguments, apparently plausible but truly misleading, are built by changing words without changing meaning.

For many of those involved in a scientific controversy, being right is important to their careers, assuring grants, tenure, and publication. For us, understanding our world is more important. Unfortunately, the either/or structure that most controversies must create, for the sake of identifying a "winner", means that most of us, and science, lose. When any scientist wins or loses, science is the poorer, possibilities have been eliminated.

An unfortunate aspect of many scientific controversies is that one side will specifically define the other side's position, and then proceed, quite successfully, to demolish that self-defined position. This battle with a strawman is always gloriously won by the constructor of the strawman, who then claims that he has defeated the other idea's champion. No prejudice is intended here. The tactic works both ways, for new and old, and is distressingly prevalent.

There are many arguments in science, between scientists, few dialogues, and almost no joint explorations of differing ideas. Unfortunately, for us and for science, many scientific arguments are produced by strong opinions based on the firm support of personal attitudes.

In the arguments (hardly a debate) between the Creationists and the Evolutionists, much effort has been spent on proving that the other side is wrong. Little effort is spent in attempting to extract an understanding of reality from what is known. Both sides distort the interpretations and explanations of the other, to discredit the foundation of the enemies' understanding. This detracts from the integrity of the two groups and distracts from our efforts to understand our world.

This work offers reconciliation between religion and science. Miraculous, catastrophic events have occurred, as told by many religions, that were caused by understandable processes, as studied by science. Re-united, these two ways of thought may help us to more completely understand our world, spiritual as well as physical. Perhaps religion was created by people at a time of crisis, to serve as a means for preserving their knowledge through a foreseeable disastrous time. Now, we see science as the finder of knowledge, becoming religious. Science has its defenders of the faith, who seem to feel that (nearly) all that can be known is already known, and that only they will find any new knowledge themselves. In other times, in other cultures, these intellectual protectors would have sought out the heretics and burned them at the stake.

This is seen most often in conflicts between true believers and debunkers, both of whom seem to take their status as proof of their correctness. Attempting to find common agreement among the true believers and the debunkers is like trying to be comfortable with your feet in the fire and your seat in the snow. In fact, the positions and arguments of both sides become so extreme it is difficult to determine which side are the debunkers and which are the true believers.

A shortcoming, sometimes a fatal flaw, of science is the need to make assumptions in the absence of knowledge. Often we simply do not know what we do not know. Usually the assumption is simply a continuation of what we think we know, either by observation or by theory, or by imagination. The folly is then that these assumptions become firmly embedded in our theory, our theory shapes our interpretations, our interpretations determine our observations, and what we assume becomes what we know. When an assumption, no matter how apparently secure, is used as a foundation for knowledge, the uncertainty and the potential for error must be recognized as an integral part of the assumption and everything derived from it.

Science often must accept what has been decided in the past, to form a foundation for progress into further discoveries and understanding. We do not need to prove 2 + 2 = 4 over and over, when we balance our checkbooks. But because the foundation determines the shape of the growing structure, a false foundation leads us astray. Our foundations are always incomplete because they must constantly be rebuilt of new material. This book presents some new material for a sounder foundation.

This book describes a world that is quite different in some respects from the world described over the last few centuries. It uses knowledge from the most recent 80 years, knowledge of the nuclear age that was unimaginable to the founders of our sciences. Like many voyages, this exploration will have a few side trips. These are excursions to consider topics that do not seem to relate directly to natural nuclear fission reactors, but seem to be essential parts of the story. There are two major side trips which we must take, to explore some complicated effects. Even though these effects do not seem to relate to nuclear fission, their consequences are so important they demand investigation. These are the expanding Universe (it isn't), and the expanding Earth (it is). The standard view of these problems became locked into our science before enough was known for us to be aware of the possible alternatives.

This book addresses the possibility that there are significant fundamental errors in our understanding of the Universe. These errors developed because of perceptions that were expressed long before our more complete knowledge of the details of the physical world. Theories of the Universe were cast in place before nuclear fission was known, before antimatter had been recognized, and were shaped by the attitudes of our ancestors.

Specifically, it will be shown that our concept of the distance scale of the Universe is wrong because of a misunderstanding of the fundamental technique for measuring distances, Plate Tectonics is wrong because a fundamental fact in the formation of the Solar System was overlooked, and our understanding that the Sun is a star led to the misleading belief that all stars are suns.

Specific cases provide evidence for these errors, when scientific judgment led our ideas astray. An incorrect estimate of a perturbing mass in the Solar System, based on the wrong mass for Pluto, led to the rejection of the perturbation analysis. Assumptions that some observations of Supernova 1987A in the Large Magellanic Cloud were meaningless and could be ignored prevented a fuller understanding of that event. Careless and prejudicial review of the measurements by van Maanen, showing physically real rotational motions in nearby spiral galaxies, justified rejection of those measurements. Cleaning out the errors will lead to a fuller understanding of the place where we live.

In this new view of the Universe, there are no miracles, and no matters of faith must be invoked. This new Universe consists of the straightforward effects of well known processes, and no strange monsters are needed to explain our observations.

In a cultural world of experts and specialists, I claim to be one only in the fields of nuclear fission, radioactivity, and radiation. This has come from my education, at Caltech, and my work experience, at Atomics International and Rocketdyne, for a while a combined division of Rockwell International Corporation, and later of The Boeing Company. I am a stranger to the other fields into which this research has intruded, and therefore a layman, as you readers are also in many of these fields. This work has benefited immeasurably from the cooperation and help that I received from many experts, even though my research led me away from accepted models. For this, I am deeply grateful.

Perhaps, in these days, the only danger I may face, unlike Galileo and Giordano Bruno, is the annoyed rejection by colleagues who are unable to face a new Universe. It is not proper in science to tell everybody else that they're wrong. Most of this book does that. I worry only that this book will be seen as attacking problems that are not recognized with explanations that are not understood. At the risk of seeming melodramatic, I am comfortable with the words of the philosopher Immanuel Kant, in his *"Universal Natural History and Theory of the Heavens,"* (1755): "I have ventured, on the basis of a slight conjecture, to undertake a dangerous expedition; and already I discern the promontories of new lands. Those who will have the boldness to continue the investigation will occupy them, and may have the satisfaction of designating them by their own names." [Crowe 1994]

I also wish to express my appreciation specifically to G. Subbaraman, F. C. Dahl, R. T. Hammock (and Lydia, Zoey, and Ian), and T. E. Dix for assistance in completing this work, and to several technical libraries, especially those of the California State University, Northridge, and of Rocketdyne, for providing essential stores of knowledge, the raw material for this study. The SAO/NASA Astrophysical Data System Abstract Service was especially valuable in retrieving scientific publications through a long range of time. I must express my appreciation to the past and present editors (F. W. Walker, J. R. Parrington, and F. Feiner, and now E. M. Baum, H. D. Knox. and T. R. Miller) of the General Electric *"Chart of the Nuclides,"* for providing an invaluable road map to the nuclear world, and to Katharina Lodders and Bruce Fegley Jr. for doing the same with the Solar System. I wish to thank researchers around the world for their generous cooperation. I particularly appreciate the efforts of Gene Watson to keep my mind open to other people's new ideas. Valuable comments were provided along the way by Ray McGinnis, Don Erway, and Duane Doty.

Original graphs were prepared using PSI-Plot from Poly Soft International, and ProbPlot from Rad Pro Calculator. The book was prepared in Microsoft WORD and most of the analytical interpretations were done with Microsoft EXCEL. The Internet and email service were essential aids.

This research has made use of the NASA/IPAC Extragalactic Database (NED) which is operated by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

Reviews of the partially completed manuscript by Harry Pearlman, Earl Curtis, Carolyn Mallory, Gail Kennedy, and Arden Wray are greatly appreciated. This work benefited from the intellectual climate established by the people of Atomics International and Rocketdyne. Some of the ideas that I had thought were my own, and new, I found to have been preceded by the thoughts and work of Paul Kuroda, Robert Driscoll, and Marv Herndon.

This book has some grim parts, and some hard parts, but mostly, it should be fun. Do we live at a special moment in time, a special place in space? The Copernican Principle says not, but for us personally and collectively, it must be special. Personally, this is the only time we have here. Collectively, humans did not exist more than a few million years ago, and Earth, now, is the only place we know of where we can live. What we see around us must be special, and rare, and will be different from what was before and will be hence. This is a special time and place, and we must learn from it, while we can. We are all more or less aware of our surroundings, our environment, our world. Awareness leads to observations, observations produce data. Data can yield information, and information gives us knowledge. With knowledge we can achieve understanding, and understanding is the foundation of wisdom. Our world seems to need some more wisdom, and we seem to be the only creatures capable of providing it.

The Universe is far different from what we have thought, and far more fatally dangerous than we have imagined. As our knowledge and understanding grow, we are forced to become the caretakers of Life.

I hope that what may at first be seen to be foolish misinterpretations of our established observations will be accepted as more nearly correct reinterpretations that will lead us to a clearer understanding of our world.

Because this has been a very personal, almost solitary, exploration for me, I will write the book in the first person singular, almost as an expedition logbook. When we have finished this book's voyage, we will still not know all that is right, but we will know less that is wrong. Sometimes, our knowledge grows to force us to leave behind our old world, and enter a new world. You are now entering the future, a new world newly known. Please embark on a voyage of discovery, with new eyes open to a new view of our Universe. I hope that you will enjoy the voyage.

*Moorpark, California*
*January 22, 2012*

# I. FOUNDATIONS

*You have to learn a lot*
*to know a little.*
Charles de Secondat

*There is no such thing*
*as useless knowledge.*
Virginia Trimble, 1996

## Introduction

It is expected that nearly everyone who chooses to read this book will be a layman in some or many of the fields that we need to explore. Because of this, I have tried to write for the non-specialist throughout. I hope that specialists will forgive my treatment of their fields in this manner, for the benefit of improved understanding of what I have written in fields in which they have no special knowledge. I have probably failed most in this attempt in my own fields, falling prey to the specialist's assumption that what is common knowledge is commonly known.

There are some major obstacles to understanding that must be overcome before we begin our voyage. These obstacles are in the form of technical terminology and tools of the trade, that intrude and obscure the meaning of what has been discovered and understood. Much of this work deals with things that are nuclear, and that word is only slightly removed from unclear. It is hoped that this introduction to terms and tools will help to make this voyage of discovery easier. While the emphasis will be on the usage exercised in this book, some alternative forms will also be discussed, since independent review of the research literature by the reader will provide powerful confirmation of this discovery. There are times when we will struggle for a word, searching for the right word when there may be none.

A helpful book for this purpose is *"Planet Earth,"* by Cesare Emiliani [Emiliani 1992]. It is about as long as this present book, and is a science book, and so forms a fine foundation for understanding what is to come. Perhaps most importantly for the spirit of this voyage (which is grim at times), Emiliani plays with our vast store of knowledge. Knowing about our world should be fun. He describes science as resting on three legs: facts, figures, and theories. To that trio must be added thought, for it is thought that links the other three and helps us to tell one from the other. (Truly, that is a recurring theme in Emiliani's book.)

The reference list includes both technical literature and writings intended for the general public, often with some duplication. This was done to promote accessibility to all, and particularly across the compartmental walls of specialized science. Excellent articles and books exist for the generalist, and the authors of those pieces have worked hard to make the matters understandable to those readers without the specialist's knowledge of the field. (An unfortunate accident of this present work being done by someone somewhat outside the research establishment is that many of the references are to secondary sources, and so only indirectly credit the individuals responsible for the research. For those unintended slights, I apologize in advance.)

Sometimes, even often, this independent review will require the reader to develop an independent conclusion, different from that provided by the researcher, an alternative interpretation of the meaning of the observations. This same approach should be applied to this book, as well.

## Consistency, Errors, Corrections, and Contradiction

Science is a continuing effort to achieve consistency of our models and theories with the reality of the Universe, and often with very small and limited parts of it. We attempt to achieve this by identifying errors, correcting them, and avoiding contradiction.

An important measure of our success is self-consistency: are the models and theories consistent with each other? It is difficult to imagine contradictory theories that are both consistent with a single reality. (General Relativity and Quantum Mechanics may be excellent examples of this problem; they cannot agree.) Astronomy has a rich history of developing theories that have been self-consistent, and even consistent with observations, as a result of careful theoretical work. But these were not valid representations of reality. However, each new theory brought us closer, in some ways, to the truth.

In some cases, it will be found that the observations are generously consistent with more than one model, and the value of consistency in recognizing reality vanishes. Consistency is an important test, but can be a dangerous trap that predetermines the outcome of analytical thought. The exercise of consistency and its ready appearance can hide errors.

Observations that don't match our expectations often carry the grim label "discrepancy." Initially, such a disagreeable measurement provides the observer with considerable personal trauma: observations are supposed to be better than before, not different! Indeed, a discrepancy may be the result of poor technique, instrument malfunction, or any of many other artifacts that may be identified and corrected, often to the observer's embarrassment and dismay.

However, many unresolved discrepancies survive, some to become part of our history, others to be dismissed, hidden, and forgotten. These small problems slip from our consciousness, surviving only in the ever-older, out-of-date literature, ignored.

Centuries ago, discrepancies in the observed positions of the five known Solar System planets (other than Earth) led to the invention of orbital epicycles. In time, more, and more complicated, epicycles were required for the elimination of the observational discrepancies, until finally it became clear that a drastically different model of the Solar System could be applied. The Sun is at the center! Unresolved discrepancies are Nature's way of saying, "You just don't understand me." Now, in our current astronomy, the Sun has lost its place at the center of the Universe, but discrepancies persist. Where is the missing mass? What is the Dark Matter? Where is the heat?

Discrepancies in the orbital positions of Uranus led to the discovery of Neptune [Burgess 1991, Moore 1995], and then Pluto [Asimov 1991, Reeves 1997, Stern and Mitton 1998]. Small, uncertain discrepancies in the orbital positions of Uranus and Neptune suggest other discoveries [Littman 1988, Watters 1995], but, as the discrepancies appear to fade with time, our interest fades, and the opportunity may be lost [Standish Jr. 1993, Quinlan 1993]. Perhaps we just don't understand. Least Squares, Myles Standish's method of analysis, smears the residuals over the orbit, and makes the perturbations average out. Least Squares gives the best result for the chosen model, but does not prove that the chosen model is correct.

Discrepancies in the precession of Mercury's orbit led to a confirmation of Einstein's General Theory of Relativity. Few similar opportunities have been found, but the observations of two pairs of binary stars, DI Herculis and AS Camelopardalis, contradict this proof [Naeye 1995]. Is our theory wrong? Perhaps not, even the conventional prediction fails for DI Herculis. We may be applying the theory improperly.

In the theory of the expanding Universe, the Hubble Constant has so far been found to be far from constant [Trimble 1996]. Different measurements, as good or as bad as they may be, give different results. The results conflict with other results, and the Universe seems to be younger than its oldest stars. With great effort, this discrepancy seems to have been conquered. Is our theory wrong? Perhaps, but at present, most efforts are directed toward reducing or eliminating the discrepancies. This is a one-sided approach that risks hiding the truth.

The best observed star, our Sun, continues to present discrepancies. Why do we not observe enough neutrinos, where did all the angular momentum go, how did it lose so much of its lithium, why doesn't it have enough beryllium? Is our theory wrong? Perhaps, perhaps not. We might just have our assumptions wrong.

SN 1987A, the best-observed supernova yet, produced a glorious collection of discrepancies [Goldsmith 1990, Marschall 1988, Murdin 1990, Woosley and Weaver 1989, Keishner 1988]. A neutron star/pulsar was expected [Lindley 1988], found and lost [Kristian *et al.* 1989], and rejected [Anderson 1990]. Some of these have been authoritatively dismissed as having no significance or reality, because we don't understand them [Bahcall 1989; Mann 1997; Cumming and Meikle 1993]. That misses the point. A discrepancy cries out for attention, *because* we don't understand it.

A discrepancy that survives easy resolution should be treasured, protected from arbitrary dismissal. These are the clues that lead to a new understanding of our world. Nature is saying: "Pay attention. You just don't understand me."

## Numbers

Since our discussions must range from the submicroscopic to the cosmological, and consider the energy of a single electron and that of stars, we need a way to manage the numbers that represent values that cover an extreme range. For that purpose, so-called scientific notation will be used whenever normal numbers do not easily cover the span. This uses a number followed by a multiplying factor of 10 raised to a numerical power. The power explains how many places to move the decimal point, and the sign, positive (usually omitted) or negative, shows in which direction. In most cases in this book this format will be used where it will be clear that a positive (or unsigned power) will be associated with a very large number, while a negative power will represent a very small number.

As an example, the average distance from the Earth to the Sun can be represented by these values:

1 Astronomical Unit or 149,597,900,000.0 meters or $1.495979 \times 10^{11}$ meters.

Since scientific notation also allows us to present numbers without using more digits than required for the purpose, or reflected by the accuracy with which the value is known or exists, this distance might be represented approximately by

$1.5 \times 10^{11}$ meters.

Towards the other end of the scale, we could consider the wavelength of green light as

0.00000556 meters

or

$5.56 \times 10^{-7}$ meters

However, to make a rule, break a rule, so wavelengths of visible light will usually be seen as nanometers, 556 nanometers for green light, or with the historical unit, the angstrom, 5,560 angstroms in this case.

Units will be used that are natural to the field being explored, with some additional clarification for particularly obscure situations. In most cases, these will be the metric units ("SI" for Systeme Internationale) consisting of the kilogram for mass, meter for length, the familiar second for time, with metric fractional units for short times and metric multiples of the year for long times. Usually, long time-spans will be so long and vague that the refinement of what kind of year is meant, calendar or mean or leap or Solar or sidereal, will be irrelevant and will be ignored.

In some cases, ordinary English (American English, here) has special names for large numbers. These are,

| | | |
|---|---|---|
| 1,000 | thousand | $10^3$ |
| 1,000,000 | million | $10^6$ |
| 1,000,000,000 | billion | $10^9$ |
| 1,000,000,000,000 | trillion | $10^{12}$ |
| 1,000,000,000,000,000 | quadrillion | $10^{15}$ |

For simplicity and familiarity, I'll use these named numbers whenever suitable.

## Mass and Energy

A bewildering variety of units have been developed to describe quantities of mass and energy. Because different units are natural to the particular uses and are so widely used in the technical literature, we will use several different units here.

The reference unit for mass is the kilogram, equal to about 2.2 pounds. The gram is one-thousandth of the kilogram, and is roughly one-thirtieth of an ounce. The atomic mass unit is approximately the mass of a proton or a neutron, and is $1.66 \times 10^{-27}$ kilograms. (A very small mass.)

The reference unit for energy is the joule, representing the energy released at a rate (power) of 1 watt for 1 second, and therefore the joule is 1 watt-second of energy. This is similar in concept to the unit used for billing electrical service, the kilowatt-hour. A kilowatt-hour is the energy released at a rate of 1,000 watts for 1 hour, or 3,600 seconds. Thus, a kilowatt-hour is 3,600,000 watt-seconds (or joules) or $3.6 \times 10^6$ joules.

One of the great accomplishments of Albert Einstein was the establishment of the equivalence of mass and energy. His truly famous equation states:

$$E = mc^2$$

The energy content of matter is equal to the mass times the square of the speed of light. This lets us calculate how much energy would be released if a certain amount of mass were destroyed, actually, converted into energy, since the energy can also be converted into matter.

1 kilogram = $3.5 \times 10^{42}$ joules

1 atomic mass unit = 931 million electronvolts

The energy content of light varies with the frequency or wavelength of the light, so that light with higher frequency (shorter wavelength) has more energy. Light comes individually packaged as photons, and

1 photon of blue light

(wavelength of 450 nanometers, frequency of $6.66 \times 10^{14}$ cycles per second, or hertz) = 2.76 electronvolts

1 photon of red light

(wavelength of 700 nanometers, frequency of $4.28 \times 10^{14}$ cycles per second, or hertz) = 1.77 electronvolts

Notice that the unit of energy for a photon of light (electronvolt) is a million times smaller than that used for an atomic particle (million electronvolts). The unit for frequency, the hertz, is just the same sort as is used for radio broadcasting as the kilohertz or the megahertz. Red light has a longer wavelength (and lower frequency) than blue light, and this extends throughout the range of light, or electromagnetic radiation. Higher energy X-rays and gamma rays have shorter wavelengths (and higher frequencies) than do the colors of visible light, and visible light has shorter wavelengths (and higher frequencies) than does infrared light, microwaves, and radio waves. The long-wavelength end of the spectrum is always termed "redder" even when it is far beyond red, and the short-wavelength end is "bluer", even though it may be far past blue. Otherwise, all electromagnetic radiation is the same, regardless of its energy or name. Its interactions with matter will be greatly affected by its energy.

In the nuclear world, a unit derived in the early days of research, the electronvolt, is the supreme unit. It is equal to $1.6 \times 10^{-19}$ joules. We will tend to use the metric multiples of the kilo-electron-volt (1,000 electronvolts, keV) and the mega-electron-volt (1,000,000 electronvolts, MeV).

Energy can be related to temperature in many cases, usually in the absolute or kelvin scale, as the cold of space (3 kelvin, or simply 3 K) and the heat of the Sun (5,600 kelvin). Standard body temperature is 310 kelvin, water normally freezes at 273 kelvin and boils at 373 kelvin.

Cerenkov radiation is a special form of light produced by high-energy electrons, traveling faster than the speed of light in a transparent medium. This radiation is completely independent of temperature. Plasma Cerenkov radiation is a low energy (radio-wave) radiation produced by electrons in a plasma [Cohen 1961], such as the cloud of protons and electrons that would exist around a nuclear fission detonation. The spectrum is roughly opposite that of the optical Cerenkov effect,