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THE INFINITE OCEAN

Relativity's Space and Time without Math

by Chongo in collaboration with José

SPIRAL BOUND FIELD GUIDE VERSION

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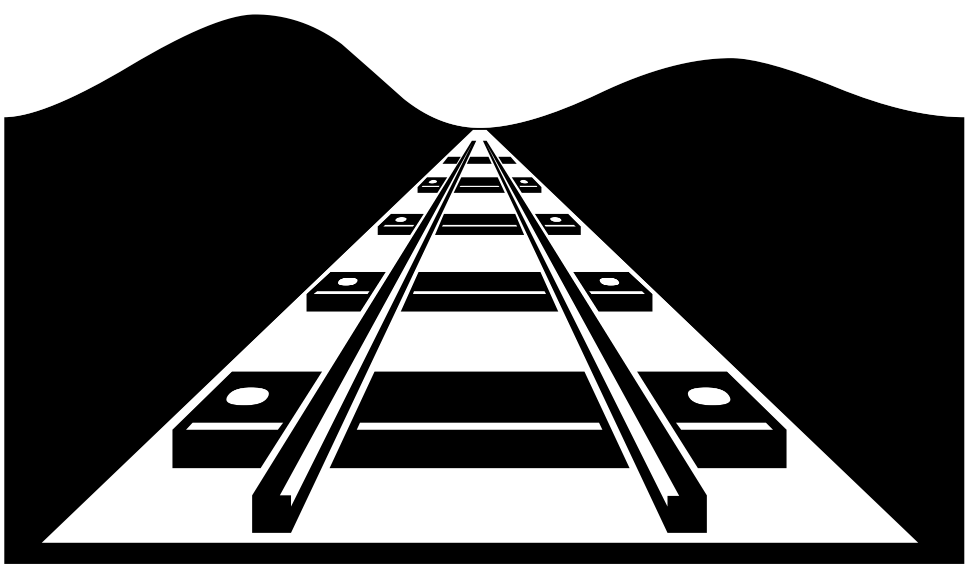
FIELD GUIDE VERSION



Relativity's Space and Time Without Math

THEORETICAL PHYSICS MADE EASY

This book is designed to educate. That is, to educate anyone, in the foundations of what is commonly perceived as an extremely difficult subject, namely, theoretical physics. This is done by excluding all math. Picture illustrations and words are used instead. Pictures and words are all that are needed for explaining theoretical physics, like relativity, for example.

The Theory of Relativity is a description of the 'shape' of the universe, and of the unstoppable motions of its time. Contrary to popular belief, the foundations of theoretical physics are not complex but simple, especially those of relativity. This is why everyone who can, should learn it; at its heart, theoretical physics is easy to understand and can be grasped within months, leaving the individual who chooses to learn it intellectually far stronger. It is mistakenly perceived difficult to learn surely because its understanding is not yet widespread. But once, neither was reading skill. The world was mostly illiterate. Ignorance ruled all. Now, nearly everyone reads, and a far better world than one without widespread literacy, is the result. Just as life is enriched by so many being literate, so can it be even more, by everyone understanding accurately how nature *really* works, starting with the *foundations* that describe it best, starting with the most fundamental, the Theory of Relativity.

An accurate understanding of nature changes forever one's view of the world. It provides hope for its future. For most, life itself is now richer than it has ever been in history, thanks, in enormous part, to science, genuine science, providing the marvels that so enrich our lives, like long life-spans, travel, communication, and medicine, just to mention a few. The world would be much, much less, in the absence of scientific understanding, no less than it would, again, most certainly be, in the absence of simple literacy being commonplace. On the whole, most people benefit from our more modern world, filled with far greater opportunities for humankind than a less modern world, a world without genuine scientific understanding (without its foundations, like without relativity), could ever offer instead. The more, overall, who learn science, the richer the world becomes.

You can help yourself individually, and help everyone else collectively in the process, by learning about the simple idea that the Theory of Relativity is. Learning is far, far easier than one might have ever imagined. And, because relativity is so conceptually simple, once learned, this learning lasts for the duration of one's entire lifetime, again, very, very easily.

☞☞ **WARNING: READ ALL OF THE FOLLOWING CAREFULLY BEFORE PROCEEDING!** ☜☜

THE READER SHOULD BE ADVISED AND FOREWARNED THAT THE MATERIAL CONTAINED WITHIN IS CAPABLE OF OFFENDING RELIGIOUS, SPIRITUAL (BOTH GOOD SPIRITS AND BAD), METAPHYSICAL, PHILOSOPHICAL, AND/OR OTHER FAITH-BASED SENSIBILITIES. THIS IS UNAVOIDABLE BECAUSE THIS IS A BOOK ABOUT PHYSICAL SCIENCE, WHICH UNAMBIGUOUSLY MAKES NO OBSERVATIONS EVER IMPLYING THE PARTICIPATION OF ANY OF THE AFOREMENTIONED IN THE WORKINGS OF NATURE. SO, SHOULD THE READER BE OFFENDED BY THE FACT THAT SCIENCE EXPLAINS NATURE IN A LOGICALLY CONSISTENT AND MEANINGFUL WAY WHILE MAKING NO USE WHATSOEVER OF RELIGION, SPIRITS, AND/OR METAPHYSICAL OR PHILOSOPHICAL PRINCIPLES, THEN SAID READER SHOULD SIMPLY IGNORE OR NEATLY DENY THE SOLID FACTUAL AND LOGICAL BASIS UNDERLYING SCIENCE; AND INSTEAD, RELY UPON OTHER KINDS OF UNTESTABLE AND UNOBSERVABLE "PROOFS" BESIDES THOSE THAT ARE READILY DEMONSTRATED IN A PRECISE, PREDICTABLE, AND REPRODUCIBLE MANNER AS ARE THOSE OF SCIENCE. FURTHERMORE, ANY ADULT READER OFFENDED BY SCIENCE AND ITS CONCLUSIONS SHOULD NOT READ A SINGLE PAGE OF THIS OR ANY OTHER BOOK HAVING TO DO WITH THE VERY TOOL RESPONSIBLE FOR ALL THE WONDERS OF THE MODERN WORLD (LIKE, FOR EXAMPLE, A LIFE EXPECTANCY THREE TIMES WHAT IT WOULD OTHERWISE BE WITHOUT SCIENCE), AND, HOPEFULLY, PURGE FOREVER FROM HIS OR HER MIND ANY THOUGHTS THAT THEY MIGHT HAVE HAD OR EVER MAY HAVE OF LEARNING SCIENCE'S RIGOROUSLY TESTED MODEL THAT DESCRIBES NATURE – *ALL* OF IT, WITHOUT EXCEPTION – FAR MORE ACCURATELY THAN ANY OTHER BODY OF IDEAS EVER CONCEIVED. APPROPRIATELY, THEY SHOULD FIGHT WITH 'HEART AND SOUL' TO ERASE FROM THEIR MIND FOREVER THAT SCIENCE AND IN PARTICULAR ITS FOUNDATIONS, NO LESS THAN THE GREAT BODY OF ACCURATE TRUTHS THAT IT HAS – SO OFTEN AT THE PRICE OF ENORMOUS LIVING SACRIFICE (e.g. THE INQUISITION) – MANAGED TO REVEAL, EVEN EXIST IN THIS WORLD. THIS IS BECAUSE, MOST SADLY, ADULTS OFFENDED BY OR AVOIDANT OF SCIENCE MAY BEST SERVE ALL BY EMBRACING A PATH LEADING INSTEAD, TO THE DISEMPOWERMENT THAT *NOT* LEARNING IT USUALLY AFFORDS; MOREOVER, IN THAT WAY THEY CAN MOST ACCURATELY REPRESENT THE GENUINE CHARACTER OF THOSE WHO SHARE THEIR PERSPECTIVE, AS WELL AS ACCURATELY DEMONSTRATE TO ALL THIS VIEW'S VERY REAL CONSEQUENCES.

(THIS WARNING IS POSTED SO THAT THE READER CLEARLY RECOGNIZE THAT, UNLIKE FAITH, BELIEF, AND NON-SCIENTIFIC PRINCIPLES, WHICH ARE ALL INCAPABLE OF EVER BEING TESTED IN ANY KIND OF CRITICAL WAY, AND THAT CAN BE EASILY ALTERED, REPLACED, OR IGNORED, FROM ONE MOMENT TO THE NEXT WITH ONE'S MOMENTARY WILL OR COMPULSION, A SCIENTIFIC UNDERSTANDING OF NATURE BASED UPON SOUND REASONING AND UNQUESTIONABLE ACCURACY, AN UNDERSTANDING THAT DOES NOT ARBITRARILY CHANGE BUT IS CAPABLE ONLY OF FURTHER REFINEMENT, ONCE ACQUIRED, IS NOT EASILY, IF AT ALL, EVER LOST; VERY OFTEN LASTING IRREVOCABLY FOR THE DURATION OF ONE'S ENTIRE LIFETIME. THIS IS BECAUSE THE GREAT STRENGTH OF BLIND FAITH BECOMES PLAIN ABSURDITY IN THE FACE OF EMPIRICAL, SCIENTIFIC SCRUTINY, *AND CAN PREVAIL ONLY IN ITS ABSENCE;* WHICH IS WHY THE INTOLERANCE OF SCIENCE IS SO COMMONPLACE IN THE ABSOLUTENESS OF UNYIELDING RELIGIOUS, PHILOSOPHICAL, AND/OR METAPHYSICAL DOCTRINE THAT INESCAPABLY *REQUIRES* EITHER ITS CENSORSHIP, ALTERATION, DENIAL, DISREGARD, AND/OR FLAT DISDAIN, OR DECEITFULLY, THE MANIPULATION OF SCIENTIFIC FACT, OBSERVATION, AND/OR CONCLUSION, TO THE END OF IMPLYING THAT FAITH-BASED PRINCIPLES SOMEHOW ACTUALLY AGREE WITH GENUINE MODERN SCIENCE, WHEN, IN ACTUAL, PHYSICAL FACT, NONE FLATLY DO AGREE WITH ANY, EVER; ANYONE SO STATING MUST FLATLY LIE IN ORDER TO SO CLAIM.)

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PLEASE, STOP AND READ FIRST!

Please note that if the reader embraces mysteries* or beliefs that he or she is convinced that they genuinely love, and he or she wishes to continue loving them, on, into the future, especially if they depend upon these ideas as a source of excitement, essential to their happiness, then the reader should not turn another page of this book. Mystery and belief CAN be exciting, especially when we are children (and as long as they are ultimately not mistakenly confused with real, physical truth, or, in particular, here in this text, confused with genuine scientific fact). Learning science, by virtue of science being the very pursuit of the discovery of physical truth, cannot avoid dispelling mystery and belief in the course of replacing them with explanation and understanding, because that is exactly what science does. In the process, the mysteries and beliefs that we may be convinced add so much to our lives, loose their capacity for doing so with the acquisition of accurate scientific knowledge. Thereafter, they may come to entertain and excite us little more, and in this way be 'gone' from our lives irrecoverably, forever, because explanation and understanding, once acquired, are never easily, if at all, really ever wholly forgotten. So if, for whatever reason, you wish to continue retaining your mysteries and beliefs, then close the book immediately after finishing reading this page, and do not open it ever again, until these ideas that might mean so much to you now, someday begin to falter in their power to bring joy, upon being faced with the certainty of the rigors that the immediate and unassailable realities of the actual, physical facts of life, as you age, are sure to eventually present in progressively greater and greater, abundance and frequency, with the continued passage of time. Should this moment arrive, the reader may then wish to revisit this page and choose to finally turn it, in order to begin discovering that the *true* story of how nature really works is *magnitudes and magnitudes* richer, deeper, grander, and far, far more beautiful, than any conjured mystery or mere belief *could ever hope to even begin to approach* (which again, to be perfectly clear, is an absolutely irrefutably true, physical fact, that turning this page and all those that follow, can begin to reveal, *to absolutely anyone*, who is willing to think).

* - Scientific mystery excluded.

Mystery* and belief

are synonyms for

ignorance* and fear.

* - Scientific mystery included. In science, besides being a synonym for ignorance, mystery is a synonym for opportunity (to discover).

THE INFINITE OCEAN

by
Chongo
in collaboration with
José

Second Edition (Field Guide Version)

RELATIVITY'S SPACE AND TIME WITHOUT MATH

DEDICATION

This book is dedicated to the memory of a committed thinker, physicist, mathematician, a very conscientious human being, a scientist, a world-class rock climber, a skilled outdoorsman, as well as my tutor, collaborator, and best friend, José. His understanding of nature led to my ultimate understanding of it which will hopefully, eventually lead to many other people's understanding of it too. We can all thank José.

José

"We are only as free, as our understanding of nature allows us to be. Hence, ignorance can only be bliss, in a world where freedom is not."

FOREWORD

by Victor Pereyra, Professor of Mathematics, Stanford University

In the few years that began the twentieth century, Albert Einstein's Theory of Relativity revolutionized the world of physics by showing that despite centuries of success, Newton's account of natural laws did not model nature's motions accurately. In contrast, Einstein's new model, the Theory of Relativity (General Relativity), did. At about this same time, another new but different model, the Theory of Quantum Mechanics, expressed the individual wave character of all energy by accurately explaining phenomena that up until then had yet to be explained, providing a model that mirrored reality exactly, ultimately, even accounting for complex biological phenomena such as evolution.

Like no others before, these two descriptions of reality changed our understanding of nature, from the very smallest to the largest, and everything in between, forever, enduring now over a *century* of repeated testing, with exquisite and unparalleled, accuracy and precision. Now, after trillions upon trillions of tests, neither has failed on any occasion ever. Together, these two descriptions of the world encompass everything existent in nature, including our very awareness of life and of existence itself. No other body of ideas ever conceived even comes close to matching their flawless history of performance or their predictive power of revelation for specifying factual truth.

The consequences of these two giant leaps in science have had immense repercussions in everyday life. From atomic bombs to nuclear energy, from computers to cell phones, lasers, and microwave ovens, the Theory of Relativity and the Theory of Quantum Mechanics have changed the world in which we live in profound ways. Now, after more than a century of unprecedented success, common and widespread understanding of these brilliant intellectual tools is still limited to the very few, even though the basic ideas underlying either can be understood by anyone capable of reading and of grasping the most simple of abstract notions.

This work attempts to expose people to the fundamental principles that underlie the first of these marvels of the human intellect, the Theory of Relativity, and in so doing, advance overall human understanding of nature by explaining its foundations in great conceptual depth, without resorting to any mathematics. Nature's space and time, and its gravity, are explained, using only words, a few illustrations, and a simplified version of our own reality, by means of an imaginary world inhabited by much less physically complex, two-dimensional versions of us.

Though far simpler than ourselves, just like our famous three-dimensional scientist Albert Einstein did, a great two-dimensional scientist among these fascinating two-dimensional creatures in our story comes to discover the relativity of two-dimensional space and time measures with respect to the motion and gravity that characterizes their much simpler world, just like it does ours. In doing so, this scientist shows us how we much more complex, three-dimensional creatures in our much more complex three-dimensional world can do the same, that is, understand the relativity of space and time measures, exactly as this brilliant two-dimensional hero in our story does. Luckily, we can do so far more easily than any two-dimensional creature ever could, given our additional dimension of height and its matching insight, which this far simpler version of Einstein could never himself have had (though is able to overcome nonetheless, just as we will overcome the similar limitation too). We can follow his rich story of scientific discovery that parallels our own equally rich story, and reach the same understanding ourselves about the character of space and time, just as this two-dimensional scientist ultimately does.

This conceptual yet thorough, non-mathematical explanation of the most fundamental and accurate working description of space, time, including the motion of big things occupying them, and most significantly, gravity, that there has ever been, can serve as a foundation for understanding an even deeper theory, the Theory of Quantum Mechanics, which is the most fundamental and accurate working description of energy (meaning everything lying within space and time) that has ever existed. Grasping relativity is the first step toward comprehending this magnificent body of ideas; a body of ideas that ultimately even leads to explaining life (in quantum theory), and moreover, can flatly *demonstrate* life's distinction in actual, physical experiments (e.g. the two-slot experiment of quantum mechanics), as well. Relativity is the beginning of this road to discovery.

No formal education is needed for this text or for its companion (*The Infinite Pattern*), explaining the other physical theory besides relativity, quantum mechanics. Simply choosing to learn is the only real step that one must take. All subsequent steps come far more easily, regardless of the depth of their complexity.

Understanding science starts with understanding its most important foundations, one at a time, beginning with what is surely the easiest yet most fundamental and essential foundation, the Theory of Relativity, which, when coupled with the Theory of Quantum Mechanics (again, see companion volume, *The Infinite Pattern*), together, rank unquestionably among the most outstanding of all human achievements, short of humankind's refinement of courage, insight, compassion, and liberty, along with their corresponding benefits for all.

This book can begin to introduce the reader to a fulfilling adventure of intellectual amazement, by means of the great human achievement that the Theory of Relativity is and the destination where the road of scientific exploration can ultimately lead, provided that we are willing to open our minds to the solid factual truth of the conclusions that constitute the substance of science. In the face of the widespread misunderstanding and misinterpretation of science that is so commonplace today, this can require great and enduring courage, deep and revealing insight, genuinely sincere compassion, and the greatest love of liberty that a truthful understanding of nature is capable of yielding to anyone willing enough to work for it, which is what one must inescapably do for the sake of gaining such fulfilling enrichment. Be assured however, that this journey of discovery is well worth the effort, unquestionably, and the understanding that can be gained, capable of enduring for an entire lifetime, and never become out-dated, as again, has been the case for what is now, well over a century, and, as will remain the case, apparently forever.

The foremost purpose of this book is

to make available to those having the least access

to the most advanced achievements and discoveries in science,

an open window

into its most fundamental foundations

so that they too can have that access.

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THE INFINITE OCEAN

Relativity's Space and Time Without Math

by Chongo in collaboration with José

Second Edition (Field Guide Version) – August 2016
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Some paragraphs are combined (concatenated), all margins reduced, and words extensively and 'creatively' hyphenated, in order to fit all text into the physical limitations presented by the binding method, while maintaining a font size large enough to make it more easily read unaided, or in the outdoors.

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Some paragraphs are combined (concatenated), all margins reduced, and words extensively and 'creatively' hyphenated, in order to fit all text into the physical limitations presented by the binding method, while maintaining a font size large enough to be read by people ordinarily requiring reading glasses.

The term "infinity" replaces the correct word of "infinitude" throughout. This was done for the sake of the understanding of the lay reader, who may be unfamiliar with the latter term, but most of all for the sake of fitting the text within the number of pages allowed, while maintaining an adequately large font for the body text.

ACKNOWLEDGEMENTS: Development and initial publication of text, including text, any illustrations, editing, and reproductions were accomplished with no resources other than the author's, collaborator's, and that of all those who helped them in their endeavors. No assistance whatsoever was obtained from any government, institution or organization of any kind. This was a purely private endeavor, sponsored solely by two free-thinking individuals, and those who provided support for them in their many years of determined effort, all of whom so loved the liberty that comes with understanding nature accurately, that they believed that for the benefit of all it should be made readily available to anyone and everyone who sincerely seeks this deep understanding of our world. In particular, Cybele Blood for her months of dedicated editing, Werner Braun for all of his technical computer assistance, Lee Parks for his artistic skills in refining and digitizing the important illustrations, and Debbie Collins at Ms. Dragon Print & Copy for her years of uninterrupted support in our endeavor.

TABLE OF CONTENTS

"Ignorance and liberty are mutually exclusive."

Introduction: MOTION AND INTUITION*

Look around, what do you see? You see 'things', things occupying space, and with its passage, occupying time. Reality seems to be made of things occupying space, and in the process, occupying time. An additional feature of our immediate vicinity is that, regardless of wherever we may find ourselves, these things that constitute reality, including ourselves and notwithstanding a couple of rare exceptions, seem always to be being "pulled" downward, relentlessly. Wherever we find ourselves, gravity seems as relentless and inescapable as time. As is readily obvious, gravity 'is' the force that is constantly pulling things downward, given something "else," namely *time*, providing the liberty for things to change their position as a result of this force, or of any other. With time, comes the capacity for things to change their position in space, for them to move. This is what we call, motion: things changing position as a result of their being pulled or pushed. We intuitively *understand* motion; we *know* that we do, it is a certainty.** How could we not?

There is yet another almost universal feature of motion that we might overlook by living in such a modern world where if, for no other reason, common, widespread understanding of the motion of the planets around the sun would perhaps unknowingly mislead us to ignore this obvious feature, even though this feature is almost universal to all of our notions of movement. That obvious, universal feature of motion is that wherever we observe movement, it is universally, of something moving, with respect to something else, like all of the local surroundings, that is *not*. That is, motion seems always to occur against a backdrop of everything else that is not moving, but is instead, stationary. If we did not know that the earth itself is constantly moving, as humans once did not, throughout most of their history, then all motion it would seem, is with certainty, innately modeled with respect to a stationary perspective. In other words, things always, unambiguously, either change position, or do not change position, that is, either they are in a state of motion, or they are stationary. According to this innate, intuitive perspective, the distinction between what is moving and what is not moving is absolute and universal. According to this perspective, nothing whatsoever can be both in a state of motion and stationary, together, in the same moment. Moving while stationary is unimaginable; it contradicts the deepest, most fundamental foundations of our very reason.

This is the intuitive way that we see motion: things moving amidst a stationary world that itself, does not seem to be doing so. It is clearly how we humans evolved to envision motion, something changing position amid all that does not. This is for the very simple reason that throughout human history, this simple picture has served human needs so effectively that it has brought us to the point of being able to question our intuition's very validity. It is in this exact way that the great thinker, Albert Einstein, discovered relativity. He assumed something much more certain than common, human intuition, because he knew something about nature that humans had never known before that time, or had been capable of knowing or of even understanding, an incredibly important detail about the world that is wholly unimportant to common intuition; that detail being that the speed of light never changes. Because it never does, our intuition's conclusion that moving and stationary are mutually exclusive states is a completely incorrect one. Not only can anything be both moving and stationary, together, <u>everything that is anything cannot avoid doing both together, ever</u>.

We, and everything else existent, are always in motion while being stationary, unless we, or what-

* - *Clocks on a Train, Relativity - The Pamphlet* is available for free on-line viewing, PDF download, or hard copy purchase for a nominal fee, at chongonation.org Library page.

** - To be clear about what is being said, we intuitively understand motion because we intuitively *believe* that we intuitively understand, owing that our intuition so determines.

ever else, are being pushed or pulled (and even then, the effects of ANY pushing or pulling can be ignored). The rotation and orbit of the earth with which we are always in motion, while being absolutely stationary, prove this. To be perfectly clear, unless we are being pushed or pulled (acceleration or gravity), we are always doing both together, moving, and standing still, as it is impossible not to, when not being pushed or pulled! But again, this is not how our intuition ordinarily works. It MUST assume that one is not the other, meaning that it must assume that moving things are not, nor can they ever be, stationary, according to it. If our intuition did not work as it does by means of the distinctions (meanings) that it makes, like stationary being distinct from moving, then our ability to interact with our local world would most likely not be as effective as it is, either, and we would not be here in the first place. But, our world has grown colossally. Our intuitive picture of the world includes the whole of the universe now.

Humanity's picture of reality has expanded vastly, to encompass magnitudes more than the flat extent of local terrain that ordinarily surrounds us in every lateral direction and upon which we map our world. It is now common knowledge that earth is a planet itself, moving, by rotating and by orbiting, around a star called the sun, along with a variety of other planets that are doing the identically same thing. The 'world' includes more, far, far more, than what we evolved to contemplate. Yet we can hardly escape being forced to do so, anyway. So our mind constructs a mental picture of all this celestial motion. We represent it by the image of a set of smaller spherical bodies orbiting a larger one, these smaller systems orbiting around the largest, central stellar body. This collection is formalized by the scientific term, solar system. The solar system, in turn, spins with the motion of the rotating wheel of the entire Milky Way Galaxy. We imagine the motion of this set of 'floating' bodies in our mind, in the same way that we imagine any other kind of weightless motion here on the surface of Earth. Naturally, this mental image makes perfect sense; because it is our very 'reason' itself that creates it, along with the firm belief in the certainty of reason's validity, owing that it is our very reason itself that determines its own validity, and with great bias. But, this intuitive mental image has a failing flaw: it persists with the notion of this collective motion happening upon a stationary stage, YET NO SUCH STAGE EXISTS; hence, the model FAILS. It is but one, among a multitude of many other intuitive simplicities, that we wholeheartedly believe (that is to say, that our reason wholly presumes with unquestioning certainty are absolutely true.), yet are utterly and completely wrong too!

Now we must know far more in order to understand our world and to operate even better in it, because the future of humankind and of human liberty flatly depend upon accurate understanding of nature being widespread, instead of how it is now. Widespread accurate understanding of nature is achievable only when recognition of inaccurate understanding of nature and the fallacy of our intuition become simple, open, common knowledge. The effort to make such understanding as widespread as is necessary begins with the individual initiating that journey that leads to such a world to actually start embarking upon it, **literally**. The content of this text stands wholly dedicated to bringing the reader who is willing enough to take the time to make the intellectual effort necessary for taking the first step toward gaining this stunning understanding that grasping relativity is, to a breathtaking vista that allows viewing what understanding relativity allows, once achieved, but equally, to demonstrate just how easily that understanding can be acquired *by anyone*, especially anyone who has taken the initiative to read to the end of this opening; as the current reader must have done to now be reading these lines. Again, anyone who can read can learn both what space and time being relative means, physically, and why relativity is, why it *must* be, true; and can never not be.

"Change can take years, and in some cases, eons; or, it can happen in a moment."

Chapter Zero

THE ORIGINAL THEORY OF SPACE AND TIME

Space seems absolute and universal, everywhere always, at any distance, anywhere. That is, no measurement of any distance ever seems to change, under any circumstance. Regardless of the units that are used to measure the distance, once this number of units is determined, it does not seem to ever change, regardless of anything, and presumably, irrespective of any motion involved. Likewise, so seem any measurements involving a combination of distances, such as those for surface areas, spatial volumes, or angles for example. In stating that measures of distances and the areas, volumes, and angles that these distances establish seem absolute, what is really being stated is that space itself seems absolute. And, just as seems the case for spatial measures, temporal intervals, that is to say, time, seems also to pass at the same seemingly absolute rate, always, everywhere, under any circumstance whatsoever, regardless altogether of anything. No clock ever runs faster or slower, under any circumstances, ever, does it not? Any accurate clock seems to run at the same rate as any other, regardless of anything or any motion; a minute is a minute anywhere, always, under any circumstance. Time and space seem wholly unaffected by motion or gravity. Is all this not true, again, always?

Another seemingly obvious fact is that although each clearly seems universal and absolute, time and space clearly seem also wholly "unalike," meaning that each is physically distinct from the other. Space can be navigated at will, locally, in any direction, while time cannot, in any way. Time has only a single direction alone: into the future. Its march is unstoppable and moreover, absolutely inescapable. This means that we simply cannot help but be continually removed from the past: it *always* lies behind our present moment; and, in like fashion, continually removed from the future: it always lies *ahead* of the present moment. Both past and future lie beyond our reach, with the present moment confining the temporal extent of our existence to a perpetual progression of fleeting present moments that, in series, constitute our lives. Reality is accessible in no way other than our immediate moment-by-moment recollections and contemplations of it (even with respect to our *recording* of events). All this is clearly obvious to anyone, and a flatly indisputable fact about reality, is it not? Furthermore, what is true for us here now must be true, at any time, anywhere, must it not?

Naturally, it seems obvious that the past and future that correspond to the earth correspond also to the moon and sun, just as this seemingly absolute distinction applies identically to the solar system, and likewise to nearby stars. Extending this idea further, we realize that this seems true for the entire universe, at any distance, not matter how far. That is to say, that it must be the same time *everywhere*, because what exactly would it mean for it not to be? How? It *not* being the same time everywhere seems unimaginable. Not knowing, we might mistakenly think that so imagining lies outside of our intellectual reach, without realizing that *we would be wholly incorrect in thinking so*. This mistaken image of universal absoluteness (along with any presumed limits upon our ability to imagine more) is best expressed as "the theory of absolute space and absolute time (measures)." It is a model we surely cannot even remember acquiring, much less how, or why; and, unless we learn differently (one way: by reading the content), it is a model that we retain for our entire lives mistakenly believing that it accurately embodies the way that nature really works. Grasping relativity can correct this misunderstanding by replacing it with an understanding that corresponds perfectly to how nature, in actual, physical fact, truly *does* work. The remaining chapters stand wholly dedicated to bringing the reader who is willing enough to take the time and make the intellectual effort necessary for gaining this understanding, to that very understanding itself.

"We see one thing. Physical existence is another."

Chapter Four

A SINGLE HUMAN PERSPECTIVE

We see a single world, one based upon a very narrow range of conditions, and what is important for the sake of understanding relativity, one based upon a very, very narrow range of speeds: slow ones (ordinarily). As a consequence, we see only a *single*, common perspective of the world, and (again, ordinarily) no other. Thus we have an image of a *single* reality, a reality unique to a single set of measures, a single set of when's and where's alone, and with a single set of when's and where's, *a single, all-encompassing past* and *single all-encompassing future alone*, universal to anything and everything. This single image that we utilize (unless we understand otherwise by understanding relativity) 'seems' to match perfectly the single world that we find ourselves existing in. It is our *perspective*. And, unless we have a basis for imagining more richly (again, by understanding relativity), we limit reality to this simple, single image of nature's measures, to the exclusion of any and all others. Nature, however, is unconstrained by any lack of capacity to imagine its richness by us. Clearly, it exists independently of any limitations that our imagination might impose upon its ways.

This single world and its single set of measures constitute the geometry of what we call our common sense. We depend tremendously upon our common sense and its corresponding single set of measures, for everything. Minimally, it is how we calculate our motions, and, because it seems to be so effective, it is also ordinarily (unless we understand more valid and accurate models) how we imagine reality being as well what we believe it indeed must be, thinking that what we see is what 'is'. But, our individual reality and the single set of measures that it incorporates are no more absolute, than any individual perspective is the *only* perspective. To understand nature accurately, specifically, to understand the relativity (inseparability) of space and time (i.e. gravity) accurately, we must first ignore the absoluteness of our simple, single construction of measures, so as to make room for a collection that is nature's richer, far more encompassing one.

Our common sense is an outcome of everything that we have ever experienced in our lives, interacting with what is the outcome of our biological evolution, namely, our body, specifically, our brain, within which our common sense dwells. It is both together because it is an outcome of the evolving events that ultimately lead to each individual one of us. The environment, that for which our common sense was selected, ordinarily never has anything but very slow speeds (when compared to the speed that light travels) and very short distances (considering the immense distances existing in the universe); for that is how things ordinarily move in our world, very slowly (when compared to the speeds of bodies far away like other galaxies, even our fastest things move much more slowly when compared to these bodies) and very nearby (when compared to the distances that encompass the extent of the visible universe). As a consequence, our common sense ordinarily leaves us equipped with a single absolute notion for the measure of space and time, as is appropriate, in a world where light moves millions of times as fast as the fastest other "things" moving (these 'things' always being something materially existent, that is, made of matter), with most things moving much more slowly—so slowly that we can 'see' them while they move, using, of course, light to do so.

The single set of measures constituting our common sense model of reality, unless it understands that time is inseparable from space and hence that there are many sets of measures, not just one alone, is, according to relativity, only convenient, but certainly not accurate. The accuracy of relativity's equations for describing nature demonstrates that. Nonetheless, to the end of perpetuating the motions of the living machine sustaining our conscious mechanism, limited as it may be in its overall accuracy, this single set of measures is spectacularly effective for the sake of our individual survival, having brought us to where we find ourselves now. Most significantly, it can be acquired independently of any formal instruction.

So, our intuitive notions need not be "precisely" true; only true 'enough' to be practical, and that they are (ordinarily). Our successful interactions with the world are a seemingly irrefutable statement of their validity. But again, this single set of measures existing in our intuitive common sense is NOT a *universal* set; *because there is simply no such thing*. Instead of being limited to just a single set of measures, and none others, like we (ordinarily) are. Clearly, nature does not "measure" according to how we (again, ordinarily) would. Nature is not subject to the constraints that a single set of measures (e.g. our intuition) imposes upon our imagination; nature is never confined by *our* capacity to imagine it. Nature, in place of one, has many, many sets of measures, and correspondingly, many, many different perspectives (all four-dimensional); each and every last one, based upon a unique motion, with not a single one being universal, but instead, like any such set of measures, each is uniquely individual, ***and each equally valid***, within an "overall" (i.e. bulk) *history* that includes future events, every bit as much as it includes present and past ones.

Thus, we are left asking, how can one abandon such thoroughly tested notions as those that have taken us so far through life and through our biological evolution too (very effectively, as a whole), and replace them with notions that nothing we have ever seen or even imagined, has implied or emulated? If our intuitive notions aren't true, then what, exactly, is? What model of measurements, for time and space alike, can replace the model that nature has provided without contradicting this same effective one that we have already? There exists such a model. It is called the Theory of Relativity. And, for measuring spatial distances, time intervals, any combination of the two, the motion of big things, or the effects of gravity, it is a more accurate model than that ordinarily provided by nature, though for the sake of surviving the rigors of life, certainly not necessarily the most practical one – *that is*, unless our understanding the precise measure of space and time, and understanding the deep truths that this precision reveals, is very probably an absolutely indispensable necessity for humankind's survival (like, for example, tracking big errant meteors that threaten collision with the earth, or sending crafts into space to direct them elsewhere).

According to relativity, conventional intuition – at least the conclusions it would ordinarily make with respect to the universe's geometry – is (again, ordinarily) very flawed. But, given a sufficiently open mind, this flawed intuition can correct itself and become incredibly insightful provided one is prepared to abandon altogether embracing some of the deepest cornerstones of one's most fundamental thinking, for the sake of replacing them with new, more correct ones. This is what makes learning relativity the most important step in understanding nature (science), at its heart, in a true way. *Ignoring our intuition is what makes learning relativity, though conceptually the simplest step, usually the most formidable obstacle one must overcome in order to begin to understand nature in the deep and sound ways that science does.* We must ignore that which we can hardly imagine not being true, in order to understand (ultimately as part of a larger picture) what, in actual fact, *really* is. It is a step that one cannot elude, without eluding the very understanding itself. Luckily, this is not as overpowering as one's intuition might, again, mistakenly imagine, that is, provided that we are willing enough to forget what has always, with certainty, *seemed* undeniably true, and embrace what irrefutably is, instead.*

* - It should be noted that embracing our set of measures as the sole and only set of measures for nature has the capacity for taking us down a path that could even threaten our very survival as a whole, by leading us into erroneously believing that science is either incorrect or inconsistent about the future. It is not.

"To understand how space 'tilts', one must understand motion; and motion is a very, very different thing from what one might imagine it being, according to intuition, tradition, and common consensus; which are all usually wrong about most things in physics, just as they are usually wrong about most things in general."

Chapter Seven

MOTION ACCORDING TO RELATIVITY

Imagine slowly passing a simple, solid, three-dimensional object through the surface of a pool of perfectly still water, keeping in mind that the surface is the *boundary* between the air and the water, and as such, does not include the water of the pool itself or the air above, nor is the surface anything materially existent like the water of the pool or the air above it is, occupying volume. An oblong, American style football would serve this purpose well, it being a simple, (effectively) solid, three-dimensional object. As the football were to pass through the plane of the surface of the pool, it would intersect this two-dimensional surface, first as a single point, then as the changing contour of a football (as a growing then shrinking ellipse [which could be a circle]), and finally, as a point again, as it finished crossing through this surface, all the while the surface remaining unrippled, smooth, flat, and still, just as it was before the football ever began entering.

Next, let us imagine further that the surface of the pool represents a two-dimensional perspective (that is, according to measures with respect to the surface). The changing outline of the object, the football, as it passes through the surface, is how the three-dimensional object is perceived, from a two-dimensional 'perspective'. From a two-dimensional perspective, it is impossible to 'perceive' a three-dimensional object, in its entirety, as a three-dimensional perspective – like ours happens to be – can. A two-dimensional perspective allows only two-dimensional cross-sections, of the three-dimensional solid object (the football). So, *no matter how many dimensions an object might have, from a two-dimensional perspective, no more than two dimensions can ever be perceived in any given moment directly* (ignoring of course any extraordinary motion that might reveal more dimensions than two, like, for example, spin).

Naturally, one can only ask, what does a shape (the football) passing through the surface of a pool of water have to do with explaining a more correct and fundamental way to look at motion? How can this image lead us to a simpler way to explain the relativity of space and time measures, or specifically, lead us to a more accurate description of motion as relativity describes it, as that is, after all, the goal of the chapter?

We can answer this question by imagining passing, instead of the simple shape of a football, a much, much more complicated shape through this surface, a single object that would intersect the surface at many points simultaneously, thus creating many *different*, individual cross-sections at the same time, instead of just a single one as the football would. A classic, outdoor, television antenna, those before parabolic antennas, it being a complicated lattice of rods, would serve this purpose well. It is a complex three-dimensional shape that would intersect the surface at many individual and distinct places, all of them small in area, like 'points', specifically, "particle" points, are small in area. We can imagine passing this complex shape of a classic outdoor television antenna, with its interconnected lattice of rods, through the surface, along a single, unchanging direction, straight down, perfectly perpendicular to the surface, and equally important, at a steady, uniform rate of motion (i.e. at a uniform speed). We will orient the antenna in such a way that no rod will be perpendicular to this direction, the direction in which it is introduced to the surface. Passing it in such an orientation prevents any rod from being parallel to the intersecting surface, thus excluding any rod from intersecting this perceiving surface in more than a single "point" (meaning an individual, discrete region), as well as any simultaneous intersection of both ends of a rod with the surface together, intersecting the surface at the same moment and as a long, rod-shaped "line," instead of a point.

From the point of view of the perceiving surface, the 'points' (regions) of intersection would change their position, as the object passed through, either approaching or receding from one another (that is, ignoring any parallel rods). *The sharper the angle of the intersecting rod, with respect to the surface of the pool, the faster its intersections would change position*. Note that the changing positions of these points, intersecting the surface, could easily be mistaken for something other than the changing contours of an antenna, passing through the surface. They could easily be mistaken for something else because, according to a *two*-dimensional perspective, they would look *exactly like* something else, absolutely indistinguishable. Instead of realizing that all that they were 'really' perceiving was a classic, three-dimensional television antenna being pushed through their world, any two-dimensional creatures inhabiting the two-dimensional surface of the pool that we are imagining, could be easily convinced, *and quite reasonably so*, that what they were perceiving couldn't 'really' be a *'higher* dimensional' shape, the antenna, passing through their world, but instead, the motion of points, or rather, the motion of 'particle points' – moving across their surface like they move across our "space"; because for two-dimensional creatures, a two-dimensional surface would be their version of space and the intersections, particles. Like us, they would intuitively imagine that this single surface alone encompassing all physical reality: everything physically existent (just as they always had throughout the past in the face of every other new discovery in science, thereby preserving the integrity of all of their *other* imagined places [like "other dimensions," alternate realities, etc.] and the corresponding lore through the metaphysical "existence" of such worlds in a "non-physical" way).

According to our perspective, imagining the changing intersections of the antenna, we imagine an antenna dropping, as a whole, with the points of intersection changing with the motion of antenna rods passing through the surface. We imagine a rod, in its entirety, occupying a volume. But, realizing that the number of dimensions to one's perspective is the limit on the number of dimensions that can be perceived (recognizing that from a two-dimensional perspective, a rod of the antenna, being part of a *three*-dimensional shape, cannot be perceived in just *two* dimensions [which are too few to encompass the greater number of dimensions – three – that the rod's shape requires]), then, by virtue of this limitation, two-dimensional creatures would perceive the moving intersections on the surface as 'bounded' points (regions) moving in *two* dimensions only, NOT in the three dimensions that the antenna would really have. *To them, they would not seem like intersecting three-dimensional 'rods' at all, but rather, like two-dimensional particles in motion, across the "all-encompassing", apparently boundless 'space' (surface) of their seemingly* *"flat" (Euclidian) two-dimensional universe, their single surface, rising unceasingly – just as our three-dimensional space seems to constantly do (rise through time) in our (minimally) four-dimensional universe!*

We can use this picture of an antenna, creating motion upon the surface of a pool of water, by it intersecting with the surface of the pool as it passes through this surface, for explaining relativity's classical description of motion in a very simple and very understandable geometric way. And so we shall. We will follow, throughout the history of their classical physics, the achievements of these two-dimensional creatures inhabiting the surface of our pool, as we explore exactly how they first discover special relativity, which works no differently for them than special relativity does for us except with one dimension fewer, and then how they use special relativity to explain gravity (general relativity). We can consider relativity this way, in this fewer number of dimensions, because, provided there is more than *one* dimension, however many dimensions there may be is a wholly irrelevant consideration to relativity. By exploring just how, like us, these creatures finally arrive at their theory of relativity in the simplicity of fewer (two) dimensions, we can see in easily imaginable and clearly understandable terms, just how relativity "works", and, just how and why it MUST be true (even though relativity may simply be a generalization of more fundamental truth, like a theory of quantum gravity, for example – as yet, untestable – may ultimately describe it more accurately).

Author's Note: The two-dimensional creatures that we are imagining in this chapter as analogies to ourselves may seem extremely simple, when compared to us, who are seemingly much more 'complex' three-dimensional counterparts of these (again) seemingly 'simple' creatures. However, for a number of very sound physical reasons, while thinking ourselves three-dimensional and consequently imagining ourselves therefore being more complex, we may truly be just two-dimensional too, no less than the creatures of our analogy are. As a matter of fact, because (as science reveals) every last observation we ever make in the universe never corresponds to anything except a collection [set] of two-dimensional photons (particles of light), we can never be *absolutely* certain that we are ever anything more than *two*-dimensional creatures too, amid the illusion of imagining ourselves in a constantly changing *three*-dimensional state of affairs. Despite exclusively three-dimensional phenomena everywhere (e.g. torus: tubes), it is physically impossible to demonstrate which is true: that we really are three-dimensional moving with respect to a fourth dimension, or instead, no different at all from the two-dimensional creatures in our analogy, who, like us, are moving also, with respect to an additional dimension, time. It is simply impossible to ever genuinely know which of the two we really are, physically, either three-dimensional or two. We can never know for sure what we really are, either two-dimensional, or three, despite how convincingly our models might imply one over the other, and despite how our being dimensionally simpler creatures might be so very difficult to believe, even though some of our imagined models (like the holographic universe model) most validly allow us to be just that simple.

Nevertheless, for the sake of explaining reality according to relativity's four-dimensional model, we will consider ourselves being *three*-dimensional instead of two, and consider the universe (that is, its history) as being four-dimensional, not three, just as the Theory of Relativity so validly describes the world (and just as it specifies that our rising surface and ourselves along with that surface are three-dimensional). Put another way, we may just be two-dimensional ourselves incapable of knowing it because our brains are so complex that they are able to think in one more dimension than our analog, even though it may exist purely as an illusion in our minds, and us, spending our entire lives probably never suspecting it even once – well, at least never suspecting once until now, upon reading this paragraph and the one preceding it.

"How can space *be* anything, without time? Furthermore, how could time ever move one tic forward, without a place – a place like space – for it to pass, and of course without something existent in that space, anything at all (like life, for example), changing, to reflect time's unstoppable passage?"

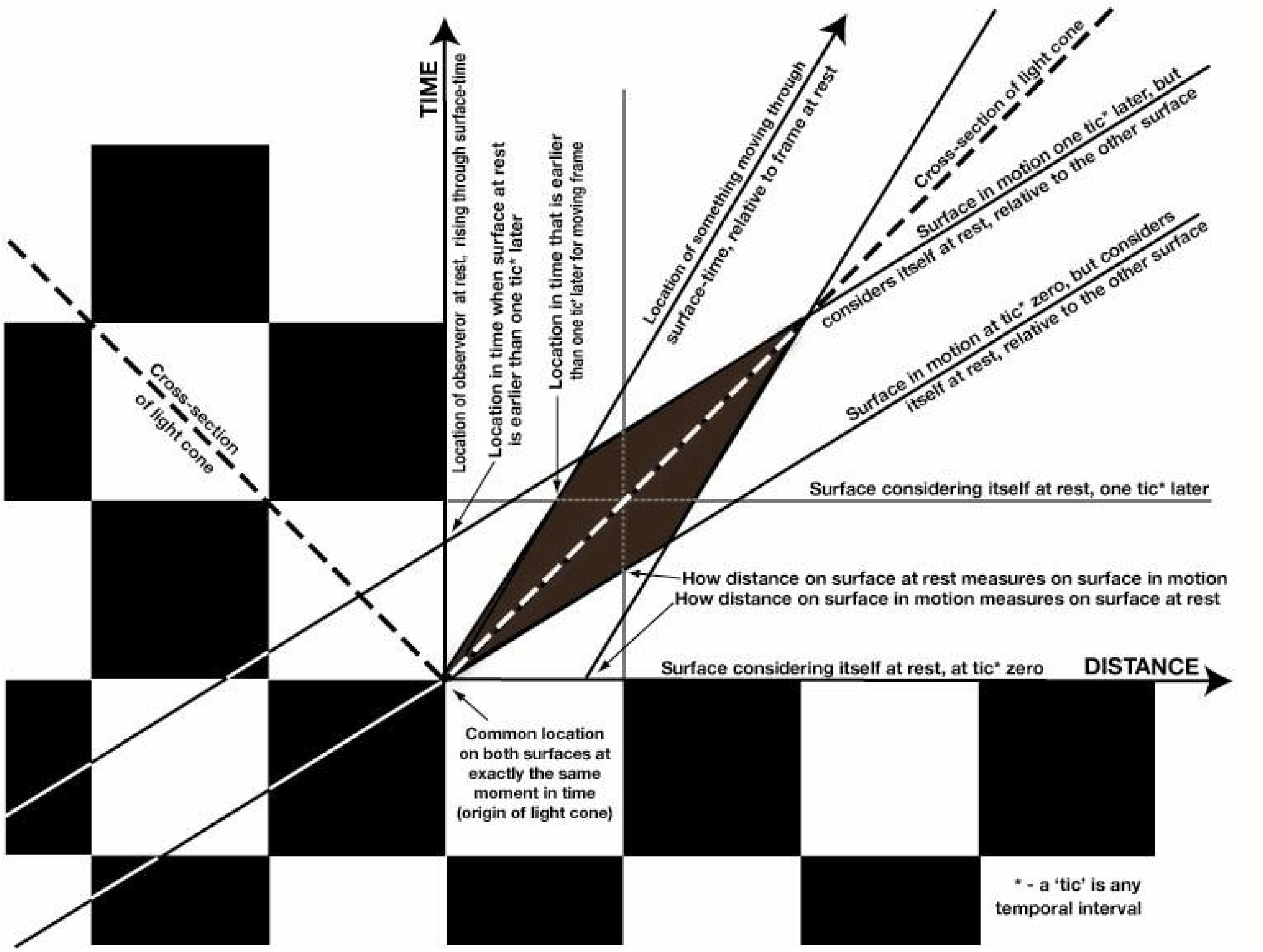
Chapter Thirteen

SPECIAL RELATIVITY'S STRAIGHT LINES

Any two-dimensional creatures trying to learn the relativity of space and time measures within their three-dimensional universe might have difficulty in understanding exactly how another surface could tilt in such a way as to be rising more slowly than their surface, with the other surface's time spanning the observing surface's space so as to be reaching into both past and future together simultaneously; and, as a consequence, shortening distances along the direction of motion while time correspondingly slowed. This would seem particularly confuisng, since they would have to reconcile how, according to the frame of reference of this other moving surface (which could likewise consider itself being at rest), the same thing would be happening *to them* (the confused ones), *and to their surface*, again, from the point of view (that is, according to the measures) of this other surface. That is, the other surface in which time was slowing would see this surface's time slowing and distances shortening, instead of them doing so on their own surface. In other words, each would think that time on the other's surface was slowing and its distances shortening, while on their respective surface, time would be passing at a normal pace and no distances shorting in any direction, relatively to any other.

They might have a difficult time imagining how such 'distortions' to *their* time intervals or spatial distances could be occurring on *their* surface, according to the perspective (according to the time and space measures) of another, observing surface, since they would see no distortions at all happening to their surface. Again, their surface would be rising just as fast as it ever could, and distances would be no shorter in any one direction than in any others. The same would be true for the other, observing surface, in which time and space measures would not be distorted, according to the measures of this observed surface. It should be noted that these distortions for one surface would be identical to the distortions of the other.

Being, by nature, two-dimensional in their conscious construction of reality (for the very same reasons that we three-dimensional creatures are three-dimensional in the construction of ours: our rising surface is [or at least seems to be] three-dimensional), two-dimensional creatures that were trying to gain an understanding of a rather uncommonly-known, new body of concepts called relativity, might find it difficult, perhaps even mistakenly believing it fully impossible, to imagine their universe beyond two dimensions, in the three that it would really have. We, however, equipped with our three-dimensional conscious construction of reality, would have no trouble at all understanding the relativity of two-dimensional surface-time, because our three-dimensional conscious construction of reality allows us to find it a most comprehensible concept. We can imagine it easily, with nothing more than a two-dimensional cross-section illustration of three-dimensional surface-time. Our three-dimensional 'surface' allows us to view this two-dimensional cross-section from a perspective in our additional third spatial dimension. This is precisely what we do when we look at the illustration below and on the next page and the page that follows it (which is opposite this page). Looking at either illustration, we see 'across time' in our universe of surfaces, and can readily see how surfaces tilt with respect to each other, as well as how such tilting 'distorts' projected measures of space and/or time distances, from one reference frame to another. (Note that these same illustrations will be ☞

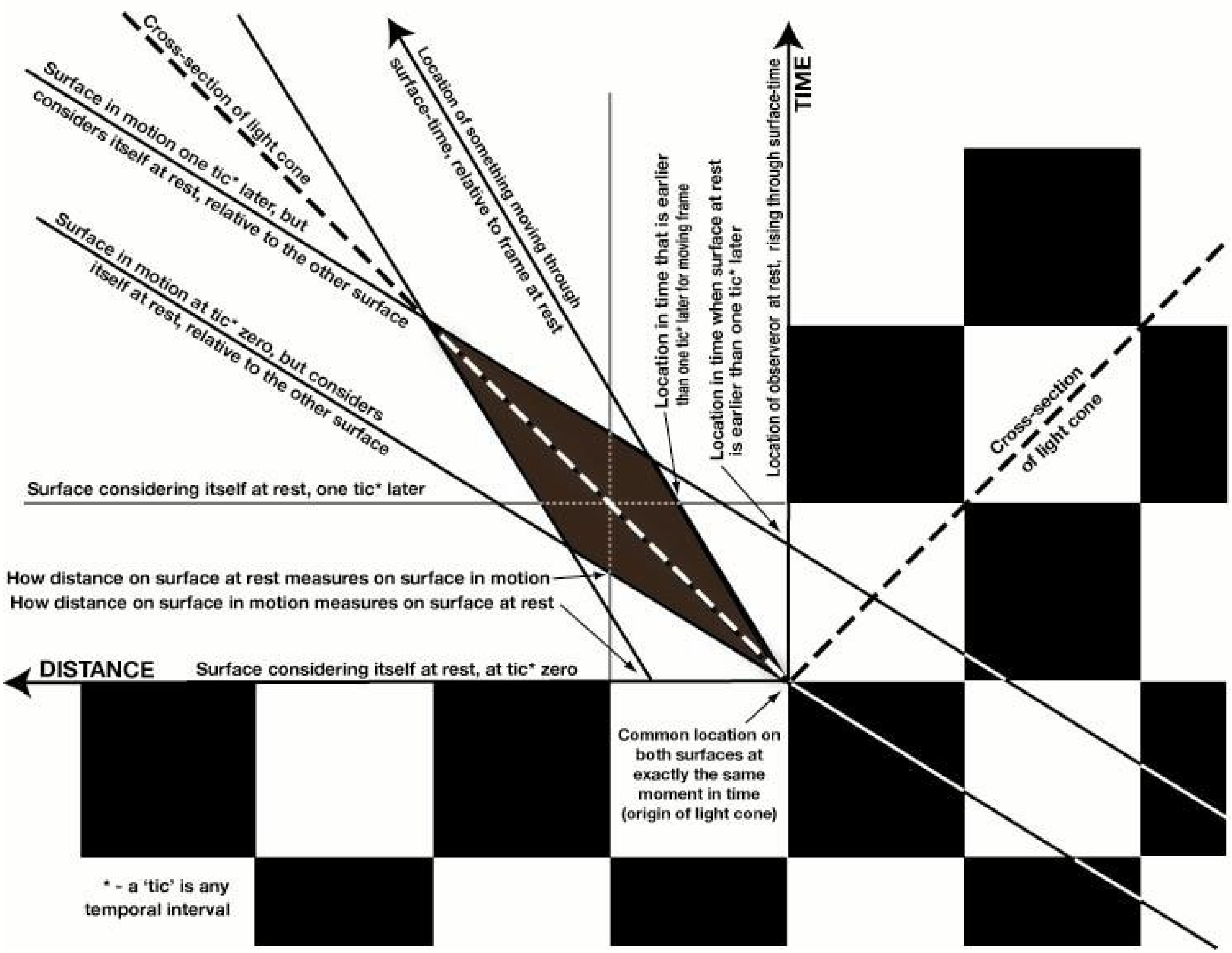


<u>CROSS-SECTION OF TWO SURFACES TILTED, WITH RESPECT TO ONE ANOTHER*</u>: The tilted, moving surface 'projects' itself onto (in three dimensions, *into*) the other (horizontal) surface, which considers itself at rest, thus making time lag, and spatial distances shorten in its direction of motion, with respect to this rigid (square) frame of reference at rest. The relativity of time and space, distances and angles, between surfaces readily reveals itself in two-dimensional cross-section. Each surface has a unique orientation, with respect to any other non-parallel surface, in the three dimensions of surface-time. Time and a SINGLE dimension of space tilt toward each other, as speed increases. They *approach* "meeting" at the speed of light, but can never do so for the simple reason that the (positive) area bounded by the diamond shaped square always remains the same as any square in the rigid frame (meaning that there will always be just "as much" space in the tilted frame as in the rigid one). In the illustration, the vertical distance of a single 'tic' can be ANY time interval. The lateral distance corresponds to that spatial interval which measures how far light travels during that time interval (up to our temporal displacement from the Big Bang, approximately 13.7 billion light years**). Applying the above illustration to our 'true', physically existent 'now' – that created by the light we see and sense everywhere (as described initially in Chapter Twelve, page 34, and again in greater detail in Appendix B, page 98, and Appendix C, page 103, illustrated on page 113) – and applying the origin point of our stipulated light cone (the one shown above in the illustration) to the opaque region around the Big Bang, places (locates) all lying *inside* the above, stipulated cone, within our [real time] 'space'. It places everything else (all other energy) outside of the stipulated light cone, beyond the volume that the light cone includes; (that is, the 'rest' of the universe, which includes the opaque, unobservable [by virtue of being opaque – too "hot" for photons of light to exist] region surrounding the Big Bang "white hole," which is a "pit" yielding the entire universe [see also illustrations on pages 34 and 113]).

* - Precise dimensions are not exact and may be slightly incorrect as a consequence. These shapes are nonetheless meant to represent perfectly symmetrical forms.
** - This is under the assumption that the universe is now, here approximately 13.7 billion years old (according to our frame of reference).

explained yet again in Chapter Fifteen, but in terms of an experiment described in Chapter Fourteen; find these illustrations again on pages 50 and 51.)

The tilting of a surface is illustrated using a very special, flexible chess-square, one which can tilt in a very unusual way, a way that is different from how we might intuitively imagine the conventional tilting of objects in three-dimensional space. On page 38 (opposite), this flexible chess-square is shown, tilted, in the upper right-hand corner of the illustration. Behind, sub-imposed beneath it, lies a rigid and square ☞



<u>THE AT-REST PERSPECTIVE ACCORDING TO THE MOVING FRAME'S MEASURES*</u>: Shown above is the mirror reflection of the illustration that appears on the opposite page. It is the same cross-section as that shown opposite, but from the perspective, that is, according to the spatial and temporal measures, of the something that is considered moving in uniform motion (motion that changes neither speed nor direction), according to its *own* at-rest measures. As is obvious, each perspective tilts the measures of the other, with respect to its own right angle (perpendicular) positioning of its time with respect to its space. Each spatial dimension, besides being perpendicular each to every other spatial dimension, is each at a right angle (again, perpendicular) to their direction for time. The spatial measures of a tilted frame cross and therefore include what are, in part, purely temporal distances according to the rigid, right-angle frame at rest. Likewise, the temporal measures of a tilted frame cross and therefore include what are, in part, purely spatial distances according to the rigid, right-angle frame at rest. What is purely space for one set of measures (according to one frame's perspective) is no longer purely space but in part time, according to the other's measures; and what is purely time for one set of measures (again, according to one frame's perspective) in no longer purely time but in part space. Hence, whether a distance is purely time or purely space is all subject to the perspective (frame) corresponding to the motion (and as we shall see, corresponding to the gravity too) that measures it.

* - Precise dimensions are not exact and may be slightly incorrect as a consequence. These shapes are nonetheless meant to represent perfectly symmetrical forms.

chessboard (only the center squares of the board are shown, not all of them), filling the remaining three corners of the illustration. (The squares in the upper right hand corner of the rigid chessboard are not shaded, in order to more clearly illustrate the single tilted square.) This flexible chess-square tilts in such a way that it becomes a symmetrical 'diamond' (or in geometric terms, a rhombus) when tilted.*

The rigid chessboard and its squares on page 38 correspond to a portion of an observer's frame of reference at rest. In other words, they correspond to an observer that moves ONLY through time, straight up, perpendicular to horizontal distances. The tilted chess-square (again, page 38) corresponds to (a part of) the frame of something moving, traveling from left to right, as seen by the observer at rest. If such a frame were to progressively slow and stop, then this diamond-shaped square would, correspondingly, continuously deform back until it coincided with the squares of the rigid chessboard. (A rigid square corresponds to the diamond-shaped square at rest [at speed zero], and progressively higher speeds correspond to progressively greater deformations of the same originally rigid square.) But, that is not all.

The square in the illustration is tilted, while retaining an EXTREMELY important quality, a quality that may seem a bit peculiar, were we to ignore that we are using two-dimensions to describe in a tangible way four dimensions, which can hardly be considered in any genuinely tangible way except in a way that would seem most peculiar to our common familiarity with fewer dimensions. *We must keep in mind that* (as was explained in Chapter Ten) *in four dimensions, things happen in ways that might wholly contradict our expectations of how things – like tilting* (again, not rotating)*, for example – 'should' happen*.

Regardless of how much it might be tilted, the area of this tilted square will ALWAYS be identical to the area of any and all rigid squares (which, of course, are all the same size). Accordingly, the length of the sides of the tilted square will *always* be *longer* than the sides of any equivalent rigid square of the frame at rest. They *must* be longer, in order to encompass the same area that a rigid chess-square, with its shorter sides, does. In other words, instead of the area of a chess-square being reduced by its tilt, the *length of the sides* of the tilted square *increases*, so as *not* to reduce this area. If it did not increase, then the area of the tilted square would, for simple and obvious geometric reasons, be reduced by tilting, and according to relativity, tilting can NEVER reduce that area (or increase it either, by *stretching* it and *creating* more). (This is a DIRECT consequence of special relativity's equations, the Lorentz transformations, though we can easily convince ourselves by means of simply examining the two different, superimposed reference frames [as reflected in the two different shapes of the chess-squares] in the illustrations on pages 38, 50, and 56.)

Maintaining the area of this square by lengthening the distances of its sides as it is tilted is a VERY, VERY important property of the tilted chess-square (and of the geometry of our universe). For it reflects an EXTREMELY significant characteristic of the geometry of any universe having a finite speed of light, like ours has – *it keeps the laws of nature (which are the laws of physics, each and every last one that there is) from ever changing, or at least from ever changing as a consequence of motion, any more than they can change with time or location, that is, be different in the past, or in the future, or at some other place elsewhere, from what they are right here, right now.* In our universe (or for that matter, in any), the laws of nature (which,

* - It is important to note that the text in this chapter solely references the illustration on page 38. In particular, reference throughout is made to rigid, *square* chess-squares and to a single tilted one, the latter corresponding to a tilted board, with tilted squares sub-imposed beneath. The two frames are illustrated in this way so that the relationship between each distinct frames can be explained in terms of their distortion of measures; but, rigid and tilted are not absolute. According to the illustration on page 39, which measures the same space and time as that on page 38, the same chess-squares that are rigid, and square according to the measures of the at-rest frame on page 38, are represented instead by a single tilted square, in the illustration on page 39. Likewise, the single, tilted square in the illustration on page 38, on the opposite page, corresponds to what are now the at-rest measures of the square, rigid chess-squares of the illustration on page 39.

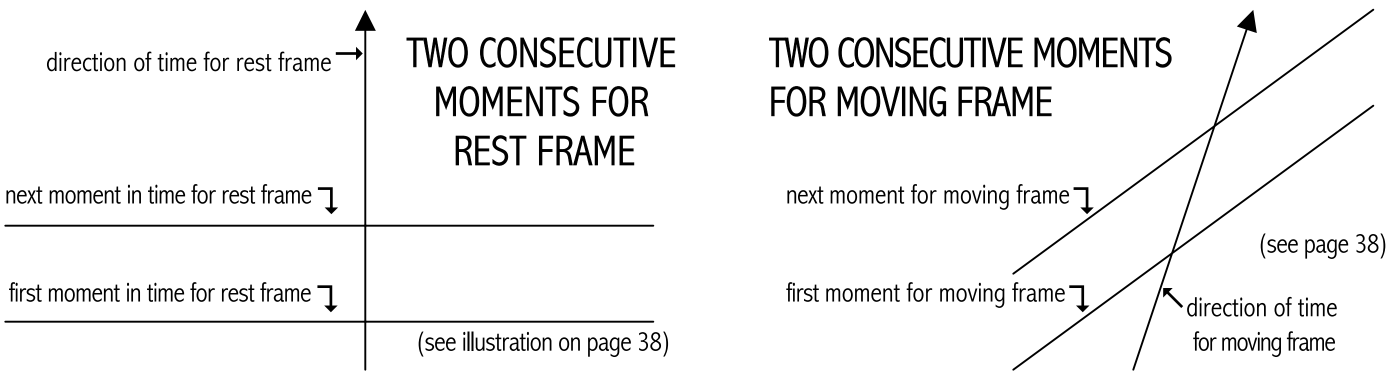
again, are the laws of physics – all of them) are inescapably the same everywhere (within the history of this universe, or again, within that of any), always, while absolutely nowhere and at no time ever, are they not. (In scientific terms, the measure of any and ALL combined space-time volumes are universally *invariant* [meaning that their measure does not change *ever*] with respect to *any* other reference frame. This is termed, the space-time metric; and its absolute invariance means that the laws of physics are correspondingly absolutely invariant too.)

A cross-section of a surface is a line. Combining the dimension of time with the one-dimensional cross-section of a two-dimensional surface along the direction of motion yields a two-dimensional cross-section of surface-time – *as well as* the illustration, on page 38. Looking at this illustration as a cross-section of surface-time, we will, therefore, always keep in mind that any cross-section of a surface extends perpendicularly, with respect to this illustration, from the line corresponding to that surface. Combining this cross-section of a surface with the dimension of time creates what we will call 'line-time', for the same very obvious reasons that two-dimensional creatures would call their realm 'surface-time'. (For two-dimensional creatures, line-time would be a simplification of surface-time, just like surface-time is the same for us.)

Two dimensions are all that are needed for illustrating special relativity, time and a *single* distance, the distance in the direction of the motion. By adding the dimension of time to the line cross-section of a surface, we create a two-dimensional frame of reference. We can obtain surface-time from line-time, by adding another dimension, one perpendicular to the other two dimensions of line-time. By adding yet another dimension to surface-time, one perpendicular to each of the other three, we create four-dimensional space-time, like that of our universe. We could add yet even more dimensions, but special relativity wouldn't 'change' – because special relativity is, essentially, *two*-dimensional only. Adding dimensions changes 'nothing' within relativity, because surface or spatial distances *perpendicular* to the direction of the motion do not change with the motion, and hence are irrelevant. By understanding relativity in two dimensions, it is effectively understood in more (at least the fundamentals), albeit unknowingly.

The illustration on page 38 utilizes the chess-squares as two-dimensional frames of reference in line-time (which again, is a cross-section of surface-time). In the illustration, the vertical line dividing the middle of the rigid chess-squares marks the path of an observer, at rest, 'rising' through time, on a surface, which is represented by the horizontal lines. For this observer, time is measured vertically, along the vertical lines. Each horizontal line, above the other, marks a particular moment in time, at consecutive intervals, which are later and later moments in the future. Each horizontal edge of a square can be considered being the single tic of a clock (though it could be *any* arbitrary interval), according to the rest frame's measures. The single surface distance is measured horizontally, across the *width* of the board, parallel to the lines between the ranks of squares. Each vertical edge, in the rigid frame, next to the other, marks a subsequent unit of distance, horizontally. Any unit of distance chosen will do. In this way, the lines between the squares of the chessboard create a two-dimensional frame of reference.

A rigid chess-square (page 38), by representing a portion of a frame of reference that is at rest, places line and time distances at perpendicular angles to each other in the same way that time is 'perpendicular' to a rising surface-time surface (or in the same way that it is perpendicular to a rising space-time space). So, in the rigid chessboard, two sets of parallel lines are perpendicular to one another. Hence, each point in line-time is the intersection of one and only one line, from each of these two sets. The horizontal line identifies what time it is, and the other, *where* it is located on the line (cross-section of the surface). This identification is called by both mathematics and the physics that utilizes it the 'coordinates' of the point, according to the grid of the measuring reference frame – in this case, the rigid, at-rest frame. By identifying individual points within the grid, the mapping of lines can be stipulated. By stipulating lines between coordinates, so can the mapping of areas and volumes be stipulated also. Thus, any point, any line, or any volume can be specified according to the single set of fixed, stipulated measures corresponding to the rest frame. Within the contest of this set of measures, the "laws" of physics are always consistent, from one moment, to the next, measuring all phenomena according to its unique specification of when and where. In the illustration on page 38, two subsequent moments, according to the rigid, at-rest grid, correspond to two horizontal lines, perpendicular to the direction of time, as represented on the left below.



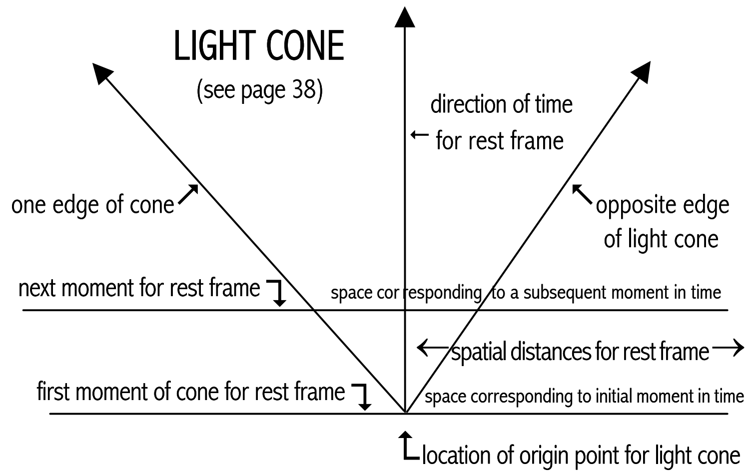
The flexible tilted square in the illustration on page 38 represents a portion of the grid of a frame of reference moving, at a uniform (unchanging) speed, with respect to the rigid, at-rest frame. Two subsequent moments for tilted grid of the moving frame correspond to the slanted horizontal lines, as represented by the slanted lines on the right above. The direction of its time is also slanted with respect to the rigid frame on the right. As is clear, the two grids map space and time differently from each other.

The left-most edge of the tilted, diamond-shaped square (just to the right of the line dividing the middle of the board) marks the path of something in motion, as it moves from left to right with respect to the rigid rest frame. Although this line charts a diagonal course across the illustration, it represents a straight-line course across the surface at rest, at a constant unchanging (uniform) speed (hence, the straight line). Because we are seeing across time, looking at the illustration, this line is diagonal instead of horizontal), across the rising *tilted* surface considering itself at rest. This line also represents the direction along which time is measured in the tilted frame, since that is the trajectory of an observer at rest on it.

So, time is measured in the tilted frame of reference similarly to how it is measured in the rigid frame, but along (that is, the direction parallel to) the leftmost edge of the tilted square, just as would be done for time with the vertical lines, in the rigid frame. In the tilted frame, distance is measured similarly, to how it is measured in the rigid frame, but along (in the direction parallel to) the lower-most edge of the tilted square. It is rising too, only at an angle, with respect to the rigid rest frame.

When a frame moves, with respect to any other, the angles between its line distances and time distances tilt, with respect to the right angles between those (line and time distances) of the frame at rest. Though the angles of the edges of the moving frame are tilted according to the measures of the rigid frame at rest, by the (or any) moving frame considering itself being at rest instead of moving, these angles do not tilt toward one another at all, but instead, are perpendicular to each other *according to the stipulated* *measures established by the frame* (of space and time, distances and directions [again, angles]) *which, of course, considers itself being 'at rest' too*, just as the rigid frame does. Though tilted according to the rigid frame, according to this moving frame, they are at right angles. A moving frame always has time and space tilting toward one another (at an acute angle in the direction of motion, like the sharp angle of the diamond-shaped square) the angle corresponding to speed, according to the measures of a rigid frame at rest, as the illustrations on pages 38 and 41 show, in the slanted edges of the tilted square.

Two diverging lines in the illustration on page 38 define the edges of a *stipulated* light cone (remembering that measures corresponding to a frame of reference are always stipulations and never anything actually physically existent). The stipulated light cone emanates from a point that is an actual common place and moment for both frames (both rest and moving). Shown at right are the edges of the cone, two lines at 45° angles, diverging from the center of the illustration (page 38), diagonally across opposite corners of chess squares.



Using the edges of the chess-squares, both the rigid squares and the tilted one, as two different frames of reference, we can see relativity in VERY understandable, two-dimensional terms, as surfaces rising past a three-dimensional shape, the shape of physical existence itself. In this simplified context (and remembering that relativity is the 'context' for reality itself), we can recognize relativity for what it truly is. <u>RELATIVITY</u> <u>IS</u> <u>GEOMETRY</u>. And most importantly, relativity is geometry that is consistent with observed (big) reality. But, having said that relativity is 'only' geometry reduces relativity to a *mere* stipulation of distances and directions (angles) applied to a set of points, because that is precisely what geometry consists of (no less than much of physical reality appears to consist as well), stipulations alone.

Being 'only' geometry may seem to reduce the significance of what is truly a monumental scientific achievement – that is, if we ignore just how important geometry is. Saying that relativity is geometry does not reduce relativity's significance in the least, it only reduces any seeming mystery. It reduces nothing else, about it. Saying that relativity is geometry says how essential its accurate description of space and time is, since relativity's geometry is a most necessary tool (in the form of a concept, since a concept is a tool – if it works!) for the science of physics to model anything existing in space and time, just as it is a most necessary tool for us to imagine and describe reality in any *meaningful* way, making geometry's, and hence relativity's, measures stipulations, stipulations that we can hardly avoid 'assuming'. And although 'only' mere geometry, what relativity implies about the character of reality is nothing short of amazing. For it reveals that the universe is actually four-dimensional, NOT three, and that there exist MANY other, three-dimensional 'realities' within it, NOT just *our* single one, being the *only* one, exclusively, as our intuitive notions might mistakenly lead us to believe (always, of course, as a matter of practical convenience).

Just as all this had escaped notice by (the *institution* of established) three-dimensional science throughout its entire initial history, so would it likewise have escaped notice as well throughout the entire initial history of our imagined two-dimensional science (at least the history of its established institutions). And this reveals that *one* of the things (there are others) that so often stands between us and an understanding of the true character of physical reality lies in the 'traditional notions' that nature seems to have built into our thinking (much like our established institutions have), as a set of seemingly automatic responses to our living condition, our conscious construction of reality being its result (see Chapter Four). Apparently provided by nature as a survival measure, this construction can diligently try to convince us to confine the possibilities for our imagination within the limits of that construction – that is, unless we learn to see beyond it, which is what learning relativity allows anyone to do. Yes, we can indeed see beyond our conventional thinking, by simply reading alone and hence imagining much more richly than before.

Understanding the 'truths' that relativity reveals allows us: first, to convince ourselves that the patterns of our 'traditions' can and indeed do often stand between us and an understanding of what is *really* true about anything, and second, that they don't *have* to if we make the very simple decision to choose that they not, by replacing them with reason – that is, unless, of course, we prefer traditional notions over truth and reason, simply 'preferring' instead not to care about what is true or reasonable, and what isn't (as we are free to do). (It should be pointed out that why we even 'prefer' anything at all, is at the very heart of quantum theory. And, it is these very ideas that are addressed, in much greater depth, in the companion volume to this text, *The Infinite Pattern* [like this book, available at www.chongonation.com], which explains quantum theory in great conceptual depth and detail – to the extent of explaining the physical source of our preferences for anything – and like here, without math.)

Lastly, in understanding relativity (and, correspondingly, in understanding the geometry of our illustration on page 38), we understand that our 'now', which is our three-dimensional 'space', is not the sole and only 'now' space in our universe, any more than any single two-dimensional surface in the imaginary universe of surfaces we are using would be the sole and only surface in a surface-time universe. In four-dimensional space-time, any particular 'now' is nothing more than a particular 'space', instead of a particular surface, 'rising' through time, just as we can imagine a surface doing, in our surface-time cross-section analogy. The only difference between surface-time and space-time is that a single additional dimension makes two-dimensional surfaces three-dimensional spaces. Otherwise, there is no difference whatsoever between the two – none. In the former (surface-time), there are different two-dimensional surfaces, and a unique *three*-dimensional frame of reference corresponding to each (unique surface). In the latter (space-time), there are different three-dimensional spaces, each with its corresponding unique *four*-dimensional frame of reference, which treats time identically to how it treats space, making no distinction at all of one from the other, which is what one easily might mistakenly do (that is, think that time is somehow 'different' from space and thus think that time is therefore not inseparably interconnected physically with it or that time is not identical to space), by not knowing about the Theory of Relativity, that unambiguously demonstrates just how and why they are the very same thing, inseparable.

Critically important note regarding the 'space' of a frame of reference and our true one: To accurately understand the 'true' geometry of the universe, *it is absolutely essential to understand what this chapter has tried to explain: that is, the difference between the purely stipulated simultaneous 'space' of relativity's frame of reference and the physically existent, actual, genuinely simultaneous 'space' of our individual, 'true' now!* This point is explained in greater detail in the first three pages of Chapter Twelve (pages 32-34) and again, by means of actual experiments, in Appendices A, B, and C (pages 89, 98, and 103, respectively).

Question: How can a 'space' ever tilt, and tilting, touch both past and future moments together, and at once, in the same single and common moment? Answer: If it didn't, then the speed of light would change with motion instead.

Chapter Fourteen

TILTING AN INDIVIDUAL "SPACE"

Up until now, we have considered relativity's geometry in terms of rising two-dimensional surfaces, in a three-dimensional surface-time universe. By adding a single additional dimension to both the two-dimensional rising surface that we have been considering thus far and to the three-dimensional surface-time universe in which this surface lies, we can turn a rising two-dimensional surface into a rising three-dimensional space, in a four-dimensional "space-time" universe, like ours is, instead of three-dimensional like our analogy. In this way, we can demonstrate the effects of relativity's tilting 'on' a 'rising' three-dimensional 'space' in a four-dimensional (hyperbolic, Lobachevskian, the kind ours is) space-time.

We can do this very easily, by conducting a very simple experiment in deep space, far away from anything (far from any gravity), and in this way, provide a description of the effects that special relativity (no gravity) creates for the space and time, distances and directions (angles) of one thing moving, in uniform motion, motion that does not change speed or direction, with respect to another thing, which considers itself *not* moving and thereby 'stationary', with respect to the thing that is considered moving at a constant speed and in an unchanging direction. This experiment illustrates the 'tilting' of space and time distances and angles (i.e. tilting time toward a single dimension of space corresponding to the direction of motion) upon a 'real' *three*-dimensional spatial volume in our physically real four-dimensional space-time universe (as opposed to a *two*-dimensional surface, among many, many others all tilted with respect to one another, in the imagined three-dimensional surface-time universe analogy to our own universe). **(Important note: the experiment described in this chapter is explained in much greater depth and detail in Appendix A, on page 89, and predicates another related experiment in Appendix B, page 98.)**

To understand tilting of a *three-dimensional* 'surface' rising through time, which is what our three-dimensional space is, a *three*-dimensional *surface* (instead of a *two*-dimensional one, as has been used in our analogy), we can imagine an experiment with a space station and a rocket-powered strobe. We conduct this experiment far out in empty space, so that the effects of gravity are negligible (just as those created by the mass [which we can consider as the 'weight'] of the 'things' – station and strobe – that we are using in our experiment are negligible too), and can be ignored. In the experiment, strobe and space station are, one at a time, accelerated to a uniform (again, unchanging) speed, in a trajectory that brings one racing past the other, so that they pass, very, very, very closely, at very, very, very, very, high speed.

First, the strobe is accelerated to nearly the speed of light in a straight line that brings it racing past the 'stationary' space station. As it passes closest, it flashes. Next, the space station is accelerarated in a straight line that brings the station racing past what is a now 'stationary' strobe. Again, when station and strobe are closest, the now stationary strobe flashes, sending light in all directions again.

After allowing a second for the light to travel three hundred thousand kilometers, the distance the light travels through the vacuum of space (or through any vacuum, anywhere, like here on Earth, for example) in a second, the observers inside the space station find themselves in the very center of a three-hundred-thousand-kilometer diameter sphere of light, while locating the strobe very, very close to one edge of that sphere of light. One second after the strobe's flash, those on the space station always find themselves positioned in the exact center of the sphere of light and the strobe always very close to one edge, *regardless* of whether it is the strobe that 'moves' (i.e. is accelerated), or the space station that does.

According to the space station, it is the *same* simultaneous moment everywhere in every direction. But, it is this simultaneous moment everywhere ONLY according to the station; for the strobe it is not. According to the strobe, this same space does NOT correspond to the same simultaneous moment. Instead, for the strobe, each plane perpendicular to any point along the direction of motion is a plane corresponding to a 'sheet' of the space in a continuous series of simultaneous moments for it. Each sheet corresponds to an earlier moment in time, in a continuous progression of such sheets, each layered upon the other along and perpendicular to the direction of motion, as illustrated at the top of the next page.

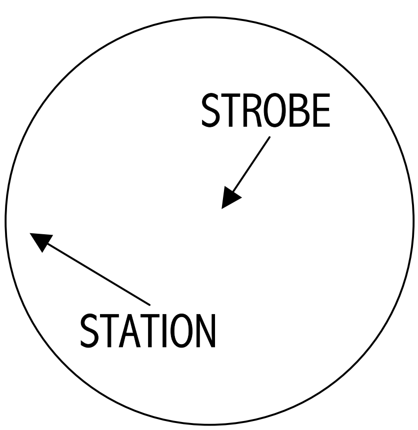
! The strobe's frame of reference* is 'tilted' with respect to the space station's frame, just as the station's reference frame is tilted with respect to the strobe's, as can be shown utilizing the illustration on page 38, applying the strobe to the moving frame, provided that the speed of the strobe is reduced to *half* the speed of light**. This makes each "sheet" illustrated opposite, top, a part of the space corresponding to progressively earlier simultaneous moments in the direction of motion, and progressively later simultaneous moments in the opposite direction. For the strobe, each 'layer' of space perpendicular to the direction of the motion belongs (meaning that each layer corresponds) to a completely *different* moment in time, *not* to the same moment, as it does for the space station. When*** depends upon motion.

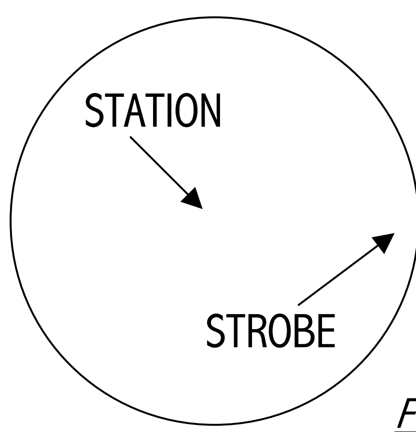
In the illustration shown at the top of the next page, the layers of space behind the strobe lies in its future (that is, correspond to *later* moments), those ahead of it, lie in its past (corresponding to *prior* moments). In the illustration at the top of the next page, the strobe's different layers of space are indexed by the vertical lines. Each layer (according to the strobe's now tilted frame) corresponds to a different moment in time. Thus we see how the strobe's frame of reference appears tilted, according to the space station's frame of reference at a particular simultaneous moment in time, one second after the strobe's flash (again, one second after the flash only according to the space station's reference frame, not the strobe's). But, everything that is true for the station is just as true for the strobe and its frame of reference as well.

* - See Chapters Nine and Eleven for an explanation of a frame of reference, based upon relativity's stipulated 'now', which correspondingly specifies, again, purely as a stipulation, past and future, according to what is 'now', dependent upon motion. Measures of phenomena will vary with motion, in order to conform to *one* set of physical laws.

** - Half the speed of light instead of 'nearly' that speed, as is described in the experiment here, fits the diamond onto the page. *** - And likewise, *where*.

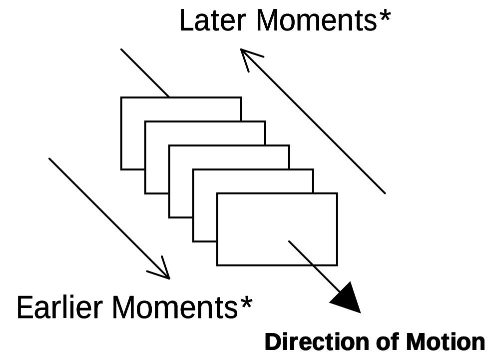
LIGHT SPHERE ONE SIMULTANEOUS SECOND AFTER FLASH, *FOR STROBE*





LIGHT SPHERE ONE SIMULTANEOUS SECOND AFTER FLASH, *FOR THE STATION*

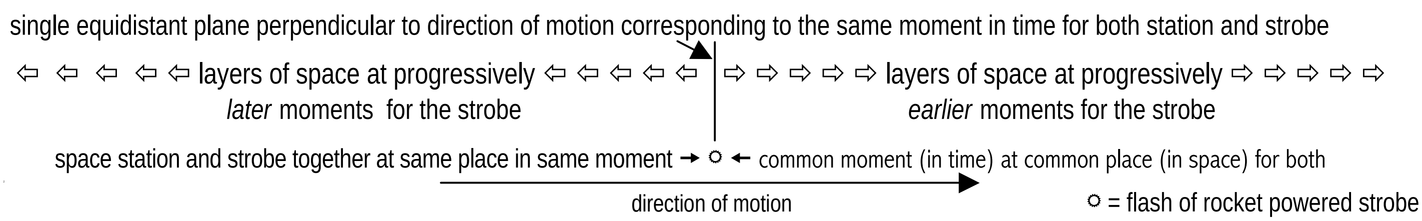
To see the strobe's frame of reference and the single simultaneous moment corresponding to it that we have up until now considered being stipulated for the space station, we can interchange the strobe with the space station in the illustration below, and, positioning the strobe in the center of the sphere and the space station to one edge, tilt the space station's frame of reference with respect to that of the now stationary (at rest) strobe, applying the vertical indexes in the illustration at right to the space station's now tilted frame of reference, the strobe's frame now being 'untilted' (meaning square).



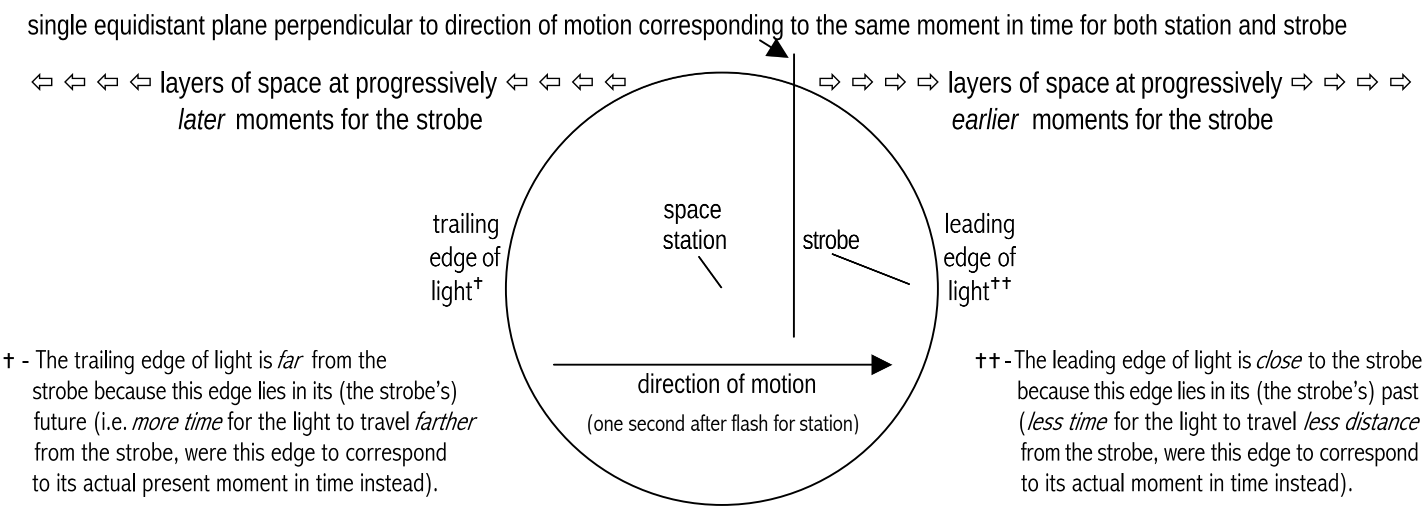
Understanding how one frame of reference tilts with respect to another, we see how time slows, by being stretched out (dilating) and how spatial distances change too by contracting, in both frames, according to the measures of BOTH time and space in any other frame. **Remember, besides being explained in much greater detail in Appendix A, page 89, this experiment is explained again, with great detail, in terms of the two-dimensional surfaces of the surface-time analogy we have been using, in the next chapter.**

* - In the context of the three-dimensional surface-time analogy used throughout the chapter, the progression of parallel surfaces shown in the illustration above would be instead a progression of parallel lines across a two-dimensional surface, each perpendicular to the direction of motion. Additionally, it should be noted that the fact that ***wholly different, physically distinct* moments at once** (together) correspond to what is a single, physical moment, according to a single, particular motion in another frame, **physically demonstrates that past and future are both just as physically existent as any present moment that intersects them** (like in the experiment above) **is.**

THE STROBE'S MANY TILTED 'NOWS' PROJECTED ACROSS THE SPACE STATION'S SINGLE SIMULTANEOUS 'NOW'



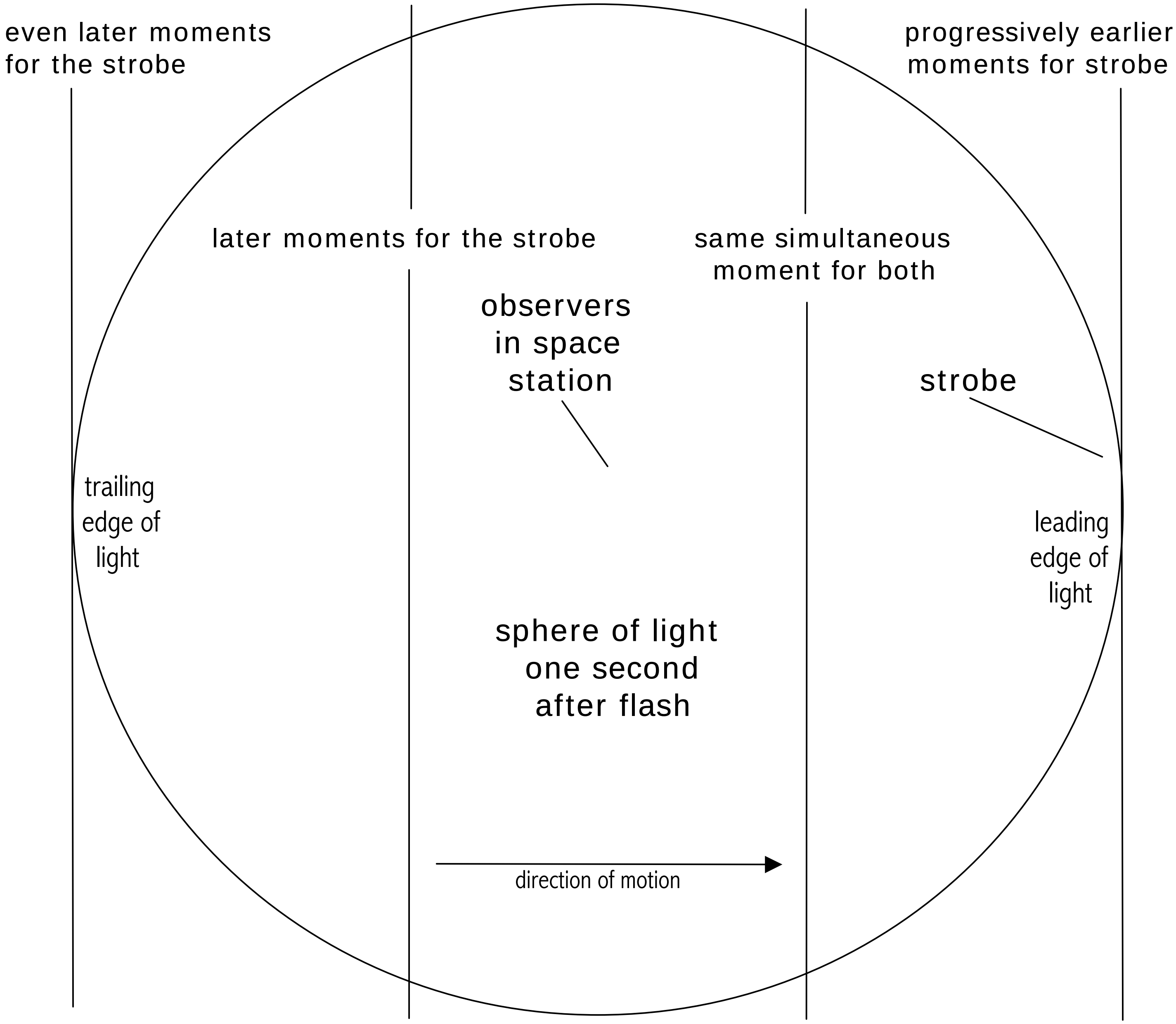
Shown above are the *different* moments in time according to the strobe's tilted frame of reference at the moment of the flash, as they intersect what is the *same* moment in time, across all space, for the station. The vertical line, representing a plane equidistant between station and strobe, is a plane where it is exactly the same time for both. Again, this two-dimensional plane is the *only* set of points where it is the same time for both. Everywhere else (i.e. for all points other than those in the single plane), it is ALWAYS a different time and NEVER the same.



† - The trailing edge of light is *far* from the strobe because this edge lies in its (the strobe's) future (i.e. *more time* for the light to travel *farther* from the strobe, were this edge to correspond to its actual present moment in time instead).

†† - The leading edge of light is *close* to the strobe because this edge lies in its (the strobe's) past (*less time* for the light to travel *less distance* from the strobe, were this edge to correspond to its actual moment in time instead).

Shown above are the *different* moments in time according to the strobe's frame of reference one second after the flash, as they intersect what is the *same* moment in time, across all space, for the station. The vertical line, representing a plane equidistant between station and strobe, is a plane where it is exactly the same time for both. Again, this two-dimensional plane is the *only* set of points where it is the same time for both. Everywhere else (i.e. for all points other than those in the single plane), it is ALWAYS a different time and NEVER the same.



FRAME OF REFERENCE IN THREE-DIMENSIONAL SPACE, TILTED

Shown above is how the strobe's frame of reference "projects" across a single simultaneous moment for the frame of reference for the space station, which is what happens when the strobe's 'stack' of spaces is tilted across the single space of a single moment of the space station, the intersection of the two stacks.

AUTHOR'S NOTE: The reader should take note that the experiment described in this chapter demonstrates the fundamental principle of special relativity: that two completely distinct sets of measures apply to each distinct frame, and most importantly, that although distinct from one another, each set of measures projects absolutely identically into the other, except that each projects as a 'reflection' (that is, in a reversed way). This is why time slows for the strobe ONLY according to the measures of the space station. According to the strobe's measures, the exact *opposite* is true: it is the space station for which time is moving more slowly. In imagining both sets of measures by how each symmetrically projects into the other, resulting in absolutely identical effects, one imagines relativity, at least simple, straight line, special relativity, in a wholly accurate way; just as Einstein did the very same thing, over a century ago, so that others could also see what he had the remarkably good fortune to see first.

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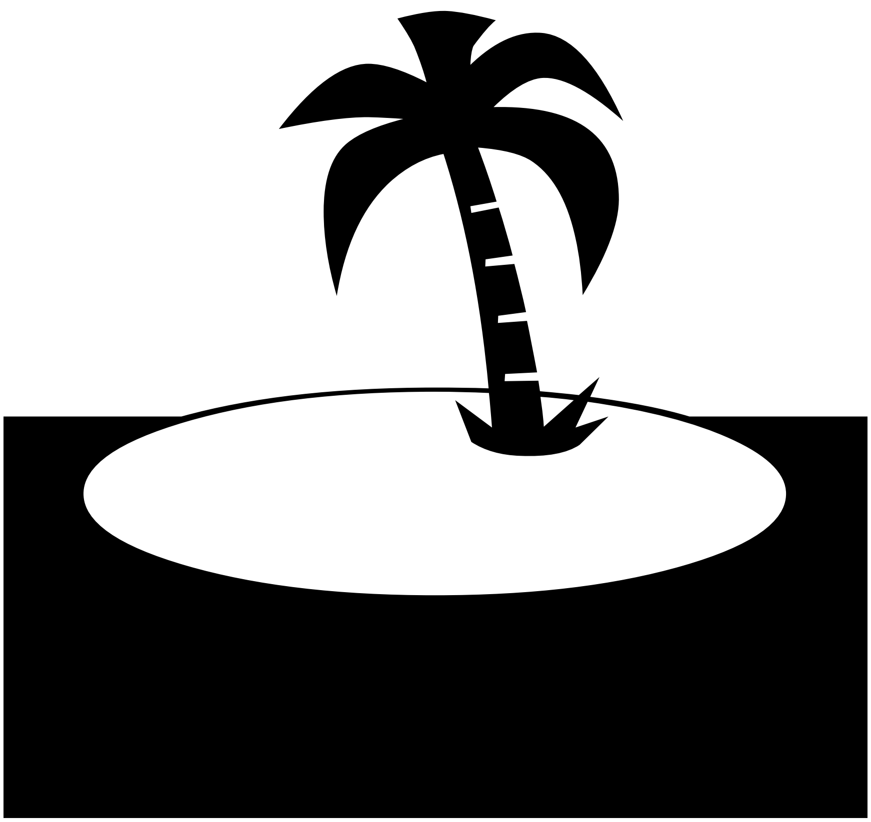

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