The Subtleties of Light

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Abstract

The foundations of modern physics are based upon a conditional constant, a paradox within itself. The "constancy" of the speed of light is valid only when considered in the context of a vacuum or empty space. I propose there is no "caveat" and consequently the speed of balanced, white light is absolute, always 300,000 km/sec. I further propose that the seven monochromatic components of light have absolute, but individual speeds, these speeds differing from the absolute speed of balanced, white light.

Based upon these premises, I explore a different explanation for the geometrical "deflection" of light proposed by General Relativity. I consider the gravitational field as a refractive medium that optically disperses light. A viable solution for the "deflection" of light is considered as a result of the curved path created by these "divergent speeds of monochromatic light." The consideration of this divergent relationship within the very nature of light raises significant questions about the curvature of space-time itself. As a result, this opens the field to the possibility of a non-geometric theory of gravity, one that may more closely align with the quantum theory.

In conclusion, I examine the historical implications of Einstein's quest, his never-ending search for the unification of electromagnetism and gravity, and his personal vision of unity that still guides us today.

Introduction

> "We find the world strange, but what's strange is us. It seems to me that we don't yet read the message properly, but in a time to come, we will see it in some single simple sentence. As we say that sentence to each other, we'll say, 'Oh, how beautiful! How could we have missed it all that time?'"

John Wheeler

When looking at old problems with new eyes, one begins to see the possibility of a subtle, yet elegant unity that exists within the very nature of light. This brings into question the very foundation upon which our current interpretation of physics is based today, the conditional aspect of the constancy of the speed of light, and more specifically, introduces the distinct possibility of absolute, but individual speeds for each of the seven monochromatic components of light.

The overwhelming experimental success of Special Relativity (SR) and General Relativity (GR) to date, suggest that changes in our current understanding of the physical world be fairly subtle, yet still all encompassing. The scope of these changes requires that we reexamine some of the most basic principles of our current view of the physical world. This brings us to some very interesting possibilities, but first it is important to look at what is currently known in some of these areas.

Nature of Light

The constancy of the speed of light is the very bedrock upon which modern physics is built today. As Einstein commented on his own work…"The second principle, on which the special theory of relativity rests, is the 'principle of the constant velocity of light in vacuo.'"[1] Yet, this foundation is built upon a stipulation, a stated condition, that the speed of light is always constant, but only when measured within a vacuum (or empty space). Although empty space constitutes a vast portion of the known universe, (the "discovery" of dark energy and dark matter actually creates quite a bit of unknowns at this juncture) it is still a caveat that raises important questions as to the validity and extent of our theoretical and practical knowledge of the physical world.

The very essence of physics is therefore conditional, dependent upon very exacting circumstances. Something sounds amiss, rather like quantum mechanics, quite frankly. Our use of semantics plays an important role here, as the words we choose have very specific connotations that can greatly influence our thinking. Niels Bohr, who was Einstein's intellectual sparring partner for many years, always stressed the importance of language and the consequent meaning and resulting interpretation of the usage of specific words.

Perhaps the speed of light is not constant, at least not with specific conditions attached to it. The language (and resulting interpretation) that Einstein chose was actually not quite strong enough. Perhaps the speed of light, balanced white light, is absolute, always 300,000 km/sec. With no stipulations or conditions attached. Period.

If the speed of light is considered to be absolute, then other assumptions about physical reality will need to be reexamined in a slightly different context. One of the most significant of these is the interaction of light and gravity, a phenomenon that has been interpreted by Einstein and Newton in very different ways.

The results of Eddington's photographic expedition of 1919 provided a dramatic validation of the effects of a gravitational field on light. It demonstrated unequivocally that light passing through this field would be bent, or "deflected." The basic principles of GR attribute this deflection to the curvature of space-time, in which light follows a geodesic; or in essence the path of least resistance. As Einstein describes in his own words,

> "…according to the general theory of relativity, a ray of light will experience a curvature of its path when passing through a gravitational field, this curvature being similar to that experienced by the path of a body which is projected through a gravitational field." [2]

In essence, it is the space-time that is curved, and not the light. The deflection of light is considered to be one of the major proofs and thus cornerstones of GR. The very origins of GR were based upon the principle of equivalence, which in Einstein's mind, demanded this deflection of light. The cause of this deflection, though, may have more to do with other inherent properties of light and gravitation, rather than the curvature of space-time.

Newton expressed his thoughts on the "bending" of light in *Opticks*. Essentially he proposed that light had weight, and as a result, the effects of this gravitational attraction to a massive body caused the light to bend.

> "Do not Bodies act upon Light at a distance, and by their action bend its Rays; and is not this action (caeteris paribus) strongest at the least distance?" [3]

Einstein extrapolated Newton's theory by proposing that the very nature of space-time was curved, and this curvature caused the deflection of light instead. Suddenly, Newton's "instantaneous" gravitational force was replaced with Einstein's elegant geometrical solution.

Semantics once again plays an important role, as the causal relationship of this optical interaction can greatly influence our understanding of this event. While Newton considered this phenomenon to be a "bending" of light, Einstein considered it to be a "deflection". The differences in these two points of view appear to be linguistically minor, yet the cosmological implications are of the utmost significance.

Perhaps there is another explanation, a completely different scenario that has thus far been overlooked. The optical properties of a gravitational field were discussed by Eddington in his classic *Space, Time, and Gravitation*.

> "Light moves more slowly in a material medium than in vacuum, the velocity being inversely proportional to the refractive index of the medium. The phenomenon of refraction is in fact caused by a slewing of the wave-front in passing into regions of smaller velocity. We can thus imitate the gravitational effect on light precisely, if we imagine the space round the sun filled with a refracting medium which gives the appropriate velocity of light."[4]

The effects of a gravitational field acting as a refractive medium, an optical lens, can significantly alter the direction of light. The well-known Einstein Cross (QSO2237+0305) is a brilliant example of the effects of gravitational lensing, a phenomenon which Einstein wrote about in the 1930's. The effects of gravitational lensing, the "attraction" of light by a gravitational mass, may possibly offer another explanation that may literally bring new light to the subject.

According to *Webster*, refraction of light is considered to be "deflection from a straight path undergone by a light ray or energy wave in passing obliquely from one medium (as air) into another (as glass) in which its velocity is different." [5] However, the dispersion of light, the separation of light into individual colors through the process of refraction, may play an even more important role in understanding the nature of this phenomenon.

Consider the following scenario. It is well known that light will "slow down" in various mediums that refract light, as indicated by their refractive index. In other words, the speed of light varies according to the nature of the medium it passes through. So, once again we have a constant that is based on specific conditions. As the conditions change, the constant changes as well. Yet there is little constancy in a constant that changes according to circumstances. Either the speed of light is constant, or it is not constant. It cannot be both!

The essential element in understanding the subtle nature of this concept, however, is determined by the fact that the speed of the monochromatic components differs from that of white light in various mediums that refract light. As white light is dispersed by its wavelength, each of the monochromatic components will exhibit individual speeds, with red light exhibiting the fastest speed (lowest energy) and blue light exhibiting the slowest speed (highest energy).

Premise

This brings us to a rather stunning conclusion, one that completely contradicts conventional wisdom and yet at the same time creates some very interesting possibilities. It deals specifically with our understanding of the subliminal nature of light, and challenges our senses by proposing a very different scenario. Each of the seven monochromatic components of light has an absolute, but individual speed, which is not the same as the absolute speed of "balanced" white light. [6] These "divergent speeds of monochromatic light" (DSML) will significantly affect the manner in which we have thus far interpreted the results of phenomenon from Eddington's historic expedition of 1919.

A "prism-like" effect is created by the gravitational field as it refracts and disperses white light into its monochromatic components. Being that these component speeds are individual, these variations will cause the light to "curve" toward the center of the gravitational source. As light passes out of the gravitational field, the monochromatic components will once again converge and will exhibit the original characteristics and absolute speed of white light.

The speed of white light is absolute, under all conditions and circumstances. It is always 300,000 km/sec. There is no contingency or stipulation attached. It is a constant without conditions. The speeds of the seven monochromatic components are also absolute, but individual. The variations in their individual speeds cause this dispersed light to turn, much as a rainbow does when light is effectively refracted and dispersed through droplets of water, with each droplet acting collectively as a prism. The longer the light remains within the effects of the gravitational field, the greater the overall degree of the arc.

In essence, it is the light that is curving and not "necessarily" the space-time. The speed of light has been a conditional "constant" on which the foundations of modern physics have been based for many years. When considering the possibility of DSML, a new interpretation of the unconditional and absolute speed of white light begins to emerge.

If the validity of this line of reasoning is found to be correct, it will greatly affect our current interpretation of the physical world. What would be the consequences of this type of absolute constant in the overall scheme of things?

One of the immediate questions raised is the difference in how and why the gravitational field interacts with other forms of electromagnetic radiation traveling at the "same speed." Another question is how this interpretation will affect our current understanding of the cosmological red shift and the subsequent interpretation of a rapidly expanding universe, with all of its consequences and unanswered questions.

This may also open the door for a completely new interpretation of gravity; one possibility is a non-geometric theory that may more closely align with the quantum theory, one based exclusively on Euclidean space. Ultimately, it may also bring into question the principle of equivalence and consequently the possibility of superluminal phenomenon. Other experimental confirmations and interpretations of SR and GR and will need to be reexamined from a different point of view. Many new questions will be raised, literally opening Pandora's Box to a host of new ideas and potentially unifying concepts and principles to those working in these areas.

Varying Speed of Light

In the year 1905, Einstein sent intellectual shockwaves throughout the scientific community by delivering his groundbreaking papers that have irrevocably changed our understanding of the universe. As a result of these daring ideas, the constancy of the speed of light has been a topic of vast speculation for many years. A variety of theories proposing a varying speed of light (VSL) have been considered throughout different scientific epochs, as noted by João Magueijo, one of the more recent proponents of VSL.

> "Even after the proposal of special relativity in 1905 many varying speed of light theories were considered, most notably by Einstein himself…"[7]

When Einstein was making his preliminary determinations on the bending of light by a gravitational mass, he wrote a paper in 1911 entitled "On The Influence of Gravitation on the Propagation of Light."[8] His brief venture into VSL was based on the concept that the gravitational field was, in effect, equivalent to a refractive medium, creating a VSL that was essentially determined by the specific density of the field. He later discarded this concept, as he further developed his theory of GR.

It is ironic but the time period in which he developed and then later rejected this highly speculative concept was during his most intuitive and productive years ever as a physicist. Einstein's initial computations on the degree of deflection were incorrect, however, originally calculating only half of the actual deflection as he allowed for the curvature of time but not yet proposing that space was also curved.

The advent of this realization necessitated the introduction of a non-Euclidean geometry, thereby abandoning the geometry of Euclid that had so inspired him as a youth. It was at this point in time, and this very critical juncture in his life, where the complexities of his work greatly increased. This ensuing endeavor required a deep foray into mathematical mire, in essence, creating the first leg of a solitary path that he would follow for the rest of his life.

Nearly one hundred years later, VSL is currently gaining consideration as a possible solution to problems that appear to be solution less. Magueijo continues,

> "VSL was then rediscovered and forgotten on several occasions. For instance, in the 1930s VSL was used as an alternative explanation for the cosmological redshift (these theories conflict with fine structure observations). None of these efforts relates to recent VSL theories, which are firmly entrenched in the successes (and remaining failures) of the hot big bang theory of the universe. In this sense the first "modern" VSL theory was J.W. Moffat's ground breaking paper, where spontaneous symmetry breaking of Lorentz symmetry leads to VSL and an elegant solution to the horizon problem."[9]

New questions regarding the constancy of the speed of light, however, have been rising more frequently over the course of the last decade. Various theories introduced by John Moffat,[10] Andy Albrecht and João Magueijo,[11] João Magueijo and Lee Smolin,[12] John Barrow,[13] and others are questioning (and rightly so) the very foundation on which our current understanding of physics is based.

Dimitri Nanopoulos, Nikolaos Mavromatos, and John Ellis have expressed the possibility that the speed of light is frequency-dependent, which is only noticeable for light coming from objects very far from the Earth and is based on Newton's gravitational constant. [14] Color based theories on VSL at the Planck length have been considered as well.[15] The theories are varied, many of the results have yet to be determined, but the important aspect here, though, is the fact that valid questions are rising. Something is definitely amiss.

John Moffat is one of few who felt that Einstein was on the right track after all. His work on VSL is somewhat different in that he is attempting to preserve the world of Einstein as much as possible, as noted by Tim Folger.

"If he was first drawn to Einstein by his mistakes, he has come to believe the old man may have been on the right path after all. He just started down it a few decades too soon."[16]

Historically

When looking back in time and studying the very essence of Einstein, an important question arises from his departure with mainstream physics and his solitary search that literally consumed the last thirty years of his life. Why did

Einstein, considered by many to be one of the greatest physicists of all times, turn his back and walk away from this new interpretation of physics that he was so instrumental in creating? Why did this man continue on this solitary path that was so blatantly, and often openly, criticized by many of his contemporaries?

"Einstein's attempt to unify was, to say the least, pre-mature, and he failed utterly. The year 1919 represents the culmination of his career; thereafter, as physicists became increasingly preoccupied with quantum theory, Einstein's views became for his peers a source of puzzlement, sorrow, and finally indifference" as noted by authors Charles Crease and Robert Mann. [17]

Robert Oppenheimer, who became one of the directors of the Institute for Advanced Study, once called Einstein "completely cuckoo"[18] while others believed he should have just gone fishing. One of Einstein's closest friends and contemporaries, Max Born, remarked that the position that Einstein took was "a tragedy, for him, as he gropes his way in loneliness, and for us who miss our leader and standard bearer."[19]

Even Einstein commented himself. "I am generally regarded as a sort of petrified object, rendered deaf and blind by the years."[20] Yet, the reverence in which his earlier works were held by many of his colleagues was aptly demonstrated when over 300 physicists turned up in 1949 for a symposium in Princeton to honor the man and to remember his greatest accomplishments.

Why was Einstein so intent on the unification of electromagnetism and gravitation? Why did he stay so dogmatically attached to only these two forces, when according to Nobel Laureate Julian Schwinger… "The fundamental difficulty with this program is that no physical fact demands such a unification." [21]

Michael Faraday once expressed a similar belief in this elusive relationship, although a failed experiment did not give him the results and subsequent proof he was expecting. "They do not shake my strong feeling of the existence of a relation between gravity and electricity, though they give no proof that such a relation exists." [22] Eddington also concurred as he wrote the following words in 1920. "Yet we cannot rest satisfied until a deeper unity between the gravitational and electrical properties of the world is apparent."[23]

Einstein's unique search was based on his ultimate conviction that the fundamental unification of electromagnetism and gravity would provide the basis for a new and complete description of reality. "His talent was in seeing the unity in phenomena that ordinary people always perceived as different,"[24] remarks Gerald Holton, an Einstein historian. "But still he could find no physical guidance, no magical insight, and because of this, many physicists looked upon his long search with barely concealed contempt"[25] as related by Banesh Hoffmann.

In his younger days, Einstein "…believed that an elementary knowledge of mathematics was a sufficient prerequisite for further work in physics."[26] Later in life, in the midst of his solitary search, Einstein lamented, "I need more mathematics."[27] Schwinger continues with his thoughtful exposition, "It was the absence of any physical clue that forced Einstein to purely mathematical speculation. In this effort, he was ahead of his time."[28]

"I believe that in order to make real progress," he wrote in 1922, "one must again ferret out some general principle from nature." [29] Interestingly enough, the word "ferret" literally means "to find and bring to light by searching."[30] In a letter written to Cornelius Lanczos on 14 February 1938, Einstein remarks some sixteen years later, "I am convinced that a completely new and enlightening inspiration is needed." [31]

However, it was not meant to be. Einstein would never discover the "thoughts of God" that he had been seeking for so many years. He spoke of his regrets to George Wald in 1952, sadly commenting, "someone else was going to have to do it."[32]

In spite of the seemingly insurmountable difficulties in reconciling general relativity and the quantum theory, as well as the collective attitude from his peers that he was literally wasting his time, Einstein nevertheless continued on and persevered with his search. The unity that he was seeking was not an option for Einstein; it was an integral a part of his being, of all that he was and forever would be. Just prior to his death, Einstein placed his hand over his heart and told his good friend Otto Nathan…"that he now felt close to success with his theory."[33]

Some have said that Einstein had a direct pipeline to God, as he would often come up with the answers first, and then spend years attempting to discern the intricacies of a particular theory. He relied extensively on that intuition as portrayed in his well-known thoughts about the quantum theory.

> "Quantum mechanics is certainly imposing. But an inner voice tells me it is not yet the real thing. The theory says a lot, but does not really bring us any closer to the secret of the 'old one.'"[34]

Although Einstein never realized his ultimate goal, his vision of unity never wavered. His conviction that the human mind was capable of comprehending reality remained with him throughout his life. His deep intuitive sense, combined with a steadfast belief in objective reality, shaped the world in which he lived.

For some time after his death in 1955, it appeared that Einstein's dreams of unification died with him. A small group of physicists carried on, but unification was definitely not at the forefront of scientific inquiry. Fifty years have now passed and unification has become a major theme with many different faces and scientific venues, as noted by Lee Smolin.

> " theoretical physics has finally caught up to Einstein. While he was shunned in his Princeton years as he pursued the unified field theory, the Institute for Advanced Study, where he worked, is now filled with theorists who search for new variants of unified field theories. It is indeed a vindication of sorts for Einstein because much of what today's string theorists do in practice is play with unified theories of the kinds that Einstein and his few colleagues invented." [35]

However, there are fundamental problems that have been plaguing physics for many years now; one of the greatest is the difficulty in reconciling quantum mechanics and general relativity. Many of the best and brightest minds in the world have been attempting to resolve these problems, but to no avail. Elaborate theories have been constructed in incredible detail, using vast mathematical tools while delving in many different directions and literally countless dimensions. The sheer energy and mind power behind the development of these theories is staggering.

Yet the amiable reconciliation of these two contrasting theories is still in great question. Even Einstein questioned the compatibility of the two theories into one, "The theory of relativity and the quantum theory… seem little adapted to fusion into one unified theory."[36] In a letter to Leopold Infeld in 1941, doubts about the future of his own works begin to surface. "I tend more and more to the opinion than one cannot come further with a continuum theory."[37] Einstein even goes further in a letter to his friend Michele Besso in 1954. "I consider it quite possible that physics cannot be based on the field concept, i.e., on continuous structures. In that case, nothing remains of my entire castle in the air, gravitation theory included, [and of] the rest of modern physics."[38]

World-renowned scientists with significant achievements in long and illustrious careers, are raising questions and sensing that something is still not right. Listen closely to their following words, as they seem to echo the very sentiment of Einstein from a time not so very long ago.

Gerard 't Hooft shares his thoughts in a recent article in Nature exploring current opinions about "The theory of everything?"

> "I suspect that the favoured interpretation of quantum mechanics

> will have to be revised. I am not saying that quantum mechanics is wrong or incomplete. But I do think that an ultimate theory will not have any stochastic elements: I side with Albert Einstein, who always suspected that nature's true equations would not allow for gambling."[39]

As others express their views as well, Roger Penrose discusses a similar belief.

> "…in my opinion, we are nowhere close to an accurate, purely physical theory of everything. I find it remarkable how many physicists will express the view that, despite some missing details and unifying concepts, we know virtually all we need to know to describe the fully detailed physical behavior of systems — at least in principle.'[40]

Carlo Rovelli concurs with his own comments.

> "Rarely have we been so far from a theory of everything. Thinking that we might be close to it is the common error of those who mistake their own expectations for the ultimate truth."[41]

Our world has become so very specialized, so intrinsically detailed that it is often difficult to see what is most obvious. The extent of our world of knowledge has grown immeasurably since the death of Einstein, but are we really any closer to understanding the true nature of the physical world. Something is definitely wrong; there is something fundamentally incompatible within our current understanding of the physical world.

The bottom line: it just does not, and will not, work.

According to Helen Dukas, Einstein once remarked, "that he thought physicists would understand him a hundred years later."[42] Perhaps the time is drawing near when new ideas and theories will offer broad insights and distinct revelations. A new and more definitive understanding of the nature of light may illuminate some of the seemingly insurmountable problems still faced between general relativity and the quantum theory.

The definitive book by Penrose, *The Road To Reality*, concludes with a dramatic statement from a 2500-year discourse on the history of the development of our cognitive understanding of the physical world.

> "It is quite likely that the 21st century will reveal even more wonderful insights than those we have been blessed with in the 20th. But for this to happen, we shall need powerful new ideas, which will take us in directions significantly different from those

currently being pursued. Perhaps what we mainly need is some subtle change in perspective - something that we all have missed…."[43]

Conclusion

The question before us is really quite simple! What is wrong with our current conception of reality? On what erroneous basis have we developed such elaborate theories that have wreaked so much havoc in attempting to understand the beauty and simplicity of the natural world?

Perhaps it is time to start over, to go back in time to the very source of the problem, our understanding of the nature of light. Perhaps we need to be more precise in our thoughts, our language, and our ultimate choice of words that describe the very foundation upon which our understanding of physical reality has been based.

Historically, it has been repeatedly demonstrated that new theories are often an extrapolation of the old, combining certain elements, discarding others and redefining our view of the world as we know and understand it. It is very important to remember, though, that it is only our interpretation of the world that has been incomplete. The world is, as it always has been; it is only our lack of understanding that has kept us from seeing through this illusory veil that nature has so eloquently presented.

This brings to mind the very words of Einstein, his famous quote that was literally set in stone by the mathematician Oswald Veblen in Princeton's old Fine Hall. "Raffiniert ist der Herrgott, aber boshaft ist er nicht,"[44] which is interpreted as "God is subtle, but he is not malicious."[45] As Einstein once explained his thoughts to Veblen, "that Nature conceals her secrets by her sublimity and not by trickery."[46]

The concluding statement of *Einstein's Dream: The Search for a Unified Theory of the Universe*, as written by Barry Parker, sums it up quite well.

> "What is important is to be able to look at old ideas in a new way. As some have said, 'You need crazy ideas - crazy enough to work.'"[47]

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