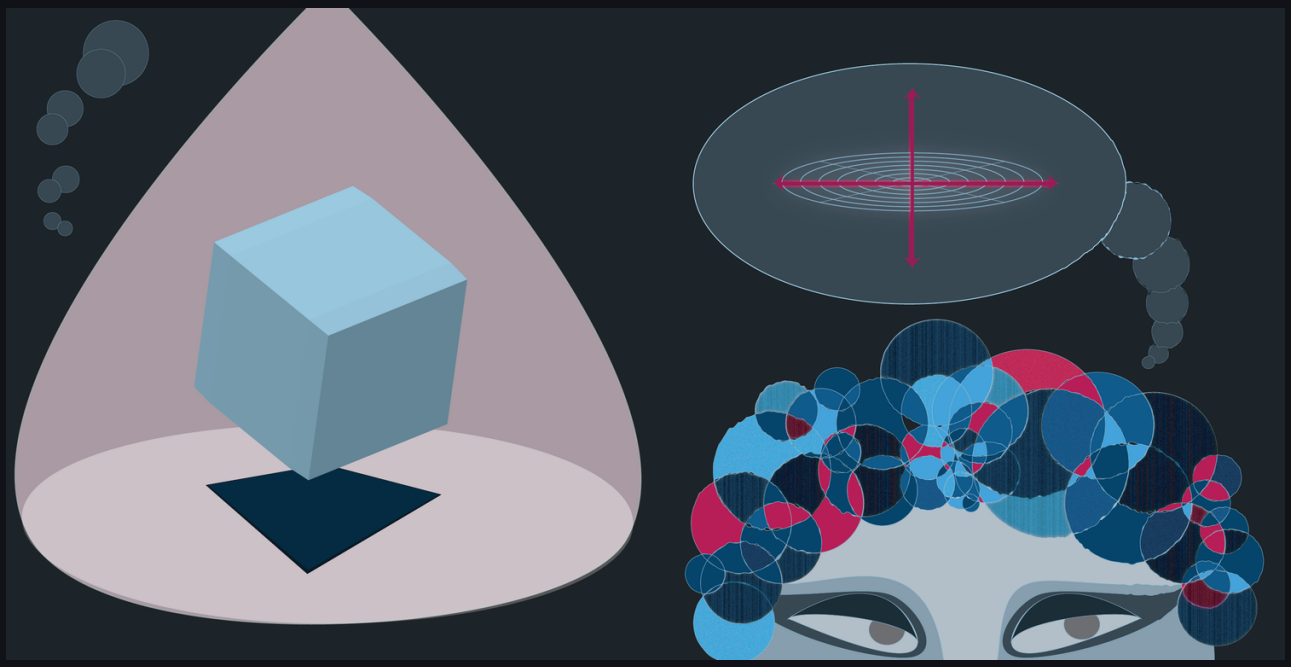

Mar 12

What Does It Mean For Something To Exist In Physics?

Astrophysics & Cosmology, Material Science, Mechanics

The word 'exist' is central to many, if not all, scientific discussions yet is almost never defined unambiguously and then utilized in such a consistent fashion that it can be applied across subject matters without contradiction. It seems that this confusion is perhaps central to the apparent stagnation of theoretical physics. The discipline is seemingly unable to rectify General Relativity with Quantum Mechanics, and this appears to be at the heart of the modern scientific failure to establish a unified physical picture of our universe. Because physics is foundational to chemistry, biology, and hence all of science, this is a serious issue*.

Math, a quantitative system of deductive inference, has been wildly effective precisely for its syntactical flexibility. As a means of communicating ideas, math utilizes a highly generalizable architecture that it can, with astonishing clarity, describe any idea no matter how abstract or *unreal*. Math also allows us to describe any recurring events parametrically in order make extraordinary predictions.

Math has thus allowed for the efficient technological production of a wide stable of useful inventions from the radio to the television, but it cannot save physics.

Why? Because despite the technological success of math's flexible syntax, its failure to distinguish between objects and ideas has evinced endless confusion for science at

large, the most prevalent of which concern the well-known logical fallacy of reification, whereby a map is mistaken for the physical ground it stands on.

Obviously, scientists who predominantly examine a map in order to develop a new more detailed map are going to lose touch with reality.

Unfortunately, many leading physicists since Einstein have concerned themselves almost exclusively with pure mathematics; i.e. the map.

Here's the thing, a word is merely a symbol for an idea. All words, and hence all ideas regardless of the language, can be divided into one of two categories: objects and ideas. For the purposes of explaining phenomena in physical reality, an existing object is a body with a location. An object is a thing with a surface: boundaries separating the inside from the out. Objects have inward extension. An idea, on the other hand, ideas abstractly link one existing object and another or an additional idea. Thinkers across the ages including Aristotle, Euclid, DeCusa, and Aquinas were acutely aware of this distinction and went to great lengths to preserve the dichotomy. An idea is thus irrational for the purposes of physics if it cannot be whittled down to its component physical actors.

The trouble is that mathematics, as a pure discipline, has no built-in distinction between objects and ideas. As long as actions can be quantitatively related, a logical mathematical statement can be made. Physics, on the other hand, necessarily begins with existing objects. Many will recall kinematic diagrams from introductory physics classes where a block is forced about on a table or within a pulley system.

We always start with such an object in physics because it is the science that principally deals with the dynamics of existing bodies.

The authority of mathematics took Einstein, himself, quite by surprise it seems. He once wrote:

> *"How can it be that mathematics, being after all a product of human thought which is independent of experience, is so admirably appropriate to the objects of reality?'*

The answer is that while mathematics can indeed describe objects adeptly, it can just as well describe ideas and it absolutely cannot tell you which is which. This means that math is not the cure-all for explaining natural phenomenon. As I've said previously, math is merely a tool and like a sharp blade, if applied incorrectly can wreak a lot of havoc.

Dr. Sabine Hossenfelder, a recent defector from the mathematical physics camp, has gone to great lengths to reveal the extent of this confusion in her book, "Lost in Math." Hossenfelder details discussions with various leading experts from the field as they detail their passion for aesthetic beauty in theoretical math. None seem in any way concerned with physical objects in their work. Recall that the particles of the standard model are in fact indexed matrices of dynamic measurements.

Even fermions like the electron turn out to be functions which describes the predictable results of experimental activities. It turns out that subatomic physics is built entirely out of relationships between actions, without a single physical actor.

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Apr 18, 2021, 2:12 PM

Think about it, when was the last time you saw a non-symbolic illustration of an electron? You haven't. Even works like this, which claim to have photographed an electron, turn out to be indirect visual [illegible] imaged because the electron is an accounting notion, not a physical object. The notion of electron actually represents the location and momentum of the electrically interactive surface of the atom. And while this way of treating the electron has done wonders for technology, it has taken us farther and farther from understanding the atom's physical structure and how it mechanistically accomplishes its mysteries: light, gravity, electricity, magnetism, and chemical bonding.

How can we retain the distinction between object and idea at this point in our scientific evolution? Well, the initial solution is to unambiguously **reserve the word 'exist' for physical objects with definite locations** and instead **call upon the word "occur" for ideas like time, patterns, functions, and dynamics.** Let's call this the "Something, Somewhere" principle of physics. We must always start a physical model with some existing structures, located somewhere specific with respect to other objects, otherwise we are describing a sea of activity with no actors.

An object can *only* be conceived of so long as it has a surface with boundaries separating the inside from the out. Afterall one can conceive of a unicorn so long as it is described, mathematically or otherwise. But in order for that object to exist it has to also have physical place: a set of static distances to all the other objects in the scene.

> In physics, moving inexistent objects or even real ideas about is egregiously fallacious. Only existents move in physics. And only such objects can ever be regarded to cause motion, and hence phenomena.

It's time we got down to using consistent language in our physical theories, so that we can begin to explain what is actually happening out there. If I have a deadline to meet, that deadline occurs, it does not exist. Similarly, the photon doesn't exist, it occurs. The atom and the Earth exist. Bosons, electrons, and all other waves are actions, not actors. They don't exist, they occur. Once we make it past this confusion, I believe we can finally get down to making sense of the very tiny and very large parts of our universe. It will also require us to identify or at least hypothesize physical actors, which might be responsible for all this well-documented quantum and relativistic activity.

**While the above views are my own, the idea of the abuse of the word "exist" in science was first brought to my attention by Bill Gaede. You can check him out at his YouTube channel here. Blogger Fatfist also inspired ideas in this post and throughout this channel.*

Michael Shilo DeLay, Ph.D.

Michael Shilo is a secretary of Nature. He completed his graduate work at Columbia University investigating the mechanics of nano-confined water.

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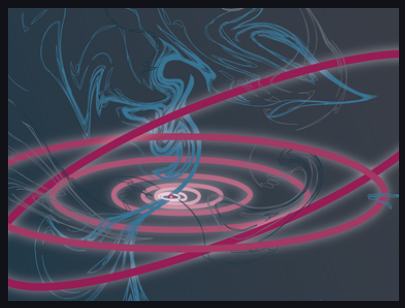
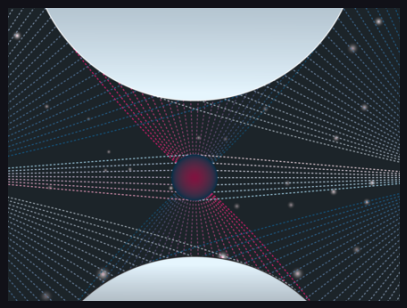


Feb 28

What Causes Inertia?



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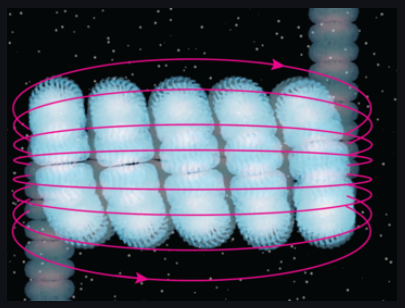

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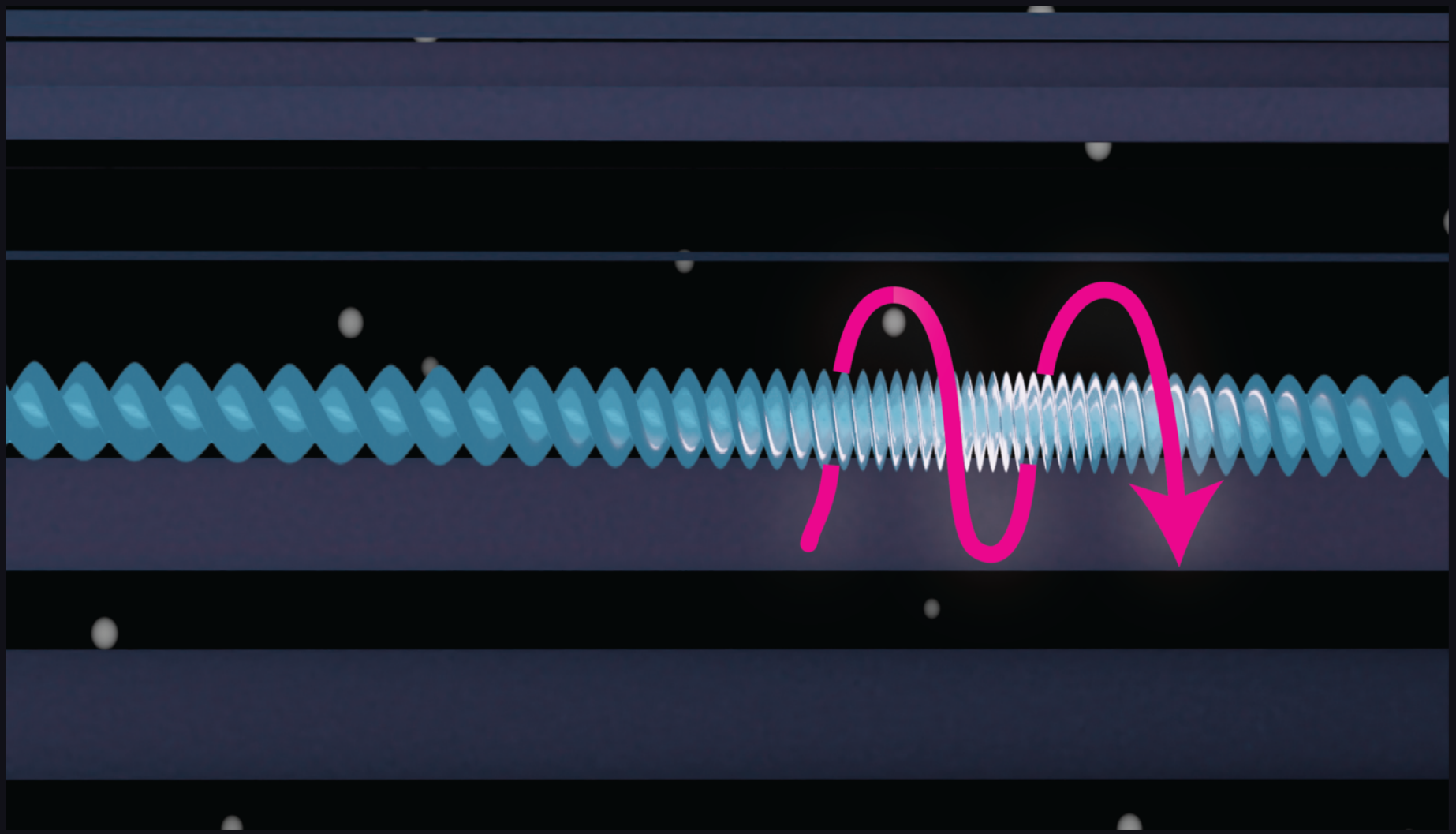

Feb 22

What is a Photon? What is Light?

Mechanics, Material Science, Light & Gravity

Where Does Light Come From?

Humans are visual animals. Unlike many of our mammalian cousins who depend upon smell, like the rats that we love to use as models for so many of our pathologies, we absolutely prize visual sensation in our daily lives. So much of our language points to this paradigm being deeply rooted in our evolutionary history.

In the words of Julian Jaynes, we "'see' solutions to problems, the best of which may be 'brilliant', and the person 'brighter' and 'clear-headed' as opposed to 'dull', 'fuzzy-minded', or 'obscure' solution." Quite ironically, the process of vision, and the phenomenon of light in general, despite longstanding adulation from from the science and mathematics communities, remains one of the murkier processes in all of nature to imagine. That is...to visualize.

Everyone from Hooke to Newton and Descartes puzzled over the mechanism behind light. If the drama interests you, check out my deep-dive into the history of those investigations, which I've laid out in a multi-part blog series called the Life & Death of the Aether. Needless to say, several thousand years of study eventually resigned to a familiar, yet paradoxical stalemate explanation for light: it's both a flood of discrete bursts called photons that sometimes behave as bullet-like particles and at other times interfere with one another like periodic impulses, or waves. There is a litany of experiments that justify both of these opposing interpretations, but don't worry - we are

well prepared to rationalize each of them in due time with the mechanical visualization proposed below.

Often the atom and light are described schematically. This can be seen in the Bohr model, with electron beads circling a nucleus. Though mathematically, the atom is no longer considered to behave this way, visual representations of modern quantum descriptions of light are scant. We propose to improve upon contemporary "particle/wave" animations, while preserving the topology of the well-elaborated, empirically anchored maths.

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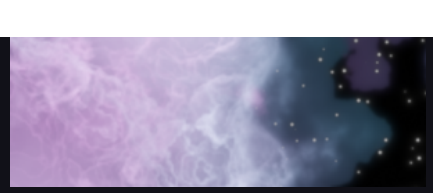
A Physical, Object-Based Model of the Photon



In the Lab...

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Apr 18, 2021, 2:12 PM

Light begins with atoms. We choose to invoke hydrogens as our atoms because they are the simplest, each having a single electron shell. From myriad empirical foundations, it has been established that 99.999% of that electron exists within 430 pm of the nucleus, while the remainder extends indefinitely. This bizarre characteristic of the atom is described under quantum mechanics by the radial distribution function (RDF) of the electron. We illustrate the tiny, thinned 0.001% of the electron (e-) shell as tiny radial filaments extending from the atomic surface. Experimentation and the corresponding RDF from quantum tell us that there is a small probability that the indefinitely extending electron-shells of any two atoms overlap, and we illustrate this possibility through these helically entwined filamentary extensions of each e-shell.

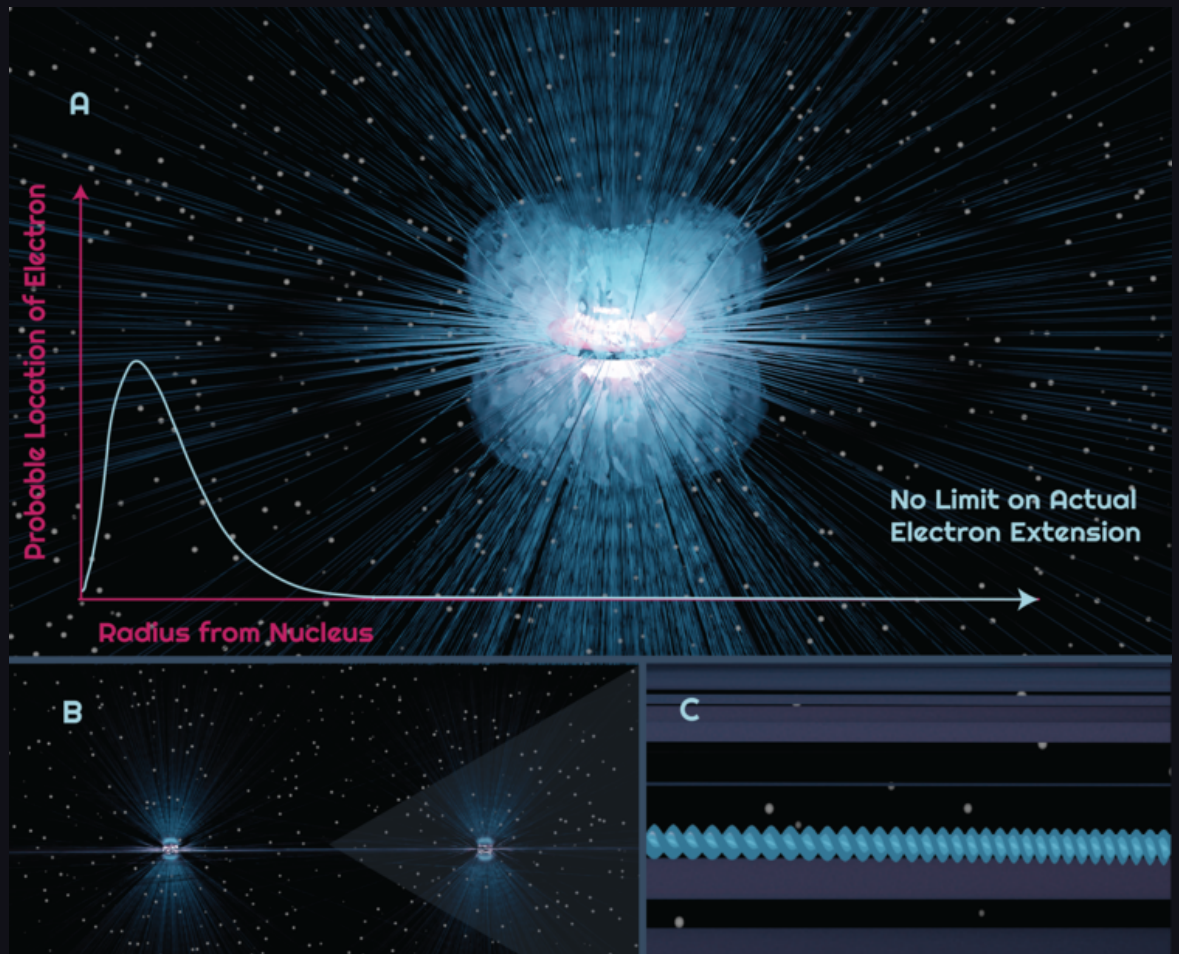


Fig 1| Overlapping e-shells Link Atoms. The radial distribution function of quantum mechanics **(A)** describes that a very thinned portion of the electron can be found to extend indefinitely, which we illustrate as a filament extending from the e-shell's surface. Any two neighboring atoms **(B)** can be considered linked to their neighbors since these thinned electron filaments overlap weakly. To visualize light, and later gravity, is useful to illustrate these overlapping e-shells with a helically entwined filaments, as shown in **(C)**.

Importantly, this overlapping e-shell substructure, as above illustrated as helically entwined e-shell filaments, is purely hypothetical. This means that while such structures are unknown and yet completely consistent with all of what *is* known. Descartes defined the term 'hypothesis' as a statement that is not submitted as necessarily true, but if true would be sufficient to explain the given phenomenon. By submitting this helical e-shell structure as consistent with the wealth of atomic data, we can begin to make sense of the photon using that hypothesis.

Now that we have a mechanism for how our atoms are connected, it is possible to imagine the photon as an elastic deformation of this hypothetical structure. Almost immediately, several features of light are clarified. First, the entwined and tensioned e-shells prepare a rectilinear path is between any two atoms. This captures the empirical fact that light follows a straight path like some sort of idealized bullet. It also secures a cause for gravity, but this is a story for another day*. We can also see that deformation of our interconnecting helix is easily be imagined to propagate as a wave, explaining the self-sustaining EM wave description of light. Recall that magnetism is produced by the motion of the e-shell orthogonal to the poles. Later posts will consider physicalizing interference of light using the model.

The natural question is – why does the intertwined electromagnetic structure deform and conduct light waves in the first place? We reflect classical photonics and quantum

mechanics in order to represent this *cause* of light. Presently, it is known that a photon is emitted when an excited electron transitions to a lower energy state. As such, we signify electron-energy through a vibratory breathing motion of the e-shell. High-energy electrons are depicted to expand and contract quickly while low-energy electrons breathe slowly. We know that the cause of this excitation may be a photon from another atomorelectric/chemical/thermal stimulation. Thus, it becomes clear that light begins with a dis-equilibrium between the energy state of two atoms and terminates dissipatively with energy equalization. It is a rebalancing process. But what can that possibly mean in terms of the work of physical atoms?

Because we may consider the atoms to be physically connected through entwined e-shells even at extraordinary distances, we can finally rationalize the atomic electron transitionthat results in the emission of photons. When any two entwined atoms have e-shells that are energetically equalized, breathing in harmony such that no pressure is exerted on their connecting structure, there is darkness…the silence of light! We can imagine that as one atom expands, the other contracts. A back and forth torsion of the interconnection proceeds harmoniously and incessantly. But only until the balance is upset.

When one atom's electron becomes excited and begins to breathe more quickly, this puts a progressively antagonistic torsional pressure upon their entangled e-shell filaments. The result is that this e-shell induces its partner to also expand and contract more quickly, elevating her energy-state in the process. In compelling the second atom to transition into an excited state, the first atom stresses their shared interconnection to progressively deform. This synchronous deformation of the partner atom's e-shells is the photon of radiation. This is not a new theory but rather a visual restatement of the facts. After the photon, the first atom breathes slightly slower, signifying energetic dissipation, and the latter slightly faster. With energy-states matched, darkness resumes between the atoms.

*Note: This idea of photonics, including the expanding and contracting e-shells idea was initially inspired by, but not to be conflated with Gaede's "Rope Hypothesis," which you can learn about here.***

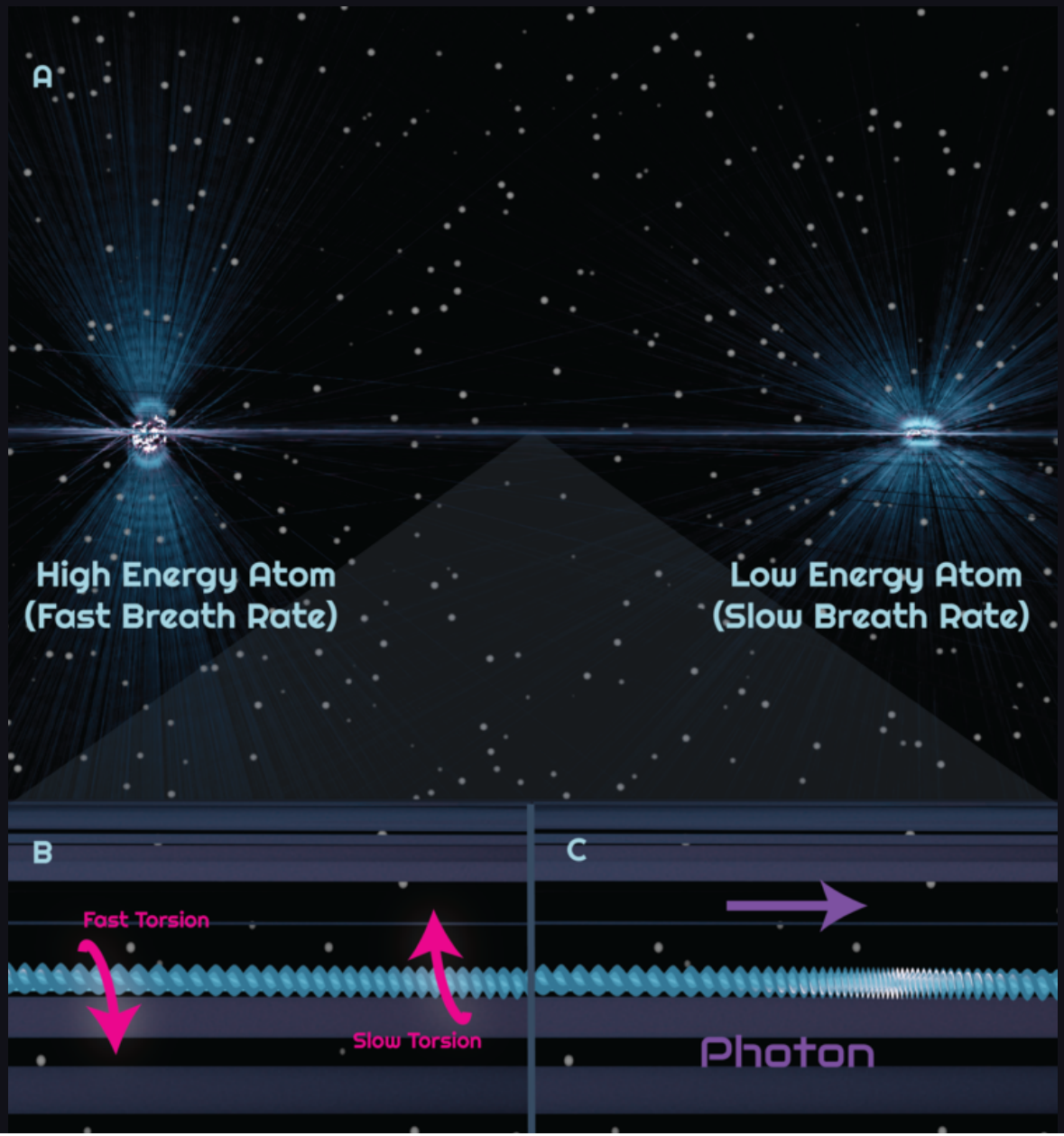
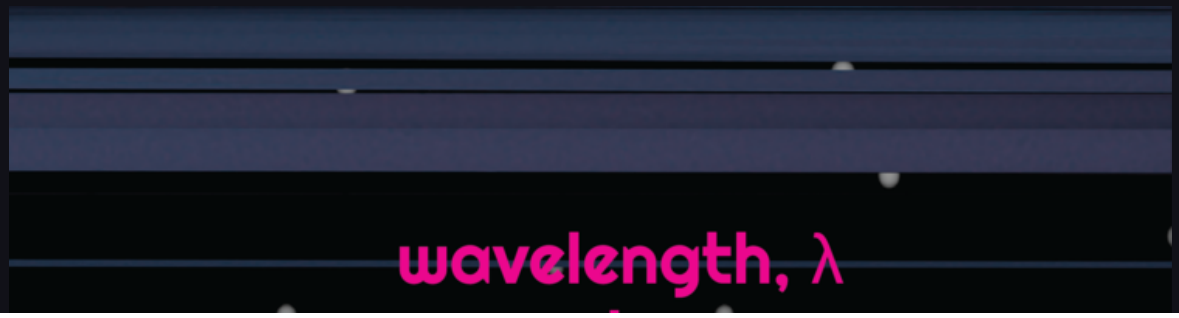


Fig 2| The Photon. The photon is long considered a product of the atomic electron transition, where a high energy electron relaxes to a low energy state. We illustrate electron energy with speed of the e-shell's expansion and contraction; a breathing motion where breath-rate signifies energy state **(A)**. Using this model, a high energy electron loads more torsional pressure upon the linking structure **(B)**. Eventually, this lop-sided torsion transmits impulse to the neighboring atom and deforms their interconnecting e-shells in the process, observed as a photon **(C)** and resulting in equalized energy between the atoms.

The photon can thus be easily imagined as a physical signal from one atom to its neighbor across their overlapping e-shells, which can be thought of as entwined e-shell filaments. This is essentially dissipation of surface tension, where the surface of the atom is the electron shell. Light is thus imagined as a discrete torsional deformation of the thinned, elastic tails of atomic e-shells, such that each photon is a singular event with a specific strength, or energy.

The more that atoms are energized, the more wound up the electron interconnection, even after equilibration. Note that the helical interconnection displays a natural periodicity, or wavelength, which signifies the wavelength of photon that might pass from one to the other. The wavelength of the helix naturally shortens as the filament is wound tighter and tighter during progressive excitation. This feature of the interatomic helix symbolizes the well-established inverse relationship between wavelength and energy of the photon.



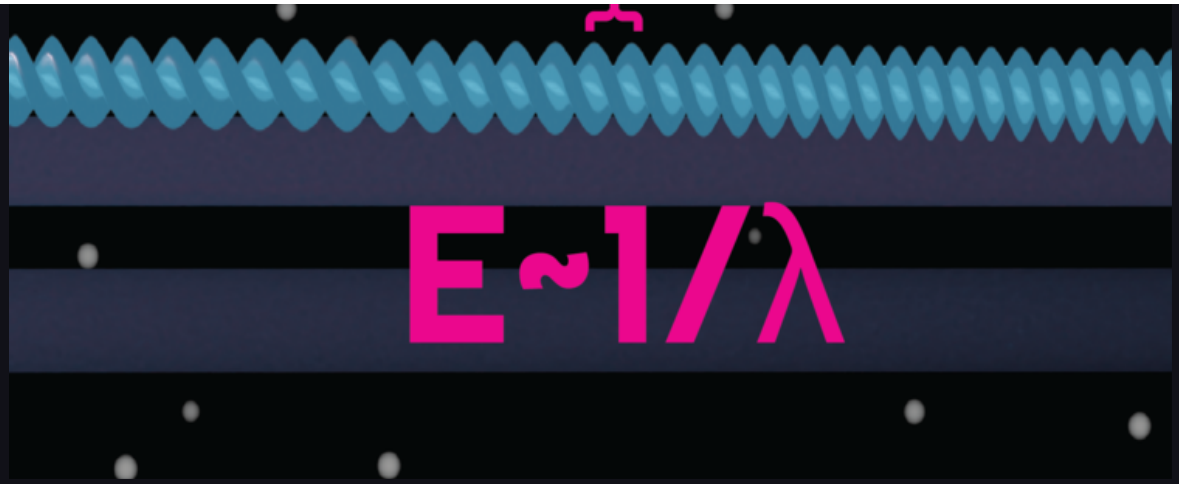


Fig 3| Wavelength-Energy Relationship. By representing entwined e-shells as a helical interconnecting structure that deforms to produce the photon, we can easily capture the energy-wavelength relationship. We can imagine that as the interconnecting structure is loaded torsionally, it will store energy elastically in proportion to the emitter atom's electron energy much like a torsion spring.

We hope this model of light serves you well. Future posts will follow up on the nuances of light's bizarre behavior. We'll use our nodal atomic model to explain reflection and relay/transmission as well as "wave interference" issues like diffraction and dispersion. Eventually we'll make it through all of your favorite atomic phenomenon. Please share your ideas in the meantime – the comments section on YouTube is wide open or feel free to shoot us an email!

Notes:

* Entwined e-shells can be termed "photogravitational helix" for this reason. These PGHelices will be invoked to physicalize gravity in an upcoming post.
** The atoms illustrated above are made of fiber, which is consistent with empirical findings, unrelated to Bill Gaede's thread world.

Michael Shilo DeLay, Ph.D.

Michael Shilo is a secretary of Nature. He completed his graduate work at Columbia University investigating the mechanics of nano-confined water.

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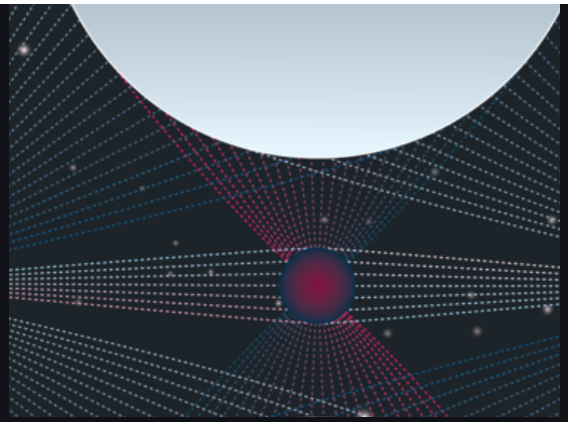
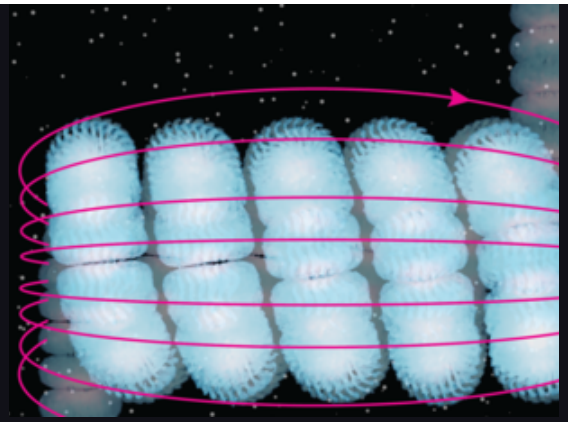
Why Is Light Speed Limited?



Mar 7

If Not Amount of Material, What Causes Mass?



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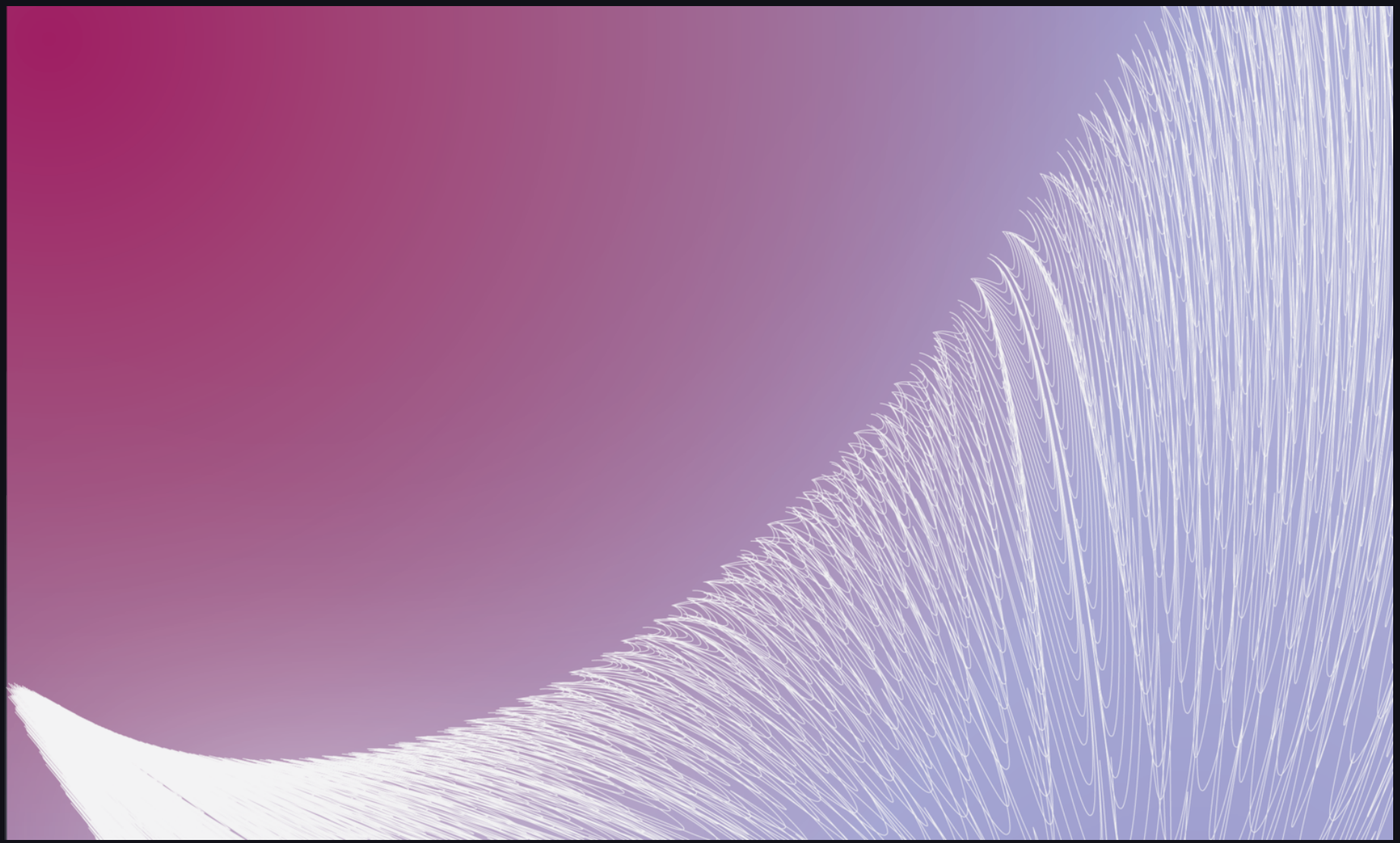


Feb 21

Why Is Light Speed Limited?

Material Science, Mechanics, Light & Gravity

Recently, we looked into the notion of time-travel and the notion of time itself. This investigation led to the realization that the laws inscribing the behavior of bodies in motion, including clocks, breakdown when their speed approaches that of light. Today I want to briefly talk a bit about the speed-of-light, and consider physical interpretations of what this limit could imply about the physical actors involved in the phenomenon.

Of course the speed-of-light (SOL) refers to the speed at which light having been emitted from a source material terminates upon another. But

what a lot of people don't realize is that the SOL is also the limiting speed by which many other poorly understood processes occur including gravity and electricity.

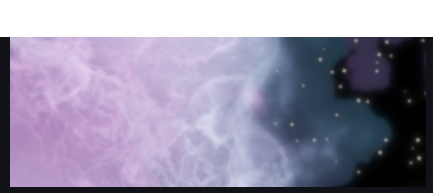
For all intents and purposes, the SOL appears to limit the speed at which events can occur in physics. This is important and obvious, because if certain events could proceed faster than light, gravity, or electricity, we would constantly be running into the consequences of actions before we perceived the actions taking place. Lightning would strike us before the storm. We would fall from the plane before parachuting out. Obviously, this violates our entire sense of rationalizing causality and cannot be

so. But what does this mean about the nature of light, gravity, and electricity as physical phenomena?

First we have to consider what a limit on speed implies for any phenomenon. Consider a ball rolling down a mountain. The ball will start out rolling slowly and accelerate according to its increasing gravitational potential but if the mountain is tall enough, eventually the speed of the ball will become limited. Why? Because the pull of gravity will be directly matched by the impeding pressures of resistance from friction-type enmeshment with soil and rocks as well as resistance from the air it must displace in order to move forward. Limits on motion in physics are provided exclusively by resistance from some other physical actors. In other words, existing objects in the path of motion are the sole cause of speed limits.

In order for the ball to make its way down the mountain, it must deform its environment. That is, it must move air, dirt, rocks, and also overcome inertia.

We'll explore the cause of this phenomenon of inertia next time but for today, consider that light, like all physical processes appears subject to the same line of reasoning. As light is a physical event, actors involved in the phenomenon must be expected to physically deform their environment. The speed of the phenomenon must imply an equilibrium by which forward acceleration is balanced by this resistive deformation of a material environment. But beyond the atoms at either end of the transaction, who are the intermediate actors when it comes to the phenomenon of light?



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This is a difficult question to answer with any certainty because physical actors involved in light appear not to have been identified. Perhaps because the tools we use for probing our physical world are comprised on these very actors and that makes their direct detection impossible by definition. For instance, we recognize that light can be accurately described in terms of the transit of photons. These photons are discrete events occurring across the span between atoms. But photons don't appear to be actors in the sense of material objects foundational to physics. Recall that photons do not necessarily appear to transfer material between atoms, but yet they do appear to transfer pressure. How can this be possible?

Well one option is that the photon is merely a wave of deformation of some existing structure that spans the distance between the emitting and receiving atoms.

This would neatly explain the limit on its speed and ability to convey pressure without material transfer. Simply put, the emitting atom only has so much power that it can drive into that bridging structure and that limits the forward impulse. That such an interconnecting structure has limits on deformation speed which also appear applicable to gravitation could indicate that the same structure is responsible for mediating that invisible phenomenon as well. So what is the structure, the shape, of this mediator of light and gravity?

I believe that while it might be tempting to consider that the popular notion of spacetime would be a ripe candidate for this interconnecting structure, it is a grave oversimplification and patent reification. A reification is when some activity or concept is fallaciously treated as a physical object. In my recent article on spacetime, I explain that

the notion merely represents an index of measurements. It is not a material actor with a shape or surface capable of pressuring other physical objects. Quite frankly, scientists do not yet have a consensus about the nature of whatever structure conveys light and gravity. Indeed, on account of their powerful descriptions of those phenomena, most experts are not even looking for physical actors. But as I've pointed out for you today, **it seems absolutely necessary to explain light and gravity in terms of a deformable mediating material between the terminal atoms.** Hence the limit on speed of photonic and gravitational action.

Next time, we'll investigate the notion of inertia; why objects at rest stay at rest and why objects in motion remain so unless pressured otherwise. Perhaps inertia will give us some clues about the structure of the necessary but hypothetical photogravitational connection between atoms.

speed of light, gravity, physics

Michael Shilo DeLay, Ph.D.

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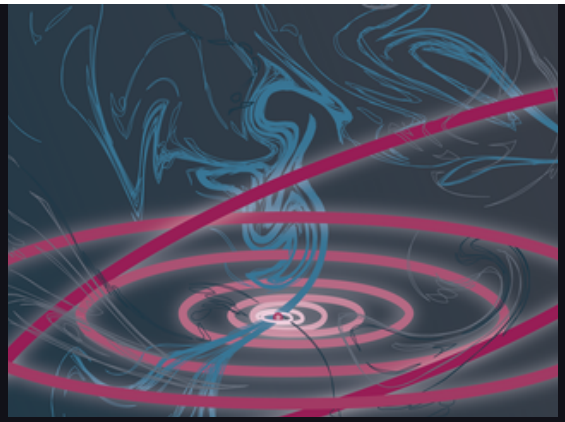

Feb 28

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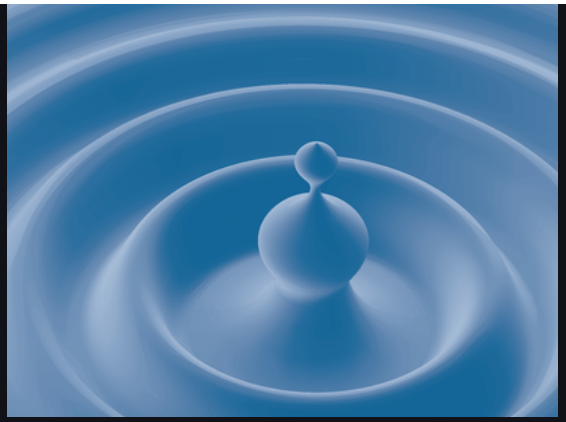

Mar 5

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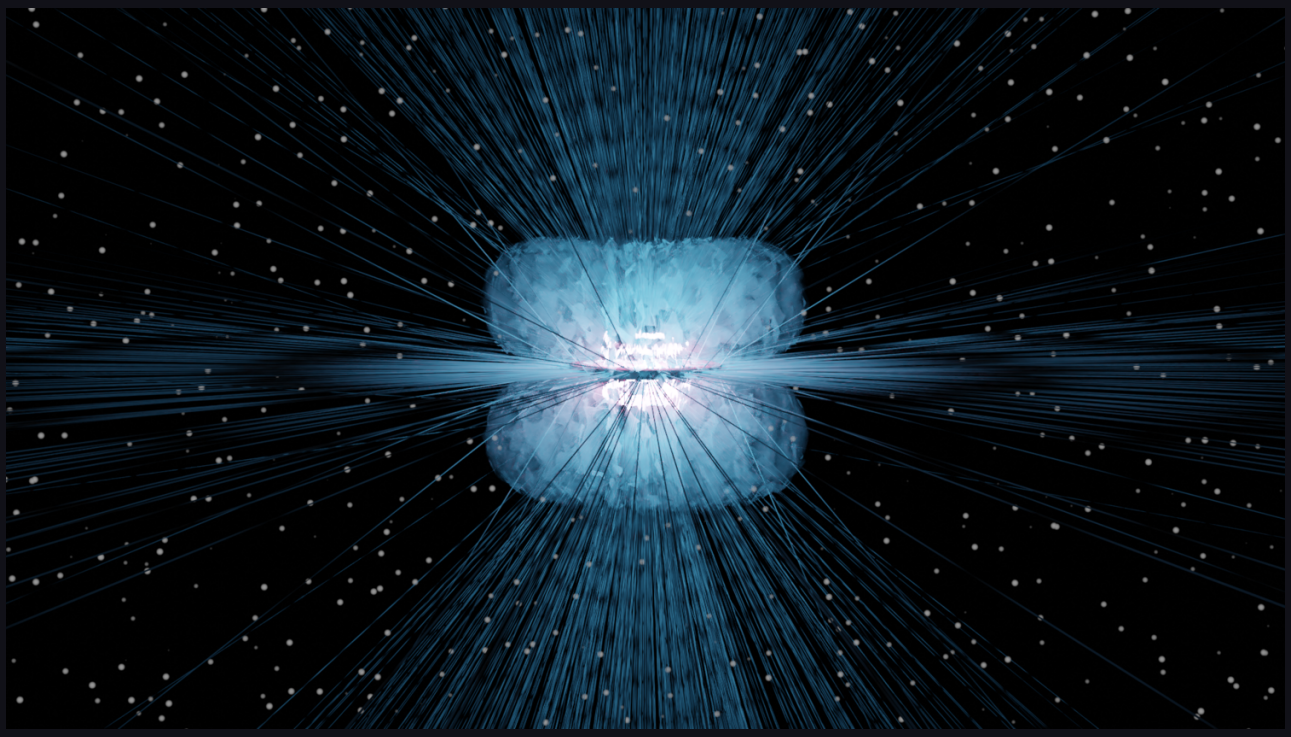


May 10

How Does Electricity Work?

Science, Technology, Astrophysics & Cosmology, Material Science

Visualizing Electricity

Electricity is a common phenomenon that we encounter continually throughout the day. Almost everyone is acquainted with electrical technology. We have also experienced sparks from arc'ed static electricity after walking across a carpeted room and grounding to metal, perhaps a doorknob. We have taken in the incredible power of lightning during a thunderstorm. And yet, when we go to find out what is actually happening during these events, we are generally met with one of two somewhat obtuse visualizations: The water pressure model or the electron-bead model. Both are analogies by degree. In in the former, electric potential (voltage) is comparable to pressure in a pipe where current is flow of water. In the latter, electricity results from little beads called electrons that travel down a wire.

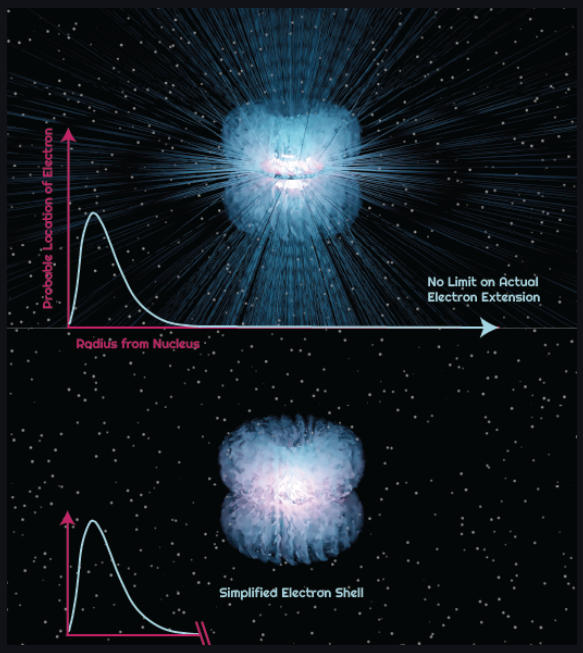
Both of these visualizations have their merits. The water-pressure model helps us conceive of abstract concepts like potential and resistance — and yet clearly the wires, capacitors, and resistors of electrical circuitry bear little resemblance to the structures of dams, pipes, and constricting conduits. The electron-bead model is highly accurate in terms of quantitative accounting, but it stretches the imagination as to how a moving bead actually produces motive pressure, other than the self-referential concept of "charge," which itself lacks visualization. To address these shortcomings, we propose the following animation: Electricity as surface-to-surface rotational gearing between electron-shells on atoms (see **movie** below). This is not the end-all-be-all visualization, but hopefully a few steps in the right direction.

This video is an updated way to visualize electricity. We hope to improve upon the old text-book style "electron-bead-flow" and "hydrodynamic" analogies.

Electricity Begins with Atoms

Any physical concept is best first understood under the simplest conditions imaginable. Later, after we gain access to the basic inner workings of a phenomenon, we can extend these principles to other situations of greater and greater complexity. For this reason, explanation of inter-atomic phenomena, including electricity, need to begin with the simplest atom: hydrogen. Hydrogen constitutes the majority of the material in existence, and in its ionized form is capable of hosting gargantuan currents throughout the interstellar cosmos.

Hydrogen has one electron, which exists predominantly within certain radial distances of the nucleus. This electron, often referred to as the electron cloud, is synonymous with the location of the surface of the atom. While 99.999% of the electron exists within 430 pm of the nucleus, there is a small chance of finding the surface extended to incredible distances. In fact, under Quantum Mechanics, the radial distribution function for the electron has no limit on distance. For our model, we represent these extensions of the electron shell as incredibly thin filaments, radially organized about the atom, as shown below in **Figure 1**:



Our visualization of electricity uses hydrogen atoms based on the radial distribution function of Quantum. Though the extension of the electron from the nucleus is unlimited, we ignore the small 0.001% of the radial distribution. These tiny filaments of the atomic surface will come in to play in more complex phenomena.

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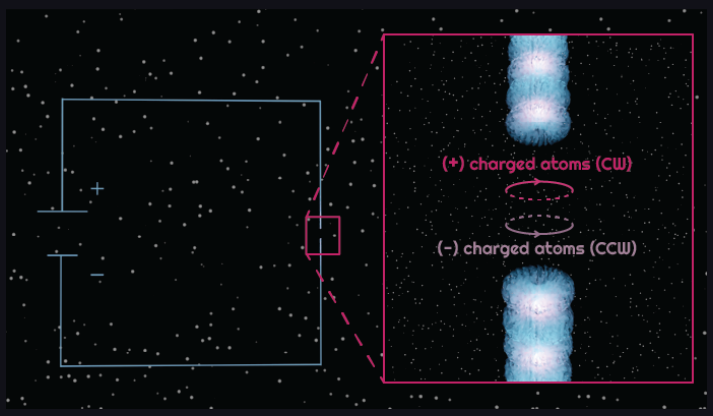
A Highly Simplified DC Circuit

The circuit shown below (**Fig 2**) is composed of single-file hydrogens. We can consider the hydrogens ionized and illustrate this as enmeshed electron shells. This is another way of showing shared electrons between atoms. We see that the electron columns at either terminal rotate opposite. This rotation illustrates cohesive directionality of angular momentum. Cohesive angular momentum of the electron shell explains the concept of "charge," where in this example clockwise (CCW) rotation represents positive (+) charge and counter-clockwise (CW) is negative (-) charge. The arbitrary assignment of sign to CW or CCW rotation is unimportant, as the conventions concerning directionality of charge have wandered throughout history. The essential feature is that, on average, the direction of cohesive rotation is in opposition between (+) and (-) charged terminals in a circuit.

Charge is also a scaled quantity. In the illustrated circuit, electrons rotate faster at the (-) terminal than the (+). This is not a general feature concerning (+) and (-) charged terminals but is rather particular to illustration of the concept of electric potential. Fast rotating shells represent greater electron momentum, and hence electrically more productive shells, than those depicted with slower rotation. Under quantum mechanics it is not possible to precisely separate the contribution of speed and directionality to electron momentum, so our visualization simplifies momentum to speed of rotation. Together, the difference in electron momentum (speed, directionality) between electrons at each terminal signifies the concept of voltage, or electric potential.

The greater the voltage drop between terminals, the greater the current produced once the two make contact. Therefore, current is the process where greater momentum electron shells (faster, more cohesive) incite weaker (slower, less cohesive) shells into motion. When the two terminals make contact, the momentum transfer between the newly engaged columns occurs rapidly, at near light speeds. The atoms stay put, however, and their electrons continue to rotate at much less ferocious speeds. This is the concept of drift velocity.



Charge is represented by direction of electron shell rotation (Clockwise, CW; Counter-Clockwise (CCW). The electric potential, or voltage, is illustrated with the differential momentum of electron shells between each terminal. Current results from fast, cohesive shells at one terminal driving the motion of less active shells at the other.

Extrapolation of the Hydrogen Circuit to Actual Wires

It's important to recognize this visualization is a highly simplified model of electricity. We simplify the differences in charge constituting voltage with directional rotation speed. In reality, while charge *is* quantized since an object can only rotate one way or the other with respect to some arbitrary axis, electron angular momentum is a continuous concept. For instance, electron momentum could deconstruct to cohesion of surface rotation and/or it could reflect rotational speed, but these are indistinguishable to the theorist and experimenter alike. In any event, it is apparent that the actual electron shells are, in fact, rotating.

Also, if we look at more complex atoms we find additional electrons. We would visualize these additional electrons as additional [illegible] with neighboring atoms. The conducting metals in real wires, for instance, have multiple polar lobes constituting their electron shells. These complex electron shapes are mathematically described by the concept of orbitals. The unique multi-lobed structure of p- and d-type orbitals on a metal atom is perhaps why they are such effective conductors. Each pair of polar surfaces within an orbital is able to productively contact neighboring atoms. Also, actual wiring in modern technology often utilizes alternating, rather than the illustrated direct-type, current. Our visualization is easily extended to alternating current by having the atoms move back and forth instead of unidirectionally — a motion which is equally capable of providing motive force at a distance through a circuit.

This visualization is just a starting point for the imagination. It is not perfect, but it moves things in the right direction. For example, it has some serious advantages over the traditional visualizations like the "electron bead flow" and "water-pressure analogy." Unlike these traditional models, we are invoking real structural understanding of the atom to sum up the phenomenon of electricity. The bead-model of the electron, also called the Bohr model of the atom, has been seriously disregarded for several decades in favor of valence shells, which we reference exclusively. The water-model illustrates potential and current well, but the analogy also fails to join what is structurally clear about the atom from quantum theory. Here we hope to have included these oversights into a cohesive visualization by providing for the concepts of charge, voltage, and current with simple hydrogen atoms moving one another through basic surface-to-surface contact.

Note: While the above model for electricity presented here was inspired in part by the ideas of Bill Gaede, the fiber-based atomics we use throughout this blog should not be conflated with Bill's atomic model.

electricity

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Michael Shilo is a secretary of Nature. He completed his graduate work at Columbia University investigating the mechanics of nano-confined water.

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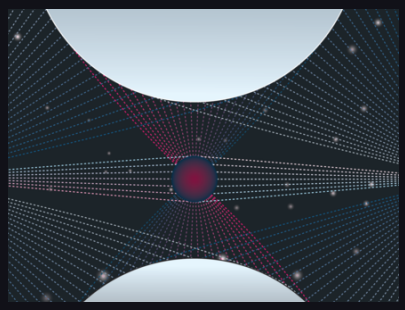

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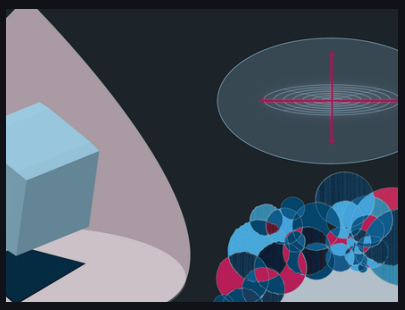
If Not Amount of Material, What Causes Mass?



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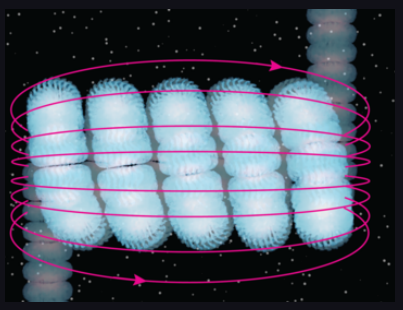
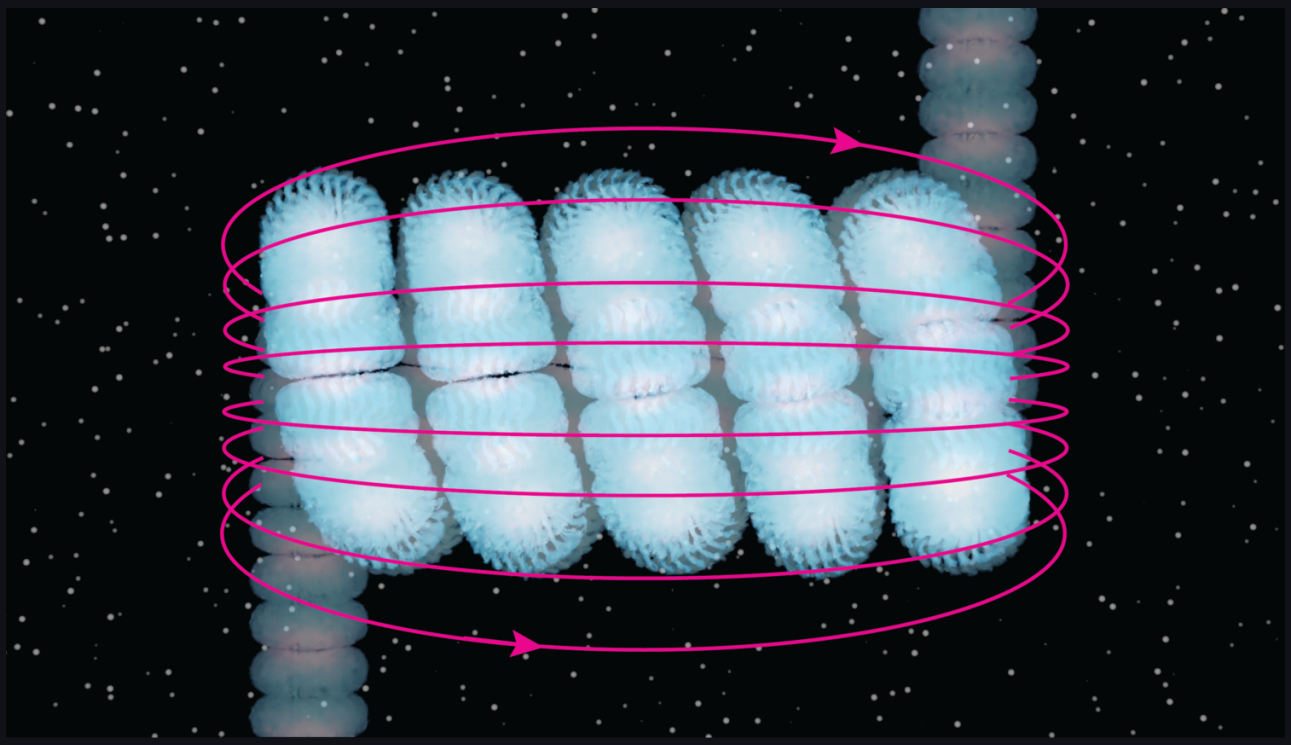


Jul 21

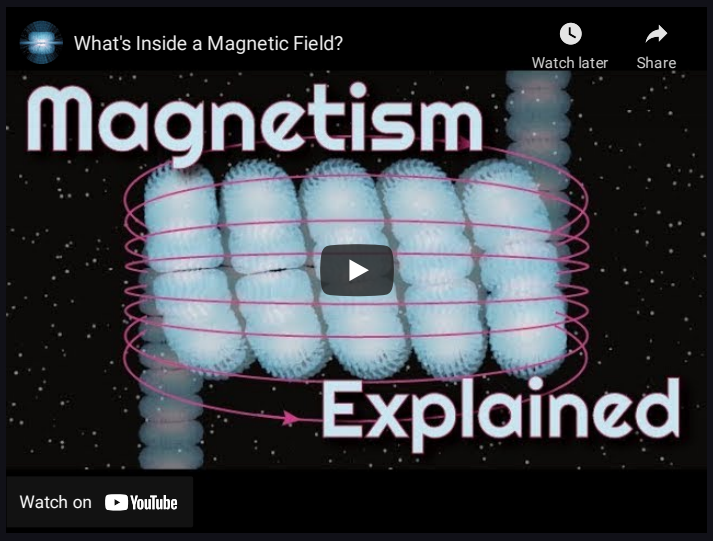
How Do Magnets Work?



Jul 21

How Do Magnets Work?

Science, Technology, Astrophysics & Cosmology, Material Science



Visualizing Magnetism

Magnetism is a common phenomenon for all, yet poorly understood by most. We become acquainted with magnetism from a very early age, maybe noticing that they're used to pin photos and documents to the refrigerator by our parents or maybe we experience them as toys. Maybe we were lucky enough to experience magnetic sand at a science

museum. If we were born in Japan, Germany, or Russia, we may have had first-hand experience with magnetically levitated trains. In any event, we each at first certainly astounded by our first encounter with magnetic attraction or repulsion a-distance between two otherwise ordinary looking objects. If you can't remember the feeling, watch this kid.

But action-at-a-distance is not a matter of magic, it is a matter of physics. Our sense of wonder for magnets may turn to an inquiry into the science behind the familiar phenomenon. Perhaps that is what led you to this page. Unfortunately, as of this publication, the overwhelming majority of explanations for magnetic action terminate in one of two dead-ends. First, you will learn that atoms are each tiny magnets and so composite materials simply behave depending on the coordination of their subunits. This obviously punts the question of what makes the tiny magnets attract? For that line of inquiry, we are generally met with the second fatal roadblock: atoms interact magnetically due to magnetic fields. Of course, this explanation, however deep one dives into the mathematical descriptions of fields, begs the question: what *is* a magnetic field?

The magnetic field of physics is a dynamic description — that is, it has both a shape and motion. This is evident from the basic unit of magnetic field strength, the ampere/m. The ampere signifies charge per time and is the basic unit of current. Hence, a magnetic field is dynamic: it what some*thing* is doing. Therefore, in alternative to traditional visualizations, our explanation of magnetism begins not with an activity like a field but with an actor: the atom.

Magnetism Begins with Atoms

Magnetism is presently understood as one side of a double-headed atomic phenomenon called electromagnetism. Electricity being the simpler of the two faces, it is all but imperative that you go back and read our work-up and watch the animation for visualizing electricity before proceeding here.

If you are short on time, I'll provide you with an extremely brief re-cap. We integrate contemporary mathematical descriptions of electricity into an explanation that we believe improves upon traditional hydraulic and electron-bead-flow models. In brief, we illustrate the concept of charge through the rotation of atomic surfaces. These surfaces, called electron shells (e-shell) or orbitals, behave per quantum mechanical electron wave functions. Surface-to-surface transmission of e-shell rotation between aligned shells of atoms constitutes electricity. Although there are never electron beads moving along in our wire, our visualization of electricity is entirely consistent with modern mathematical representations. Current flow is merely reimagined as propagation of *in situ* e-shell surface rotation.

This is an updated way to visualize electricity. We hope to improve upon the old text-book style "electron-bead-flow" and "hydrodynamic" analogies.

We utilize the simplest and most abundant atom, hydrogen, for our explanation of both electricity and magnetism, since it has only a single electron forming one e-shell orbital. We fashion a simple, hypothetical single-atom-thick wire from ionized hydrogen. The ionization indicates that the atoms electron surface is not localized by enmeshed with its

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neighbors. We can extend the electromagnetic principles applied to hydrogen across other more complex elements and molecules by the careful addition of orbital surfaces, recognizing that new e-shells may pair [illegible] others may rotate freely and separately contribute to magnetism.

Visualizing the Invisible

Magnetic action is next explained as a natural extension of the aligned rotation of conducting electron surfaces in a current-carrying wire. Through the vertical transmission of rotational momentum between atoms through polar surface contact, a horizontal interaction is also introduced toward their equators. The magnetic field, B, of the atom describes this surface motion, which occurs 90 degrees orthogonal to current, I (see **Fig 1A**).

The reason that magnetic action extends beyond the current-carrying wire's apparent surface is that while 99.999% of the electron exists within 430 pm of the nucleus, there is a small chance of finding that surface extended to incredible distances. In fact, under Quantum Mechanics, the radial distribution function for the electron has no limit on reach. For our model, we represent this unusual quality of the atom as rarefied extensions of the electron shell: incredibly thin filaments, radially organized about the atom (**Fig 1B**).

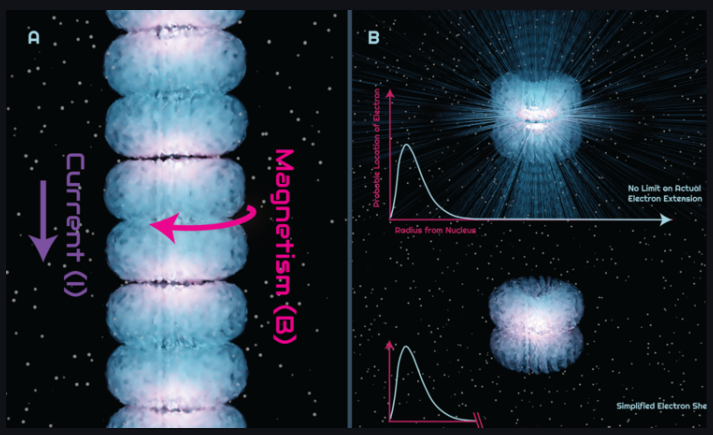
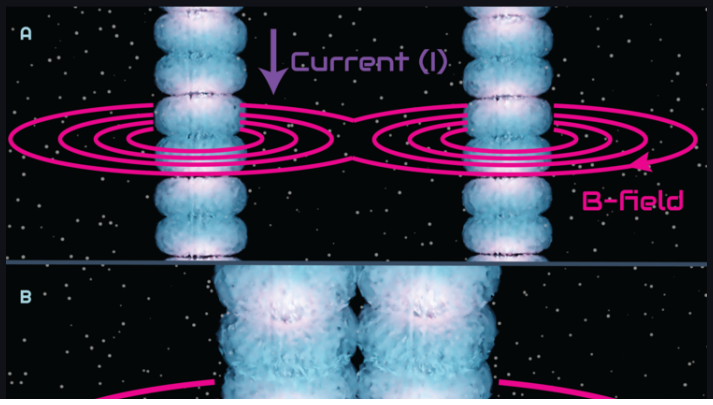


Fig. 1 Magnetism is visualized at the atomic level as the lateral interaction between aligned orbital surfaces of atoms. Magnetic field is orthogonal to current as shown in (A). The transmission of lateral interactions beyond the apparent surface of the wire is made possible because of the thinned extensions of the atom's e-shell (panel B top), as described by the electron wave function of quantum mechanics. We omit these extensions throughout the visualization (panel B bottom) for clarity but they are always assumed present and responsible for transmission of invisible action.

We imagine the physical extensions of the atomic surface are responsible for the action-at-a-distance. Lateral magnetic motion of conductive rotating e-shells thus synergizes between current-aligned wires, pulling them together as shown in **Figure 2** below (panels **A** and **B**). This illustrates the basic principle of magnetic attraction. By inverting one of the wires, we find that currents are now opposed, as are the magnetic actions of each column's atoms (**Fig 2C**). The clash of opposing effort between e-shells in each column drives the wires apart and illustrates magnetic repulsion.



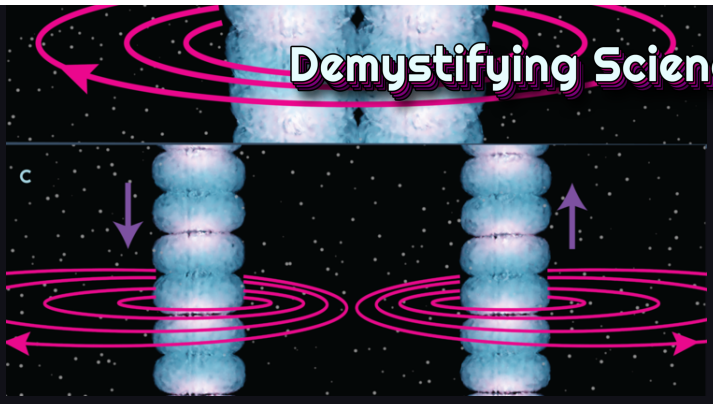


Fig. 2 Magnetic attraction is understood as synergistic effort by current aligned and in-contact e-shells in (A). The combined magnetic field, also called induction, results from the combined motion of these aligned atomic surfaces (B). If one current is inverted, the lateral action of each wire pushes opposite the other, resulting in a repulsive effect (C).

The Electromagnetic Coil

To construct the most basic magnet imaginable, we coil up our single-file hydrogen wire as shown in below in **Figure 3**. Coiling of the wire aligns the lateral motion of all e-shells on the surface of the composite cylinder (**Fig 3B**). The combined flow of the coil's composite surface appears to track out from one end of the coil and into the other. The composite magnetic field describes this pole-to-pole flow of the coil's atomic surfaces.

It is now easy to understand how the magnetic attraction between current-aligned wires multiplies through the coil's architecture, since lateral efforts align and combine. If we bring the North pole of one coil near the South pole of another, the radial extensions of the e-shell enmesh laterally and pull the coils together magnetically (**Fig 3C**). Inverting one coil and pitting South vs. South or North vs. North poles has the opposite effect, where the conflicting effort of each coil's atoms push them apart (**Fig 3D**).

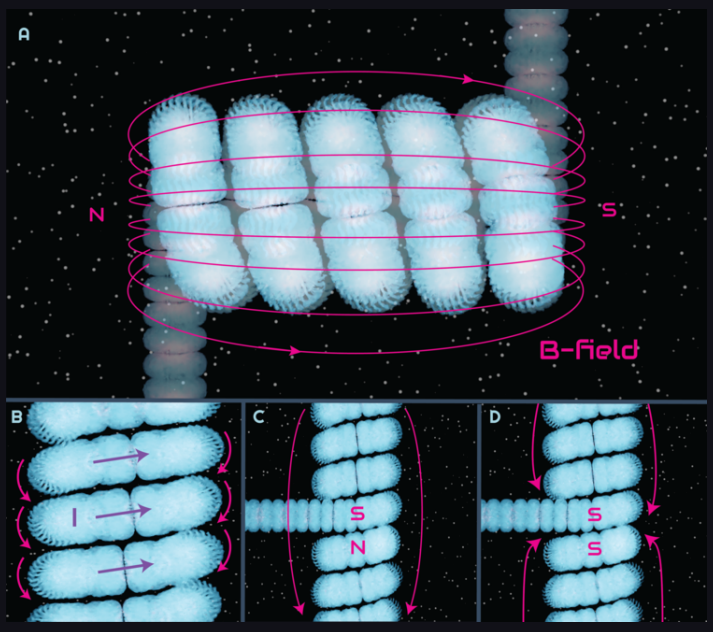


Fig. 3 The simplest magnet, a solenoid (A), is fashioned by coiling our single-file hydrogen wire so that on all surfaces current and magnetism are aligned (B). The result is cohesive surface motion of all atoms on the composite cylinder. If we bring two coils together with similar orientation, an attractive synergism is observed between their e-shells (C). If we invert one coil and bring them together we observe the clashing of oppositely oriented e-shells pushes them apart (D).

Extrapolating This Simplified Explanation

Again, any visualization of intricate physical processes inherently necessitates simplification. Here, we have utilized a single-atom-thick [illegible] ionized hydrogen for our demonstration and readily acknowledge [illegible] wire exists naturally, its likeness is probably only found in the deep reaches of outer space. In our every-day reality, we only encounter synthetic electromagnets comprised of more complex atoms. This means those metals have additional surfaces. In common conducting materials, such as copper, there may be several polar contacts available for electromagnetic interaction.

Even more complex metals, like those found in a bar magnet, appear to utilize separate orbitals for bonding and conduction than those involved in magnetism. We would visualize distinct magnetized e-shells as freely rotating, and spatially isolated from the conductive bonding lattice. This is why "permanently" magnetized materials do not exhibit a current. Furthermore, the relevant magnetic e-shell surfaces in bar magnets still retain the essential pattern of the spiraled coil from our depiction. We are working toward an animation of these complex atoms and will present an appropriate visualization in a future post/video.

One final note is that often the strongest magnet is a combination of a magnetizable metal with a coil. A magnetizable metal has unencumbered e-shells distinct from bonding and these surfaces are readily incited to magnetic cohesion through contact with coil's extended atomic surfaces. Often, cores of electromagnets utilize iron or nickel for the very reason that these elements are highly susceptible to the magnetic behaviors (moment) of proximally excited atoms in the coil. By contributing aligned e-shells to lateral rotatory action, the iron/nickel atoms amplify the strength of the coil's electromagnetism.

Note: The fiber-based atomic model for magnetism presented here was inspired by the ideas of Descarte, Faraday, innumerable mathematical physicists, and especially the ideas of Bill Gaede.

magnetism

Michael Shilo DeLay, Ph.D.

Michael Shilo is a secretary of Nature. He completed his graduate work at Columbia University investigating the mechanics of nano-confined water.

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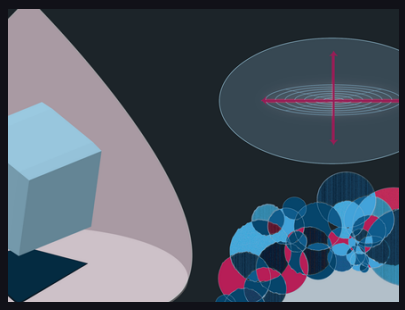

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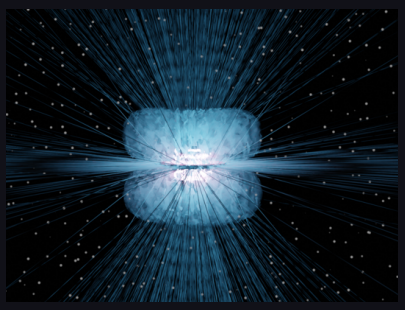

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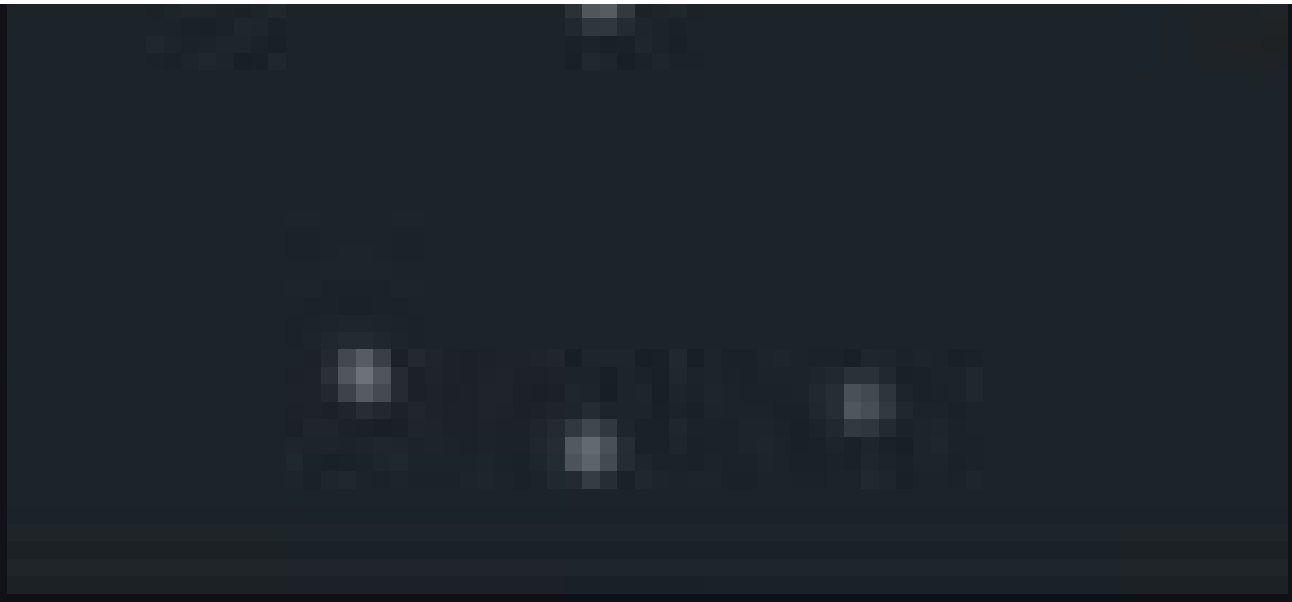


Mar 7

If Not Amount of Material, What Causes Mass?

Light & Gravity, Astrophysics & Cosmology, Material Science

We've clarified the key physics term energy previously. Mass is another often confused word in the wider scientific conversation. For instance, it is often misused to signify the amount of material in an object.

This is the common conception, and one generally taught in academic textbooks. It absolutely works that way most of the time in our everyday worlds. However, **the "mass as quantity of material" definition starts to break down when we look at events occurring at the atomic scale.**

Recall that **some quarks have more mass than atoms**.

On the other hand, the proton is much, much more massive than the quarks that comprise it. That is unless you include virtual quarks, a somewhat debatable addition, in which case the top quark is more than 100 times heavier than the proton it's integral to! What's going on? If mass does not mean the quantity of material, what is the unambiguous and consistent meaning of the word?

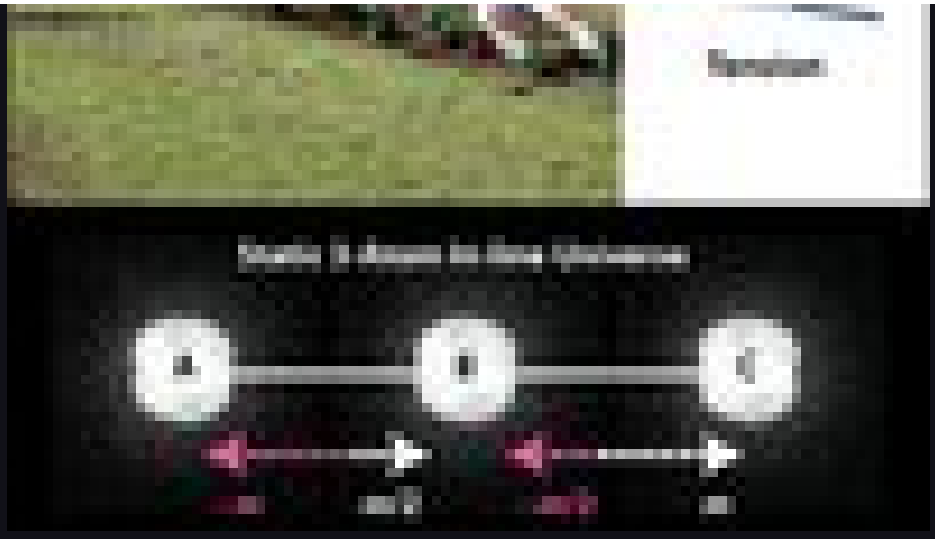
The development and confirmation of the Higgs process in recent decades has successfully detailed the quantitative affairs which terminate in the subatomic world's apparent mass. But **perhaps mass is best comprehended more generally through the oppositional notions of inertia and gravity.** Congruence of these concepts provided the pivotal equivalence that initially allowed Einstein to formalize his General Theory of Relativity.

Einstein, in recognizing ideas by his contemporary Ernst Mach, realized that inertial mass had to be the product of bodies being held in place by their surroundings. Gravity, on the other hand seems to depend upon the distance between bodies. **Clearly mass refers to some action being done between materials that can affect both inertial and gravitational experiences.** But what exactly *are* the atoms doing to each other during these phenomena?

Well, atoms behave *as if* they are pulling on one another.

One way to **visualize mass** is to imagine atoms connected by an imaginary tensile structure.

Consider a tiny three atom universe in this context. As pictured below, imagine each atom pulling on the others ceaselessly with some fixed effort called mass, *m*. Atom B in the center must split its effort to pull against each of the opposite ends. The end atoms A and C can put all of their effort in one direction but in doing so they directly oppose one another.



Mass can be thought of as atomic pulling effort. This team of athletes is analogous to an atom pulling on another. Below is a 3-atom model universe with no motion due to perfectly balanced outward pull among the atoms. Inset image adapted from Wikimedia courtesy of John Moore.

Because all of this tugging (mass) is balanced directionally, equally and oppositely, there is no motion in this tiny universe. However, **if we attempt to pluck any one of these atoms from the chain, it will resist inertially due to that web of tension**ed connectivity.

Now what happens if we inject a fourth Atom D into this universe (below), **connecting it to all the others but setting it slightly out of line?** If we let go, and allow the tugging system to equalize, we will begin to observe some motion since the pulling efforts are suddenly unbalanced. Atom D, must have its mass effort split three-fold. The same goes for Atom B. But Atoms A and C, however, have only to split their efforts between two others each. The result is a net downward force upon the newly introduced Atom D. Atom D is thus forced to relocate despite its best *mass* efforts to pull away. Such constitutes a rudimentary version of gravitation.

A fourth atom is connected off axis to our previously static 3-atom in-line universe. Because atomic mass is unbalanced, modeled here as atomic tugging effort, motion appears when the atom is released.

In this way, you might find it useful to visualize the word mass as meaning outward pull from one object upon the next in a network of interconnected bodies.

This visualization of mass works great at size scales below the atom too, where the sub-atomic material is being held in place through a process of tensegrity.

Each subunit within the atom pulls on the next and this process contributes to the overall structural cohesion and compressive strength of the composite. This allows us to understand how subatomic structures can be more *massive* than the larger objects that they constitute.

Obviously this is only a *visualization* of what's happening, and as of today there are no apparent structures connecting atoms to one another physically. Einstein, Poincare, and Minkowski's mathematical construct of spacetime allowed them to describe with unprecedented accuracy how paths and clocks are affected during this tug-o-war between bodies.

And while one must concede that spacetime is not actually a physical surface like your

countertop, at the same time experiments have repeatedly shown that the volume between atoms is not truly empty. Perhaps the vacuum will thus one day surrender its secret structure to investigators, rationalizing the apparent action at a distance of gravitation and inertia, among other physical anomalies like entanglement, once and for all.

physics, cosmology, science, mass

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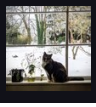

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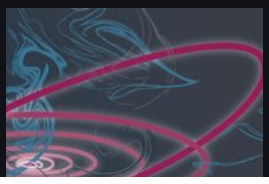

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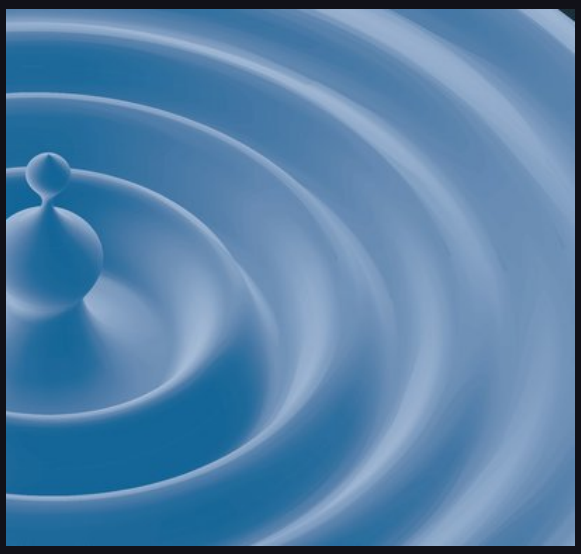
What Causes Inertia?



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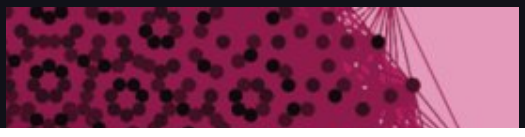
The Higgs Boson is an Action Not an Object



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The Life and Death of the Aether (Part III)

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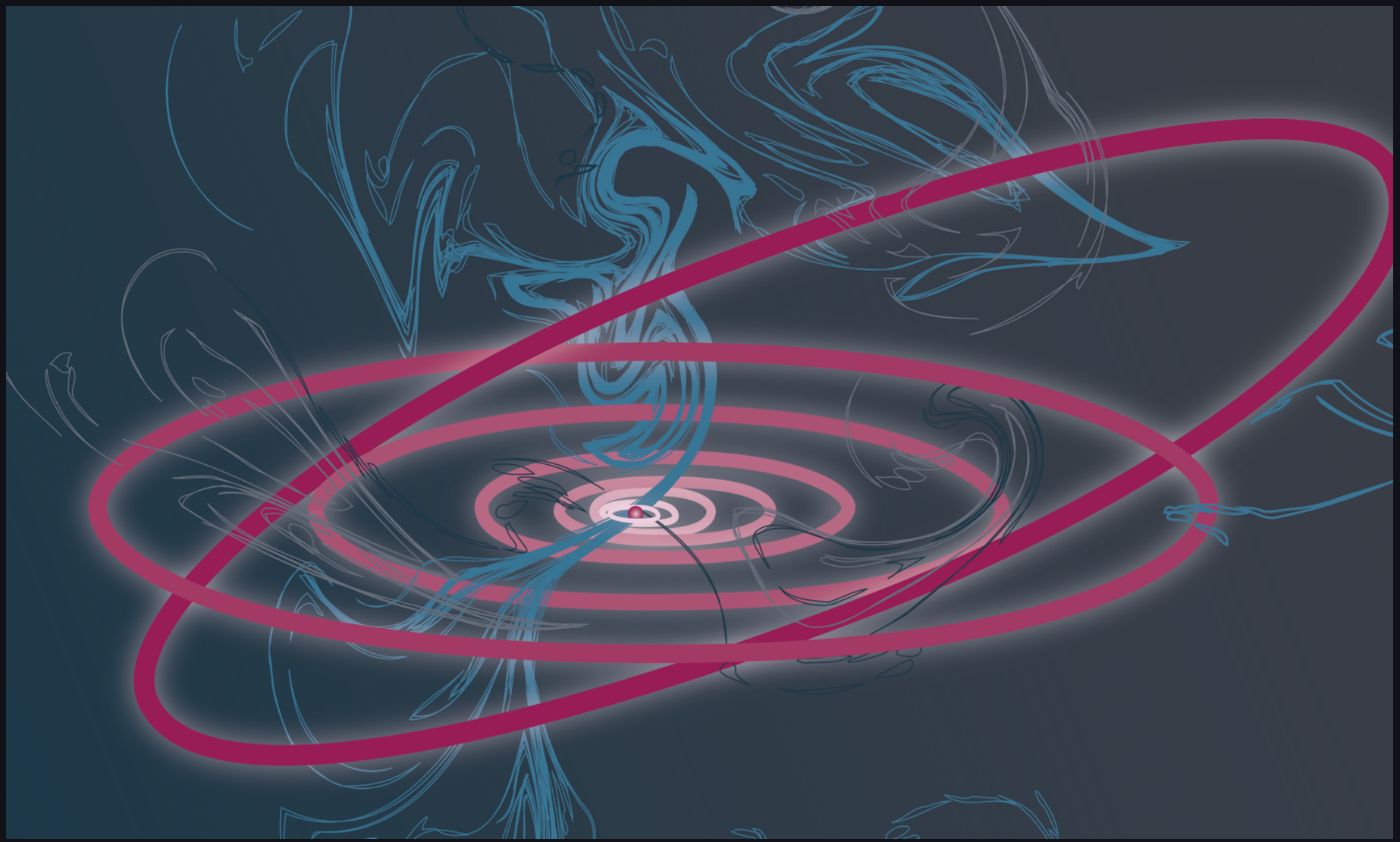


Feb 28

What Causes Inertia?

Astrophysics & Cosmology, Material Science, Mechanics

Last time, we looked at the idea of a limit on the speed of light. We reasoned that all physical motions are slowed for one of two reasons: because other objects get in the way or because something pulls on them. Today we'll look into the cause of Newton's observation that an object at rest or in motion remains so unless pressured otherwise. That this object will push back against such an interceding pressure, even in outer space, is called the phenomenon of inertia. Let's demystify inertia.

Inertia means tendency toward idleness, from the Latin *iners*. Some examples of inertia are easier to rationalize than others. Imagine a ball sitting atop a mountain. Without us pushing (accelerating) the ball it stays on top of the mountain. This is easy to understand: the upward pressures acting upon the ball due to friction from below and gravity pulling downward are equalized. Air pressure from each side of the ball is equalized as well.

If our ball does not move, it is because all external pressures are balanced.

If we pressure the ball to move and nudge it over the lip of the mountain, gravitational pull will take over and the ball will gain velocity and momentum in proportion to this. The ball's momentum reflects its mass, a measure of gravitational pull, which grows based on the quantity and quality of its atomic composition. We could say that momentum

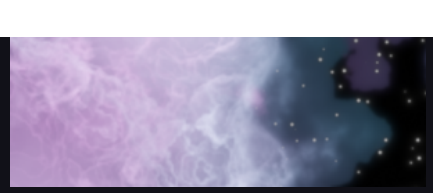
quantifies a body's inertia once it is in motion. Without motion, inertia can only be gauged by mass. Think about it; heavy objects at rest are difficult to displace. On Earth, inertia makes a lot of sense.

But what about a spacecraft trying to navigate around an asteroid field in the weightlessness of outer space? Here there are also few frictions to impede the forward motion of the craft and no local gravity holding it in place. So what happens during a turn to avoid an on-coming asteroid? Must the craft reckon with inertia? Yes, there is some hidden pull present, which resists the spacecraft's adjusted acceleration even in outer space!

The astronauts onboard the spacecraft feel something similar to gravity during the turn, which pulls them to the side of the craft opposite the new trajectory.

Engineers have imagined harnessing this sort of inertial pull to provide artificial gravity on future space stations by continually rotating them.

So what *is* the cause of this on-demand gravitation in outer space, away from large bodies like Earth? The answer seems to have been put forth by Ernst Mach in the mid 19th century. Mach suggested that simply removing the spaceship from Earth's gravitational dominion does not remove the Earth's gravitational influence altogether, but merely dilutes its authority. By this same principle, each of the adjacent bodies in the solar system indeed exerts some non-dominant but important gravitation effect upon the spacecraft. Even the asteroid, which the craft is turning to avoid, pulls some upon the ship. In other words,



In the Lab...

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all bodies surrounding the ship, however distant, large or small, will pull upon it. The net effect of this universal pulling is what we signify with the concept of inertia.

What Mach suggested was rather profound, if only for its simplicity. Inertia means that all of your atoms are gravitationally entwined with all of the atoms around them. And though our everyday inertial experience is ruled by the multitude of atoms comprising the Earth, **you can test your connectivity to the rest of the surrounding universe with a simple experiment: Fill a cup with water and with your arm outstretched, spin around in a circle.** You will notice that the water "sticks" to the side of the cup. The water has very little friction holding it to the side of the container. And if only the Earth's gravity were at play, the water would fall level with the horizon. The only explanation for what you're observing, is that all of the other atoms in your world, including the atmosphere, sun and stars, are indeed exerting some meaningful pull upon the water to resist its relocation. The mechanism by which one of those atoms pulls upon yours remains a topic ripe for investigation.

gravity, unity, physics

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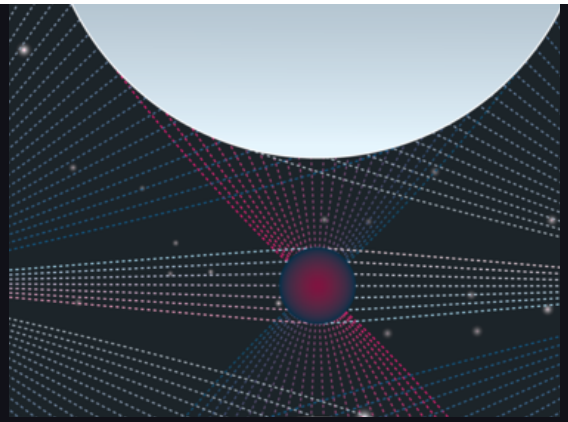

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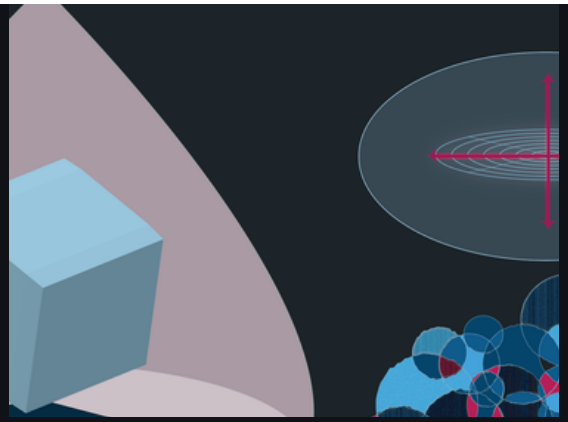

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