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Planetary Energy Dynamics, Part I: On the Tides

K. E. Thorp

MD, Department of Radiology, Sparrow Health System, Lansing, MI.

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Address for correspondence: k.t@earthlink.net

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INTRODUCTION

In 1687 Isaac Newton published what came to be regarded as the greatest and most enduring work in the history of science, *Philosophia Naturalis Principia Mathematica*, in which he advanced the principle of universal gravitational attraction. Newton claimed that gravity, an attractive force by which bodies are drawn toward one another, governed all celestial dynamics and, in essence, held the universe together. The evidence he presented in support of his claim was flimsy but his thesis gained traction largely on the basis of its mathematical analytics. By the 18th century his gravitational hypothesis had become widely accepted among scientists **(Figure 1).**

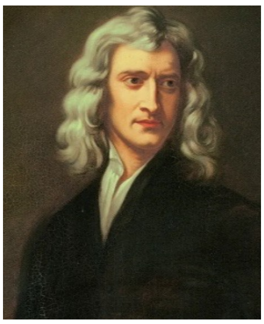

Figure 1.
https://www.space.com/15898-isaac-newton.html

Newton neither explained what the gravitational force was nor how it came into being. Thirty-five years later in the second edition of *Principia* he commented:
'I have not yet been able to discover the cause of these properties of gravity from phenomena and I feign no hypotheses . . . it is enough that gravity does really exist and acts according the laws I have explained, and that it abundantly serves to account for all the motions of the celestial bodies and of our sea'.

Newton claimed that in their transit across the sky, the sun and moon engendered attractive forces that are responsible for the observed diurnal, monthly, and seasonal tidal fluctuations. He never explained why this gravitational force, which supposedly affects bodies in a uniform manner on the basis of mass, acts preferentially on water but not upon nearby solid objects. Nor did he explain why the tides are higher in some regions than in others or why, even along the same coastline, the times of the high and low tides may differ considerably.

Through mathematical induction Newton accounted for the two high tides and two low tides that occur each lunar day and, furthermore, showed that the tidal range, i.e., the difference between the highest and lowest water levels, should be greatest at the times of the new and full moons during which times the sun, moon and earth are in alignment, i.e., at 180° to each other, thereby reinforcing the effect of gravity. On the same basis, the tidal range is lowest during the first and third quarters of the moon when the sun, earth and moon form a 90° angle, aka 'quadrature', at which times the gravitational forces of the two bodies were ostensibly mitigated.

Newton assumed that the ocean surfaces were in static equilibrium with the gravitational forces of the sun and moon but over the decades it became apparent that his hypothesis could not explain many tidal phenomena. Based on his theory, for example, the daily inequality of the tides, i.e., the difference in wave height between successive high tides or low tides should be zero at the equator and gradually increase in higher latitudes. And yet marked diurnal inequalities are found in the equatorial regions of the Pacific while at the poles the daily inequalities are near zero. Other tidal phenomena, as we will see, resist explanation by Newton's hypothesis.

Despite its limitations Newton's theory provided a practical framework upon which current tide theory evolved over the next 350 years. As tidal behaviors were examined in greater detail, however, it became obvious that many other factors were in play. Scientists were confronted not with one but a multitude of problems and gradually came to realize that a single universal equation was all but impossible.

After Newton scientists went about devising mathematical models that accurately depicted local tide behaviors and various other anomalous phenomena. Ancient philosophers were skeptical of such approaches claiming that mathematics only addressed quantitative aspects and provided little insight into underlying causes. The question of tidal origins had been a topic of interest among scientists well before Newton came onto the scene.

In 1600 English scientist William Gilbert published his work *De Magnete* in which he examined the properties of magnets and, based on the known behaviors of compasses, deduced that the earth itself was a large magnet. His claims were affirmed by 20th century scientists who discovered a geomagnetic field generated by a so-called geodynamo, the mechanism of which is based on interactions between the earth's rotation about its axis and its molten iron core. In a later work Gilbert argued that the orbits of the planets as well as the tides were due to magnetism. Gilbert's 'magnetic philosophy' gained popularity and became part of mid-17th century cultural thought.

In *Principles of Philosophy* (1644) French philosopher René Descartes **(Figure 2)** went even further and advanced his universal 'vortex theory' claiming that the sun's rotation generated a large swirling magnetic vortex which formed a medium in the solar system in which the planets orbit and rotate **(Figures 3 & 4).** On the same basis every star forms the center of its own vortex system with the entire universe but an endless expanse of vortices. Descartes' assertion, too, has been roundly affirmed by modern astrophysics.

Figure 2.
https://www.worldhistory.org/image/12757/rene-descartes/

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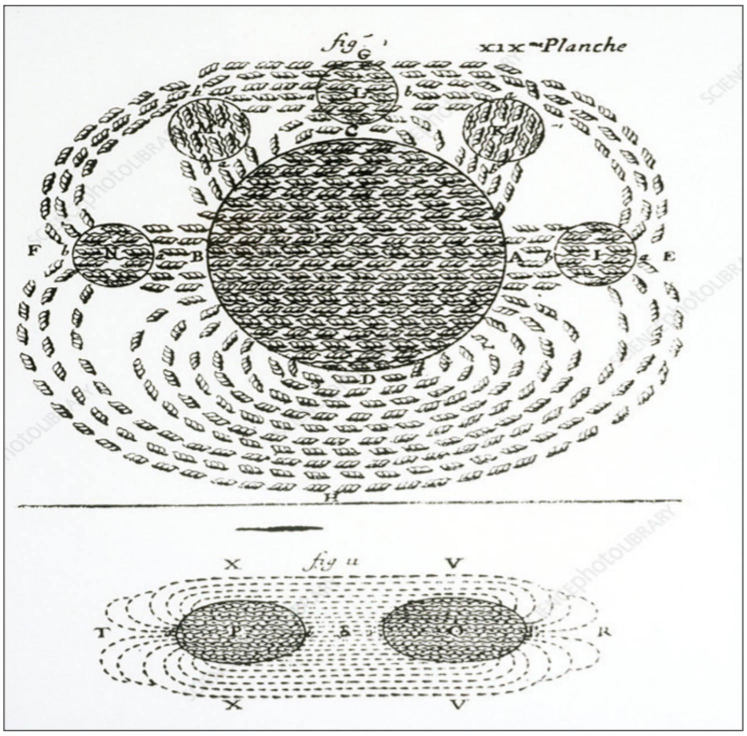

Figure 3. The first known artistic depiction of the geomagnetic field published by French philosopher Rene Descartes in *Principles of Philosophy* (1644). Shows attraction between the magnetized earth and rounded lodestones. Lower image depicts the field between two adjacent magnets.

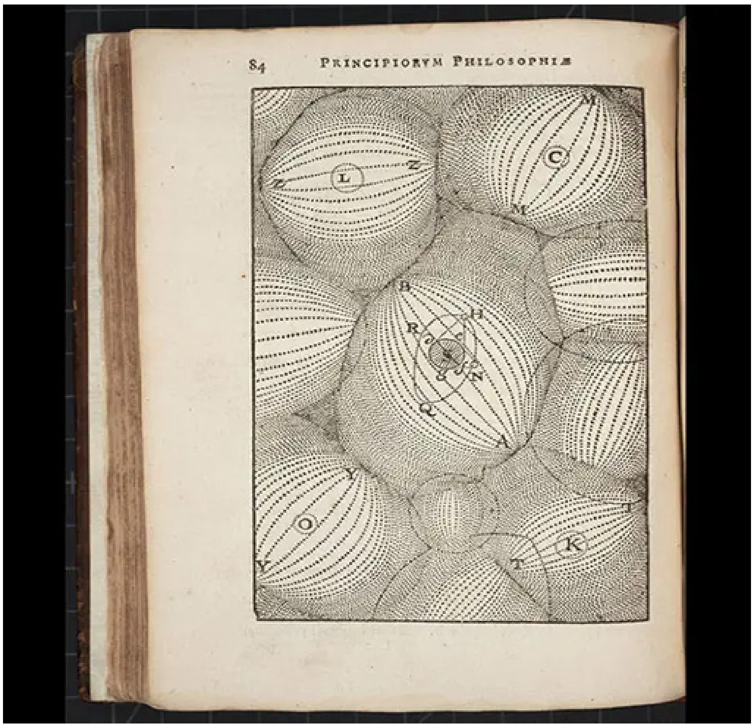

Figure 4. Illustration from Descartes' *Principles of Philosophy* depicting his universal vortex hypothesis in which all solar systems throughout the universe are organized on the basis of magnetodynamics.

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All tidal theories advanced during the 17th century were arbitrarily dismissed after introduction of Newton's gravitational theory. It is widely recognized that no scientific hypothesis can ever be proven and that theories must be excluded on the basis of their inability explain phenomena. And yet scientists of the time never gave the magnetic hypothesis a second thought.

The evidence presented herein points to the sheer implausibility of Newton's theory of universal gravitational and shows, instead, that Gilbert's magnetic hypothesis, driven by the mechanics of the geodynamo, explains the numerous anomalous tidal behaviors inexplicable on the basis of gravitational theory. As we will see, a long stream of counterevidence began to emerge in the 19th century which should have alerted scientists to the tenuous nature of Newton's flawed conception.

TIDES IN HISTORY

The tides have been one of the most widely discussed natural phenomena in history and, prior to the emergence of modern scientific discourse, fell under the general rubric of natural philosophy. Much of what is now known about the tides was described as early as two thousand years ago and thus current ideas cannot be easily separated from those which preceded the scientific era.

In general, the ancients rendered accurate descriptions of tidal phenomena but were inclined to invoke supernatural causes. The evolution of ideas concerning the tides is part of an ongoing attempt by modern science to understand natural causes and, moreover, to explain such phenomena on a rational basis. Much of the historical content presented herein is from David Cartwright's comprehensive work *Tides: A Scientific History* (1998).

In his 1st century AD work *Geography*, Greek writer Strabo credits Stoic philosopher Posidonius (131-51 BC) as being the first to ascribe cause to tidal phenomena claiming they were due to the 'revolution of heavenly bodies'. We don't know exactly what he meant by 'revolution' since Copernicus' heliocentric astronomy was still far into the future. Like other early commentators Posidonius held that tidal behaviors were more influenced by the moon than the sun.

Posidonius wrote that when the moon reached 'one sign of the zodiac' (30^o) above the horizon the sea began to swell and cover the shores until it reached the meridian point (90^o) whereupon it slowly retreated until the moon once again reached one zodiac sign above the horizon. As for the monthly lunar revolution he correctly reported that high tides occur during the new moon, decrease until the first quarter, then increase until the full moon, at which time they decrease until the third quarter and, finally, increase until the new moon comprising a bi-monthly oscillating cycle **(Figure 5)**. Posidonius was also the first to comment on the diurnal inequality of tides and noted that it was minimal at the southwest tip of Spain near Gibraltar but quite pronounced in the Arabian and Red Seas.

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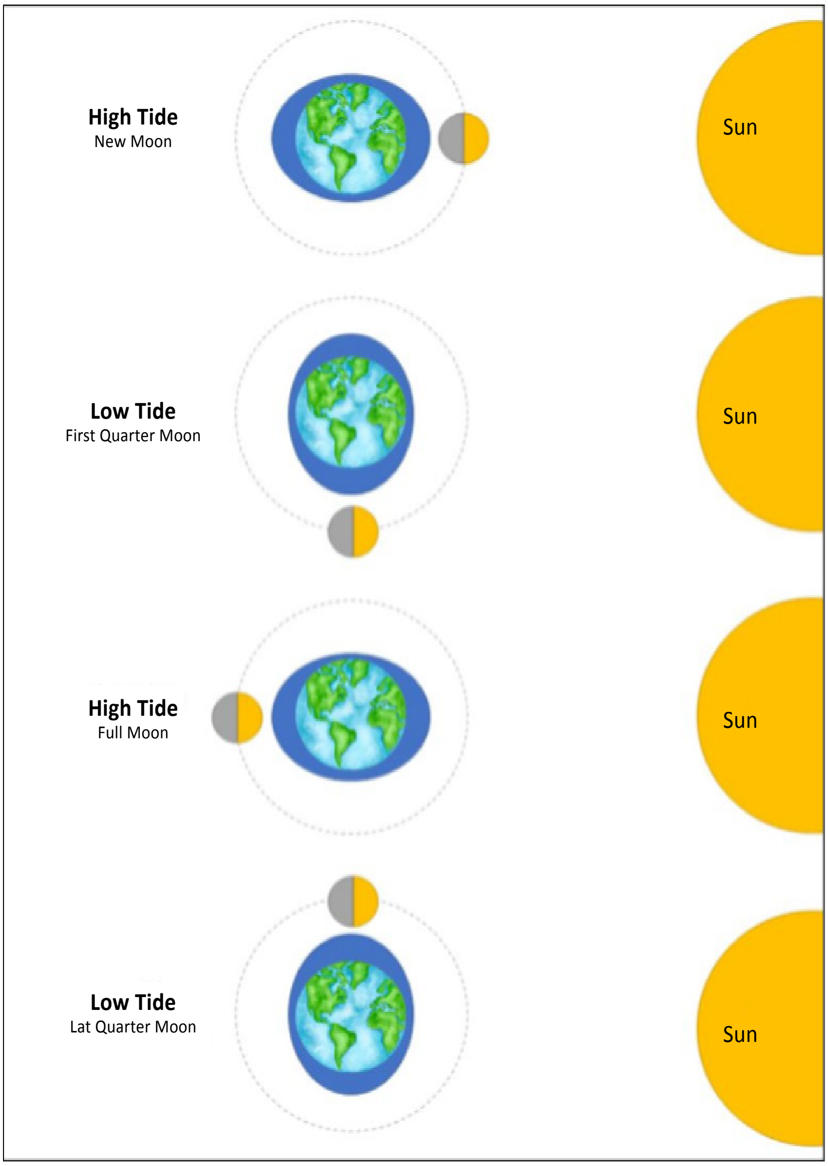

Figure 5. Geometric interactions between the earth, moon and sun that give rise to the bimonthly high-low tidal cycles.

In his description of the annual tidal rhythm related to the sun and the earth's precessional motion Posidonius described the tidal fluctuations incorrectly but his error was recognized and emended by Roman writer Pliny the Elder a century later. In *Natural History* Pliny writes 'all these tidal effects are increased by the annual changes of the sun, the tides rising up higher at the equinoxes'.

Six centuries later in his work *The Reckoning of Time*, Venerable Bede of Jarrow Abbey (672-735), focusing more on quantitative aspects of tidal phenomena than had ancient commentators, reported that in 12 lunar months (354 days) the sea rises 684 times (not the expected 708) indicating that tidal fluctuations were more aligned to the moon than the sun. His most significant contribution was to recognize that high tides don't occur simultaneously on all coasts: 'On the same shoreline those who live to the north of me will see every sea tide both begin and end much earlier than I do, whilst indeed those to the south will see it much later'.

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Robert Grosseteste (1175-1253), on interactions between the moon and sun in tide cycles, claimed the sun strengthened the moon's tides when in conjunction (180^o), i.e., at the new and full moons, but this effect weakened as the moon fell out of alignment with the sun towards the first and third quarters, i.e., quadrature (90^o). Such dynamics gave rise to a twice-monthly high-low tide cycle.

Grosseteste's writings, says Cartwright, signal a shift by medieval philosophers toward explaining tidal phenomena based on natural causes. His writings, regarded as authoritative for centuries, were cited by 17th century scientists. By this time science had come to view itself as the 'new' natural philosophy and its investigations centered on acquiring insight into the underlying patterns that organize our world system. From this brief review it is apparent that Newton made no original contribution in terms of describing tidal phenomena but, rather, simply applied analytical logic to a body of received tidal knowledge with deep roots in antiquity.

The most consequential development influencing the emerging scientific perspective involved the work of Nikolaus Copernicus (1473-1543) who, in *On the Revolutions of the Celestial Spheres*, overturned Ptolemaic geocentric astronomy and, in its place, advanced our current heliocentric framework in which earth was no longer center of the universe (or even the solar system) but simply one among many planets revolving around stars. Scientists thus faced the task of integrating existing tidal knowledge into the emergent Copernican system. Two obstacles stood in their way.

The first involved coming to terms with the three primary planetary motions of revolution, rotation and precession and their impact on tidal behaviors. If the earth was no longer the stationary center of the solar system, Copernicus having shown that it revolved around the sun, then it only stood to reason that the day-night cycle must be a product of rotation about its own axis and, furthermore, that the annual seasonal cycles must somehow be related to its precession.

In advancing his theory of universal gravitational attraction Newton claimed that all three motions were a result of gravity. Based on current knowledge of the geodynamo, however, rotation is the primary mechanism by which the geomagnetic field is generated and it is not at all apparent how this motion is affected by gravity. And to ascribe earth's revolution around the sun or its wobbling precessional motion to gravity may be an even greater leap of faith.

The second hurdle was more daunting. It is hard for moderns to fathom the difficulty early scientists had with the notion of 'attraction' as it implies action at a distance mediated by unseen forces. Two millennia earlier Aristotle had coined the term 'occult' to distinguish between phenomena that are apparent to the senses and those which lie hidden. The idea of an attractive force like magnetism, as proposed by Gilbert or Descartes, was abhorrent to most scientists. In his *Discourse on the Tides* (1616) Galileo called it a 'lamentable piece of mysticism'. Such aversion to action at a distance played into the eventual triumph of Newton's gravitational theory as its effects were obvious to even the blind.

In *Astronomia*, astronomer Johannes Kepler (1537-1630), who articulated the three laws of planetary motion, stressed the necessity of an attractive force: 'if the moon and earth were not constrained by animal force, or some other equivalent force, each in its own orbit, the earth would ascend toward the moon . . . and the moon would fall toward the earth. If the earth ceased to attract (to itself) the waters of the sea, they would rise and pour themselves over the body of the moon'. In a later work he remarked, 'the causes of the ocean tides seem to be the bodies of the Sun and Moon attracting the ocean waters by a certain force similar to magnetism'. And he

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explicitly distinguished between magnetism and gravity: 'the body of the earth likewise attracts its own waters, an attraction we call gravity'.

So here we have early scientists attempting to come to grips with unseen dynamic forces relating to the tides with which they had no intimacy. Kepler's argument regarding the necessity of an attractive force, for which Newton's gravity would become the default solution, augured the murky conceptual waters science would be compelled to navigate in the ensuing centuries. And, to cut to the chase, Kepler misrepresented the scope of the problem.

It is impossible that a single force like gravity acting on its own could induce planetary motions such as revolution, rotation and precession, just as it cannot cause the tides. Based on a single force, i.e., attraction, what is to prevent large bodies from being drawn successively closer to one another with eventual annihilation of intervening space? How can the earth attract the moon into a stable orbit without simultaneously repelling it? The difficulties regarding the tides are further compounded by the liquidity of water. Pure logic demands two distinct forces not only in solar system dynamics but with the tides neither of which, unfortunately, can be gravity.

NEWTON'S LEGACY

While in his twenties Newton (1643-1727) deduced that the earth and moon must attract one another in a manner like how a falling apple is attracted to the earth. He knew from the work of Galileo and Kepler that the moon orbits the earth and over the decades derived mathematical equations depicting the relationship between gravitational attraction and orbital motion which forms the basis of modern scientific understanding.

Newton's mathematical treatment of his concepts was impeccable. His equations accounted for the orbital motions of the sun and moon and their influence on tidal phenomena in a way no other theory of the time could. But we should note that his work describes empirical geometric relationships that would hold true for any constellation of forces responsible for generation of the three planetary motions, i.e., rotation, revolution and precession.

Even after publication of his work Newton remained highly skeptical of action at a distance. In a letter to theologian Richard Bentley in 1692 he wrote 'that one body may act on another at a distance through a vacuum without mediation of anything else . . . is to me so great an absurdity that, I believe, no man who has in philosophical matters a competent faculty of thinking could ever fall into it'. Clearly gravity was the least onerous possibility for Newton. Transmission of invisible forces through an empty vacuum is one thing, through a magnetic medium quite another.

Newton's work thus provided a mechanism explaining planetary attraction and tidal phenomena along with a mathematical framework by which empirical observations and measurements could be collated and verified. But, as Cartwright observes, Newton's theory was in desperate need of refinement. A number of his inductions were outright wrong and it fell upon the next wave of Newtonian mechanists to improve and widen the scope of his hypothesis.

Even into the early 18th century leading members of the Académie Royale des Sciences in Paris balked at Newton's theory in favor of Descartes' vortex theory. The Académie had launched projects in French seaports to study and improve tidal science and its predictive capacity and, in 1738, offered a lucrative prize for the best philosophical essay on *Le flux et le reflux de la mer*—the flood and ebb of the sea.

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In 1740 the prize was shared between four contestants only one of whom supported Descartes' theory. The other three, all of whom were mathematicians, regarded Newton's theory as 'incontestably proven' according to Cartwright. What was incontestable, of course, was the rigorous logic Newton applied in his analysis of geometric relations between the earth, moon and the tides. But once again these equations would hold true for any force(s) that conspired to produce the tides. Each of the three finalists extended the implications of gravitational theory in unique and unexpected ways.

Colin Maclaurin, of Edinburgh, pointed to the deflection force generated by the earth's rotation, aka the Coriolis effect, that is now believed to play a role in tidal dynamics. Leonhard Euler, from St. Petersburg, showed that due the fluidic nature of water the determinant influence on the tides was exerted not by the vertical component of the gravitational force field but, instead, the horizontal. Daniel Bernouilli, of Basel, analyzed the geometrical structure of the 'equilibrium tide' generated by the combined influences of the sun and the moon and computed a table that would allow calculation of times of high water anywhere across the globe. The Académie's competition was exactly the shot-in-the-arm Newton's theory needed to thrive and flourish.

The most critical breakthrough in mathematical modelling of the tides occurred a half-century later in the writings of Pierre Simon, Marquis de Laplace (1749-1827) in his magnum opus *Traité de Mécaniques Céleste* (Treatise on Celestial Mechanics) in 1799. Laplace's dynamic approach was a radical departure from Newton's static equilibrium model. Laplace assumed that a host of factors such as the shape and depth of the coastlines and ocean basins, the resistance of water to applied forces, i.e., friction, the earth's rotation and the Coriolis effect, and even resonance patterns set in motion by wave interactions all affected tidal behaviors. Laplace, as well as theoreticians like Bernouilli, Euler and Lagrange, collectively developed the science of fluid mechanics which, regarding tide theory, evolved into what became known as geophysical fluid dynamics. Most of these ideas were based on complex calculus and trigonometric functions. We thus enter a new and increasingly abstract world of tide analysis in which mathematics plays a decisive and dominant role. The next step in this transformation occurred in the early years of the 19th century.

Thomas Young (1773-1829) gave a series of lectures between 1802-1807 to the Royal Society that would form the basis of a dynamic oscillational theory of the tides - literally a 'wave' theory. Young commented, 'there is indeed little doubt, that if we were provided with a sufficiently correct series of minutely accurate observations of the tides, made not purely to the times of low and high water only, but rather to the heights at intermediate times, we might form by degrees . . . almost a perfect set of tables as we already have for celestial bodies'.

Early tide measurements consisted of visual observations that charted the times and heights of high and low water levels thus providing a finite volume of static data. While measurement of tidal extremes is not difficult accurate determination of the times at which they occur is challenging. Obtaining measurements too early or too late produce falsely high or low values. Such difficulties emphasized the need not only for more exact but more frequent tidal observations.

This recognition eventually gave rise to the need for measuring the entirety of the wave cycle. And with accurate measurement of tide cycles over extended lengths of time scientists realized they could compare these behaviors with the cyclical behaviors of the earth, moon and sun. This gave rise to what became known as harmonic analysis. What a stroke of genius! But still it offered no insight into the origins of the tides.

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Along with growth of tide theory came an equally impactful revolution in tidal measurement techniques. The most significant breakthrough was the automatic tide gauge that allowed for continuous monitoring. The first tide gauge appeared in 1828 after which a steady stream of mechanical refinements ensued. By 1850 automatic tide gauges were in use throughout ports in Britain, France, and the US. This technological revolution completed the metamorphosis of Newton's static tide theory into the new dynamic framework. Tides became continuous waveforms that could be observed and studied on the basis of their oscillatory behaviors.

Laplace and Young were succeeded by a legion of mathematicians - George Airy, William Thomson, Horace Lamb, George Darwin - all of whom made incremental contributions to harmonic wave analysis, a method by which causal inferences could be drawn based on temporal and geometric wave properties. This, in turn, conferred greater degrees of specificity and predictability. Questions surrounding tidal origins became relegated to historians and philosophers.

MAGNETIC FIELDS

In 1269 French scholar Petrus Peregrinus wrote *Epistola de Magnete* (*Letter on the Magnet*) in which he described the magnetic properties of iron needles and lodestones. Magnetic force seemed to be concentrated at opposite points on the lodestone he called 'poles' which exhibited different behaviors. He established that poles of the same type repel each other while unlike poles attract one another. Now called a dipole field, this is the simplest kind of magnetic field (MF) **(Figure 6).**

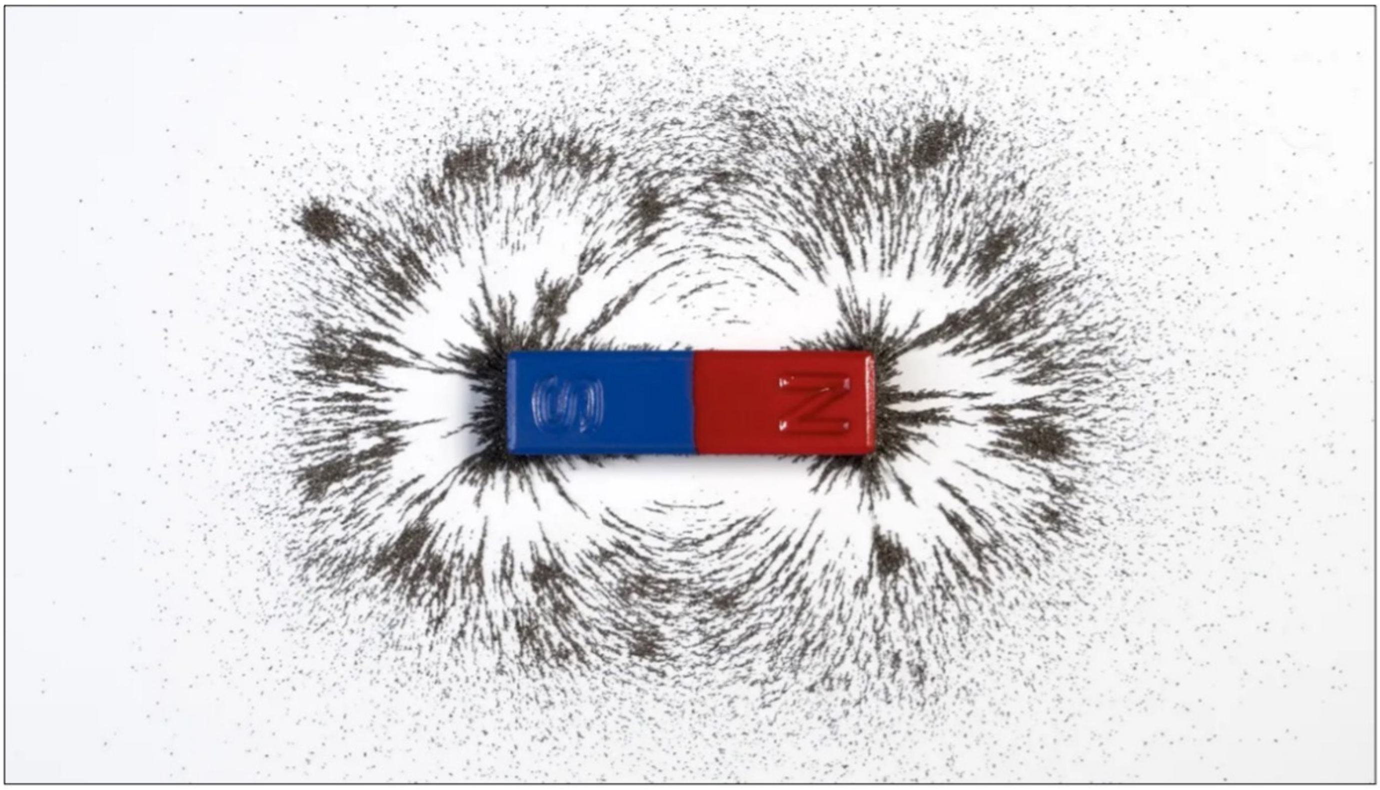

Figure 6. Magnetic lines of force in a simple dipole field.
https://www.livescience.com/physics-mathematics/why-do-magnets-have-north-and-south-poles

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In the early 17th century William Gilbert observed that small magnetized needles adhered to the surface of a lodestone along longitudinal lines in a manner similar to how compass needles aligned themselves. Based on such semblance Gilbert deduced that the earth itself was a magnet writing that 'rays of magnetic virtue' spread out in every direction forming an 'orbe' the center of which resides in the earth. Such 'rays', later called 'lines of force' by Michael Faraday, are directional components of all MFs.

By the end of the 17th century systematic measurements of the earth's surface confirmed the presence of this geomagnetic field and British astronomer Edmund Halley had developed a global system of 'contour' lines. Magnetic lines of force exit a magnet at the north pole and re-enter at the south pole thus forming a closed loop of spiraling field lines. Based on this convention the geographic north pole of the earth represents the magnetic south pole **(Figure 7)**. If one suspends a bar magnet on a string allowing it to rotate freely, its north pole will tip upward in the southern hemisphere, downward in the northern hemisphere, and remain horizontal near the equator. Such upward and downward deflections, known as inclinations, are measured in degrees.

At the north and south poles force lines abruptly orient themselves vertically, i.e., the angle of inclination approaches 90^{O}, as field lines emerge from the geodynamo at the south pole and return at the north. The geographic points on the earth's surface where vertically oriented field lines converge in the north and diverge in the south represent the magnetic poles. These poles are distinct from the geographic north and south poles which plays into the phenomena of rotation and precession.

The earth rotates about an imaginary line drawn between the geographic north and south poles and this rotational motion plays a primary role in generation of the geomagnetic field. At both north and south poles the geographic and magnetic poles offset one another by about 11-12^{o}, aka magnetic declination, which gives rise to the earth's curious wobbling motion and which, in its annual revolution around the sun, results in unequal distribution of sunlight over the two hemispheres and the seasons.

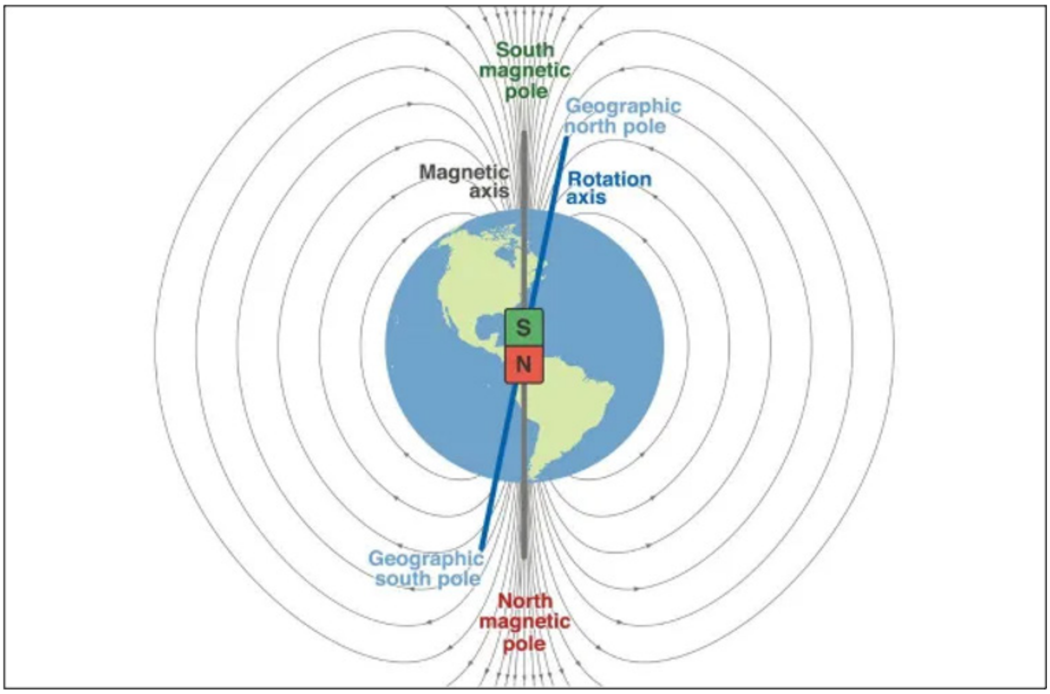

Figure 7. Illustration of directional and pole relationships of the earth's magnetic field. https://www.thedailyeco.com/magnetosphere-definition-location-and-function-72.html

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The earth's MF is generated and sustained by flowing electric currents in its molten iron core induced by interactions between the opposing forces that cause precession. Gilbert, Kepler and Descartes couldn't have known this at the time as the relation between magnetism and electricity was unknown. Only in the 19th century did such insights begin to emerge.

In 1820 Danish scientist Hans Christian Ørsted observed that when he turned on an electrical current it deflected the needle in a nearby compass. The needle was neither attracted to nor repelled by the wire carrying the current but, instead, aligned itself obliquely to the current. This behavior is caused by what is now called the Lorentz force which operates at a 90^{O} angle to the MF and plays a pivotal role in the generation of MFs.

Around the same time French scientist André-Marie Ampère discovered that parallel wires carrying electric currents interacted magnetically and, when moving in the same direction, attracted each other and, when in opposite directions, repelled each other. This is to say that electric currents flowing through conductors like copper or silver generate MFs surrounding the wires.

Building on such work Michael Faraday made a series of discoveries that underlie our present understanding of electromagnetism (EM). When he passed a coil of wire through a MF an electric current was generated. This is known as Faraday's law of induction. So Ampère discovered that moving electric currents induce MFs while Faraday found that moving a conductor through a MF generates electrical currents. There seems to be some kind of reciprocity between magnetism and electricity raising questions as to its basis. At first glance this is nearly as puzzling as action at a distance.

Since electricity and magnetism are distinct forces with entirely different properties, clearly electricity can't transform itself into magnetism any more than magnetism can transform into electricity, and it is axiomatic that something can't come out of nothing. Faraday's genius was to recognize the necessity of a third force, what he called dielectricity, that mediates interactions between magnetism and electricity and, as we will see shortly, gives rise to both.

Faraday's other seminal contribution was to introduce the field concept which is indispensable to modern physics. Fields, comprising both spatial and non-spatial elements, are the medium through which energy is transmitted from one body to another. Had earlier scientists been familiar with the field concept they probably wouldn't have been so skeptical of action at a distance.

Fields function on the basis of pressures and gradients and manifest spatially as force. Gravity exists as a field. Magnetism is a field. Electrical currents move in a field and, based on the experiments of Ørsted, Ampère and Faraday, we could say that magnetism and electricity are but different aspects of the same field. Dielectricity, progenitor to both magnetism and electricity, forms the primary field out of which the other two arise, which means that the three exist in a conjoined relationship. Dynamics between these three interactive field modalities is detailed by Ken Wheeler in his remarkable opus *Uncovering the Missing Secrets of Magnetism* (2014) which must be regarded as the final word on the subject.

Faraday, pioneer experimentalist, was not mathematically inclined and it fell to James Clerk Maxwell several decades later to render mathematical proofs of his work in *A Dynamical Theory of the Electromagnetic Field* (1865) and *A Treatise on Electricity and Magnetism* (1873) unifying electromagnetism and light. It is said that the notion of the dielectric field was implicit in Maxwell's equations but, for reasons unknown, he never developed the concept further.

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In 1895 Dutch mathematician Hendrik Lorentz derived the first mathematical equations in support of what is now eponymously known as the Lorentz force. According to Lorentz the combined effect of electric and magnetic forces on a moving particle induces a third force perpendicular to the MF causing deflection of the particle. Lorentz's law of force was verified experimentally by physicist J.J. Thompson in 1897. So fundamental is this force to EM phenomena that it has been canonized in the now-famous Right Hand rule **(Figure 8).** But the fact that experimental phenomena correspond to some abstract mathematical equation says little about the nature of the phenomenon itself.

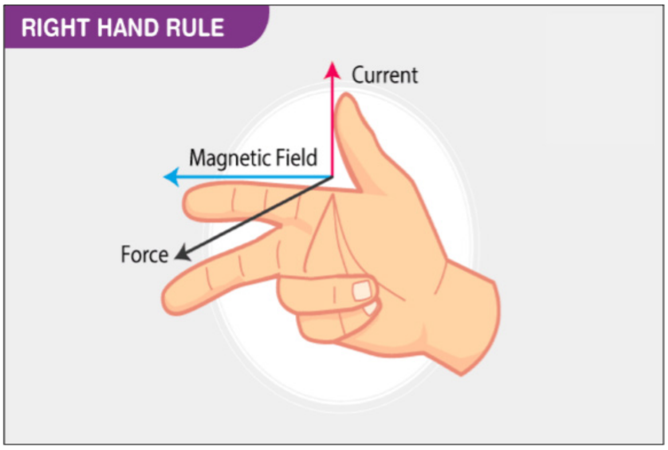

Figure 8. Right Hand Rule illustrating directional relationships between magnetic field, dielectric field and electric currents.
https://byjus.com/physics/lorentz-force/#lorentz-force-formula

By all accounts MFs are generated by electric currents flowing through a conducting medium and the question thus arises as to how these currents both *induce* and then *interact* with the MF to create a third force which supposedly asserts its effects at 90° angles to both? Does the conducting medium play any role in such interactions or is it entirely passive? And what about the supposed 'particles' that the electric and magnetic fields are said to deflect? Lorentz's explanation is unfounded and absurd. There is no need for theoretical particles in explaining such phenomena.

The Lorentz force is nothing other than the dielectric field first described by Faraday. The deflection is produced by the interaction between the magnetic and dielectric fields which repel each other and, in other settings such as electrical power generation, induce electric currents. And, to make matters even more convoluted, this primary organizing force, Faraday's dielectric field, acquired yet another moniker in the past half-century by scientists seeking to explain various celestial phenomena.

ACCRETION DISK

In the mid-20th century astrophysicists, questioning the basis by which orbiting bodies constellate around suns and stars or how such orbiting objects come into being advanced the idea of the accretion disk. Originally a mathematical concept born of necessity, accretion disks were later confirmed observationally and detailed models now explain their structure and function [1-4]. Accretion disks, thin wafer-like circular structures surrounding stellar objects like stars and suns, are ubiquitous galactic phenomena and, while different types are described, we are interested in a particular variety.

In evolving star systems 'protoplanetary discs' are revolving and rotating collections of gas and dust particles that swirl around a central radiant body and are said to be the gestational medium of planets, asteroids, and comets within those systems [5-8]. Besides engendering the circular motions of revolution and rotation, accretion discs are said to possess an attractive force that causes orbiting material to spiral centripetally. By some accounts the purpose of this motion is to feed materials to the central star **(Figure 9).**

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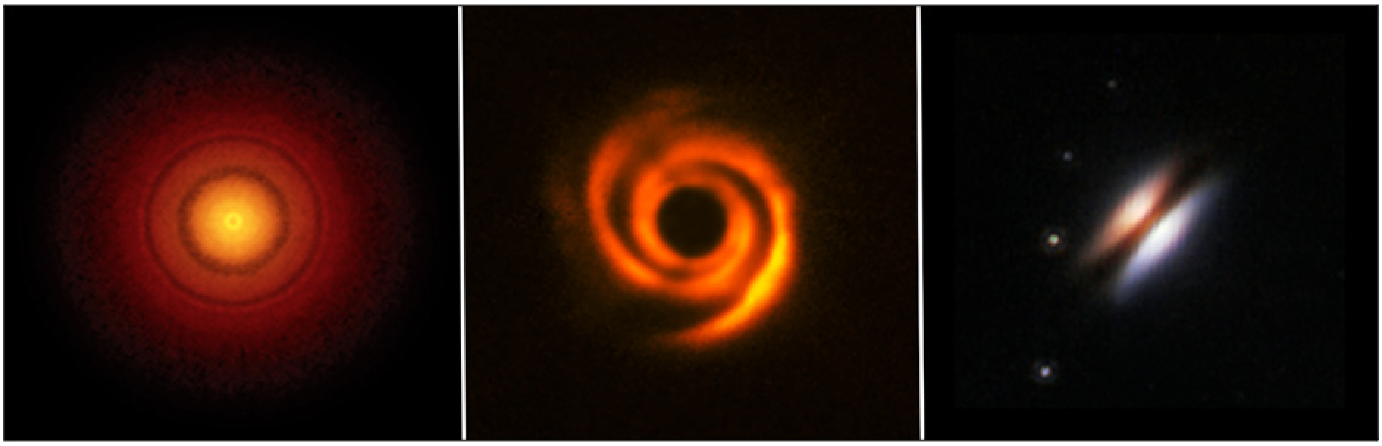

Figure 9. Images of accretion discs in deep space obtained by the Webb Telescope. https://webbtelescope.org/contents/media/images/2020/60/4784-Image

From a dynamic perspective, protoplanetary discs are not dissimilar to the concentric rings surrounding Saturn composed of innumerable particles, primarily ice and rock, of varying size and, by latest count, up to 274 moons. The particulate material in these concentric rings is said to be fragments of comets, asteroids, or moons broken apart by Saturn's powerful gravitational field. This doesn't quite make sense given that the strength of Saturn's gravitational field approximates that of earth **(Figure 10).**

Figure 10. Image of Saturn and its ring system. https://www.labmanager.com/scientists-compile-cassini-s-unique-observations-of-saturn-s-rings-29040

The various types of accretion disks are examples of Faraday's dielectric field at a macrocosmic scale. The motions engendered by this primary field are circular and centripetal and culminate in the formation of solid objects like asteroids, moons and planets. This is the only viable explanation for the presence of particulate matter in Saturn's rings or the belt of asteroids between Jupiter and Mars [9,10]. The fact that accretion discs are not always visible does not mean the force is not always present.

Scientists claim that earth's revolution around the sun is due to the gravitational pull of the sun but this is unlikely: given that gravity is distributed uniformly over the surface of large celestial bodies how is it that the earth's orbit (and the orbits of most planets) occur in a relatively narrow plane centered near the sun's equator, i.e., the ecliptic? And why for that matter is the moon's orbit around earth also centered near the earth's equatorial plane? If planetary revolution were due to gravity, then orbital paths should be distributed randomly around a central body. The near universal phenomenon of ecliptic planes seems to mandate a disc-like field exerting a centripetal force. And from this one is led to conclude that gravity itself must be secondary to the force generated by the accretion disk.

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Calling this primary induction field the Lorentz force doesn't describe its purpose or function and should be abandoned given that Lorentz didn't even explain it correctly. Equally ill-suited is the term 'dielectric' since it connotes the amphoteric effects of electric currents in a fluid medium. The term was regrettably coined by Faraday's colleague William Whewell a 19th century opinion leader in tidal research who advanced other dubious notions. The functional nature of this dynamic force is best designated as the accretion disk or densification field. The Chinese simply call it Yin. And wherever this originating force-field is present magnetism and electricity are not far in abeyance.

Regarding the geomagnetic field and its origins, we must ascribe planetary revolution around the sun as well as the rotation of earth about its own axis to the solar-generated accretion disk. The angular separation of the true and magnetic poles can only be the result of repulsion between the dielectric and magnetic fields. That this occurs at the poles makes perfect sense given that as the magnetic lines of force come into closer proximity at the north and south poles the force concentrates and the field becomes stronger by almost twofold compared to the equator. Such repulsion accounts for the third planetary motion of precession.

Scientists claim that precession, the annual wobbling motion of the magnetic poles around the true poles, is caused by the gravitational pull of the sun and moon on the earth but there is no evidence whatsoever to support this claim. Near the turn of the 20th century Irish physicist Joseph Larmor described the very same wobbling motion in the nuclei of atoms. Atomic nuclei consist of protons and neutrons which, like planets in a solar system, are said to rotate or 'spin' about their axis and generate a MF, a so-called 'magnetic moment'. When materials are placed in an external magnetic field their nuclei acquire a repetitive precessional motion the rate of which is called the Larmor frequency. How is it that at the atomic level the precessional motion is conceived as a magnetic event while at the planetary level scientists continue to invoke Newton's defunct law of universal gravitational attraction? Someone hasn't done their homework.

Magnetic resonance imaging technology is but a sophisticated development on Faraday's original experiment in passing a wire coil through a MF and inducing the flow of electricity. We must conclude that the precessional interaction between magnetism and the dielectric field was responsible for the generation of electric currents in Faraday's experiment just as we must draw the same conclusion regarding the origins of electric currents in the earth's core (which scientists have yet to explain).

A small twist of irony: strongly influenced by Faraday's work Larmor advanced the first geodynamo theory in 1919 but it was roundly rejected by scientists of the time. Seventeenth century scientists rejected the magnetic hypothesis as it implied action at a distance; early 20th century scientists simply couldn't imagine how such a mechanism inside the earth was made possible.

THE GEODYNAMO

The unfolding 20th century geodynamo saga, from a chronological perspective, is straightforward: as seismic data gradually emerged depicting the earth's vertically stratified internal structure, it became obvious that events necessary for MF generation must occur at the core, which begins ~2900 km (1800 m) beneath the surface and extends to a depth of ~6400 km (4000 m) to the very center. The core has two layers, an outer liquid shell ~2250 km (1400 m) thick composed of molten iron and small amounts of nickel, and an inner solid core with a radius of ~1300 km (800 m) **(Figure 11)**.

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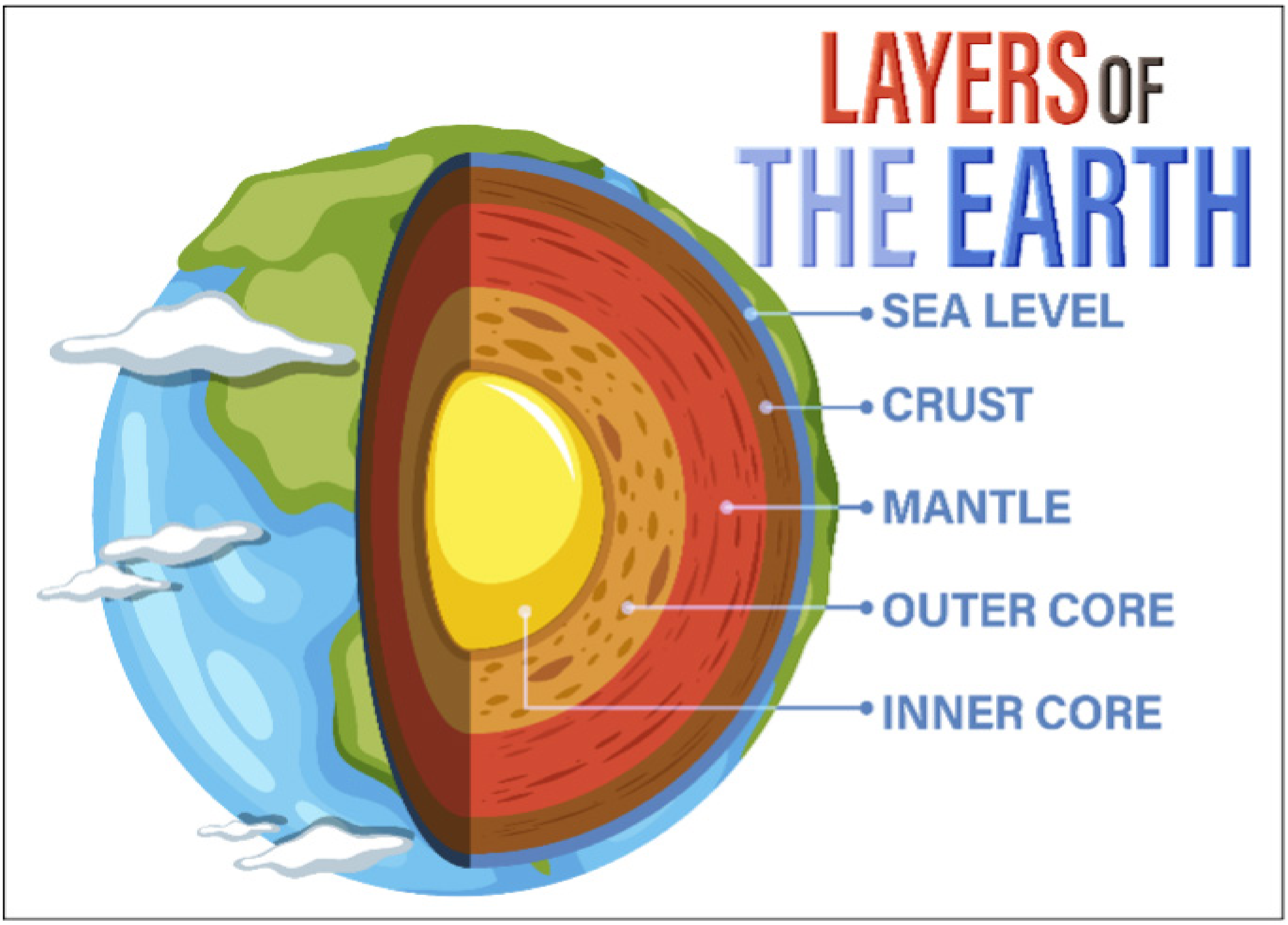

Figure 11. Graphic illustration of earth's inner layers.
https://www.freepik.com/free-vector/diagram-showing-layers-earth-lithosphere_36362492.htm#from_element=cross_selling__vector

By the mid-1940s physicist Walter Elsasser advanced the first acceptable, i.e., fortified by obtuse mathematical logic, dynamo theory proposing that the earth's MF was generated by electric currents induced in the fluidic outer core. From that point onward theoretical models continued to successively build upon each other and evolve based on emerging data. The first widely accepted mathematical model of a self-sustaining dynamo was advanced by Glatzman and Roberts in 1995 and, though it has limitations, most scientists accept that it accounts for many of the features of the observed field **(Figure 12).** Much of the material in this account can be found in *Our Magnetic Earth: The Science of Geomagnetism* (2010) by R.T. Merrill and *The Earth's Magnetic Field* (2023) by William Lowrie.

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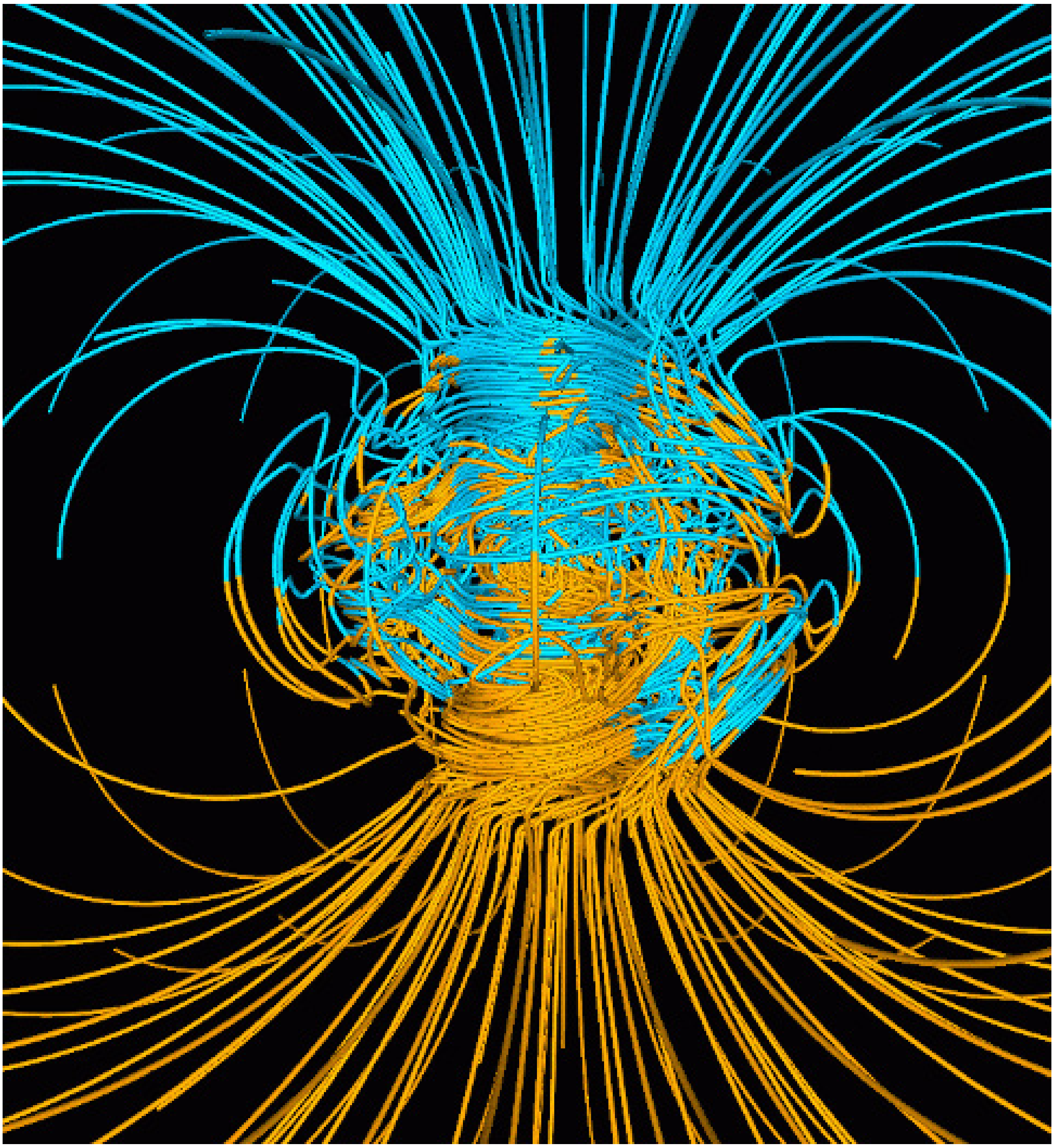

Figure 12. Glatzman-Roberts simulation of the complex geomagnetic field.
https://upload.wikimedia.org/wikipedia/commons/d/d5/Geodynamo_Between_Reversals.gif

The dynamo mechanism appears to be ubiquitous among stars and planetary systems. The sun possesses a dynamo and it is thought to be the basis for MF generation in other star systems of the galaxy. Within our solar system dynamos have also been found in Mercury, Jupiter, Saturn, Uranus and Neptune. At least one of Jupiter's moons has an active dynamo. Mars' dynamo is defunct. The dynamics that drive all dynamos involve formation of a swirling vortex affirming Descartes' original surmise. The premise of Elsasser's theory was that electric currents in the outer core generate earth's MF. This much has been affirmed. Unfortunately, however, electric currents are not confined to the core.

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Electric currents are found throughout the earth's mantle and crust as well as in the oceans all of which are electrical conductors [11-19]. Such 'telluric currents' were recognized in the 1860s. Electric currents are also found throughout the atmosphere, concentrated especially in the ionosphere and Van Allen belts of the magnetosphere where they form a system of ring currents that interact with the solar-generated interplanetary MF, aka heliosphere, and electricity-laden solar winds to influence weather patterns on earth and mediate phenomena such as geomagnetic storms and the aurorae borealis and australis. Evidence thus tells us that the geomagnetic field is generated at more than one site.

From Faraday's work we know that wherever electric currents arise one also finds magnetism and dielectricity. Simply providing a mechanism by which the MF is generated overlooks the more fundamental question as to how the earth itself came into being which necessarily involves the accretion disk. Is it accidental that in all accounts scientists emphasize the central import of the Lorentz force in the earth's core, mantle and crust as well as in atmospheric phenomena? Here Wheeler's work greatly clarifies matters.

The accretion disk/dielectric field and magnetism repel one another, says Wheeler, because they are diametrically opposing forces: whereas the dielectric is circular and centripetal, i.e., counter-spatial, literally creating bodies through compressive force, magnetism induces expansional 3-D fields. Magnetism doesn't just occupy space it creates it. Contrary to Newton's belief there is no such thing as empty space. The two opposing fields exist simultaneously and are inseparable. And by Wheeler's account, if I understand him correctly, electricity is a hybrid force mediating interactions between these two primary field modalities.

Because we are mainly concerned with tidal phenomena our focus here is limited to the geodynamo. Part II of the series addresses accretion field dynamics and the origins of the four primary planetary elements, Earth, Water, Air & Fire. In Part III we examine in greater detail the influence of solar dynamics on planetary phenomena.

Based on volcanic eruptions and lava flow it has been known for millennia that the earth's interior is very, very hot. By the same token the seismic undulations of earthquakes and the violence with which volcanoes are prone to erupt suggest that pressures increase at greater depths. Ambient pressures at the earth's center are said to be about 3.6 million times that at the surface. Scientists imply such pressures result from the cumulative weight of materials but undoubtedly interactions between the accretion field and geodynamo contribute to the gradient.

In the outer core temperature effects dominate causing iron to melt but at greater depths asymmetric pressure buildup prevents liquefaction so that the inner core remains solid. In any event the fluidic nature of the outer core permits rotation of the entire core with respect to the mantle thus generating electric currents and magnetism. If matters were this simple then the earth's MF might be a simple dipole but such is not the case.

While both inner and outer cores rotate in a counterclockwise direction like earth they do so at different rates. The solid inner core is said to spin slightly faster than the outer core and this differential movement contributes to the MF. Moreover, the rotational frequencies of the cores exhibit periodic acceleration and decelerations. While the main part of earth's MF is core-generated magnetizations are also induced in the crust and mantle which contribute to the field. Evidence is also overwhelming for the presence of another dynamo in the ionosphere which generates part of the outer shield that protects against solar radiation. Scientists thus speak of complex quadrupole and octupole

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fields the shape and strength of which, for reasons unknown, are in continual flux. Measurements suggest ~10% of earth's MF is non-dipole in nature. Another feature of the geodynamo is a system of cylindrically shaped magnetic vortices distributed throughout the liquid outer core [20-23]. Since these vortices cannot be directly observed much of the current knowledge comes from studies of solar vortices. Scientists have yet to reach consensus as to their exact purpose but, from our dynamic perspective, such vortices would seem to be intimately tied into the functions of the accretion disk given that they are driven by pressure and temperature gradients.

Much as tornadoes on the earth's surface arise because of pressure and temperature differences between the upper and lower boundaries of weather cells, dynamos are based on convection dynamics in which hot fluidic material moves upward along the inside of a column while cooler fluid flows downward creating circulating convection currents. Such vortical dynamics are entirely driven by accretion/dielectric and magnetic field interactions.

Scientists claim these spiraling cylindrical structures result from an interaction between the Lorentz and Coriolis forces and serve to amplify and sustain the primary MF. Supposedly the Coriolis force induces the circular motion but this is dubious since this force, which some even call a 'pseudoforce' or 'fictitious force,' is itself said to be induced by earth's rotation. There is no need for such ad hoc conjectures once it is recognized that the accretion disk and its rotational force drive such phenomena.

So, in summary, evidence gathered over the past century has provided a wealth of information as to how the geodynamo generates the earth's MF as well as the nature of its field. The field is non-uniform and varies irregularly in direction and magnitude across the globe. Field strength is surprisingly weak. Compared to the ~1 Tesla (T) pole strength of a standard neodymium magnet, geomagnetic field intensity approximates 25-65 µT, less than a thousandth in magnitude.

Counterintuitively the lowest intensity is not at the equator as one might expect but in the Atlantic Ocean between Africa and South America, aka the South Atlantic Anomaly, which is thought to be caused by asymmetric flow patterns in the outer core. Fluctuations in field strength have been recognized since the 17th century and since 1900 intensity has declined by ~10%. The rate of this decline has accelerated in recent decades leading some to claim that a pole shift is underway. Evidence regarding this possibility will be examined in greater detail in Part III.

SUN-EARTH-MOON CONNECTIONS

Based on evidence we have examined it is obvious that gravity has no role in planetary energy dynamics and is little more than the tailwind of the accretion disk. Having shown the sheer implausibility Newton's hypothesis, not to mention his claim of a single universal force, we are left with two tasks: first, to show that interactions between the accretion/dielectric and magnetic fields account for the dynamics between earth, moon and sun and, lastly, to show how these same forces conspire to produce tidal phenomena. But first we must briefly examine the energetic underpinnings of the solar system.

The sun, the central body of our solar system, is a huge sphere of rotating and precessing plasma which itself revolves around the center of the Milky Way galaxy. Its diameter is over 100X that of earth and total mass more than 700X greater than the combined mass of all the planets in our system. Plasma, composed mainly of ionized hydrogen and helium, is generated in the outer shell of the sun's interior, aka the convection zone, in which reside the

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system of solar dynamos. The solar MF, composed of interpenetrating dipole, quadrupole and octupole components, is significantly stronger than that of earth and, like earth's, fluctuates remarkably in terms of strength and spatial configuration **(Figure 13).**

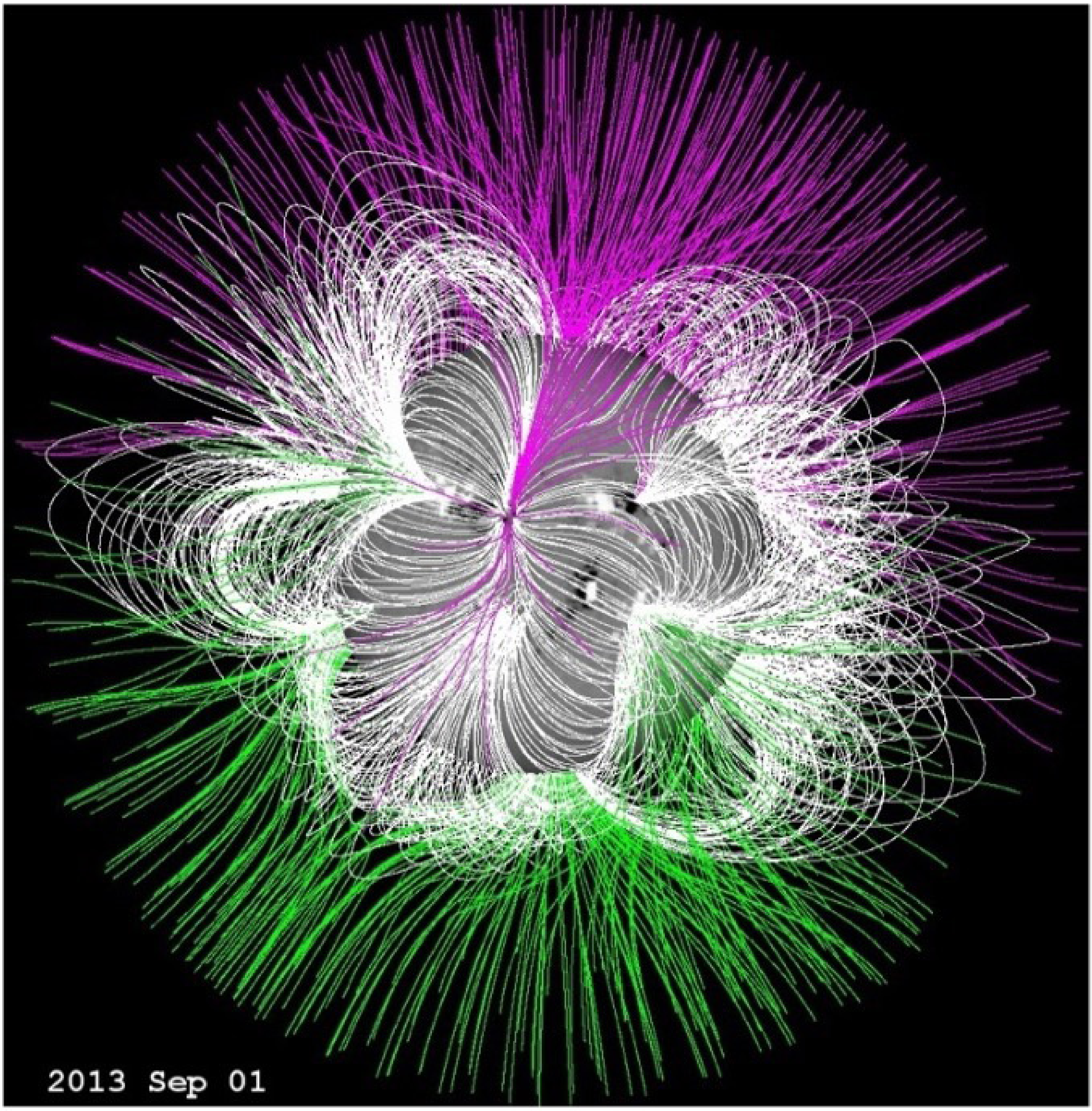

Figure 13. Computer-generated simulation of the complex solar magnetic field
https://svs.gsfc.nasa.gov/vis/a000000/a004100/a004124/PFSS_0400.jpg

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In an 1808 paper in *Annalen der Physik* German naturalist Alexander von Humboldt reported his observations of a 'magnetic thunderstorm' involving atmospheric light displays. The connection between sunspots and geomagnetic storms was first made in 1859 by astronomer Richard Carrington who observed through his telescope intense flashes of light in a cluster of sunspots. Less than a day later the most intense geomagnetic storm ever recorded made its entry into earth's atmosphere. Called the Carrington event, auroral activity was seen as far south as Italy and Cuba and caused interruptions of telegraphic transmissions. Carrington intuited a connection between the solar flashes and atmospheric phenomena. By the late 19th century, following Maxwell's unification of electromagnetism and light, Irish physicist George Francis Fitzgerald proposed that sunspots emitted a conducting material, now called plasma, that escaped the sun's atmosphere and reached earth days later.

In the 1970s the Skylab space station transmitted images of the sun's corona and associated dark regions, aka coronal holes, along with huge eruptions at the sun's surface, aka coronal mass ejections (CMEs), which are the source of the solar wind streams that induce geomagnetic storms on earth. Around the same time the Helios 1 and 2 satellites returned evidence affirming the energetic nature of interplanetary space, aka the heliosphere. Data established a connection between CMEs in the solar corona and turbulent plasma flow in the interplanetary medium which possessed quite different attributes compared to regular solar winds. The heliosphere mediates interactions between the fluctuating solar MF and earth's MF and forms the basis of what we now call 'space weather'.

The heliosphere, the interplanetary medium that envelops all planets, is a vast expanse of open space extending in all directions from the sun into deep space which confers dimensionality upon the solar system. Its outer boundaries, aka the heliopause, is where the sun-generated field is delimited by the opposing field from the adjacent interstellar galactic medium. This is precisely the same notion advanced by Descartes in his crude hand-drawn images from the mid-1600s. About 99% of 'space' is said to be composed of plasma emitted by radiant bodies. Plasma, the fourth state of matter, i.e., pure force, is composed of dielectrically charged particles, i.e., protons and neutrons, electricity and magnetism.

That interplanetary space is magnetic in nature is well established [24-27]. The rotational motion of the sun generates spiral-shaped flow lines of escaping plasma, called Parker spirals after astrophysicist Eugene Parker who predicted their existence in the 1950s [28-30] **(Figure 14).** The sun is thus encircled by a system of flow lines possessing both toroidal and radial components carrying plasma throughout the solar system. The field is said to possess N and S poles with N pointing toward the sun and S pointing outwardly and to be divided in two by an undulating stream of electricity known as the heliospheric current sheet. Given the presence of electric currents in the equatorial accretion disk one must conclude that the magnetic component of the heliosphere is generated *de novo* throughout the entire solar system.

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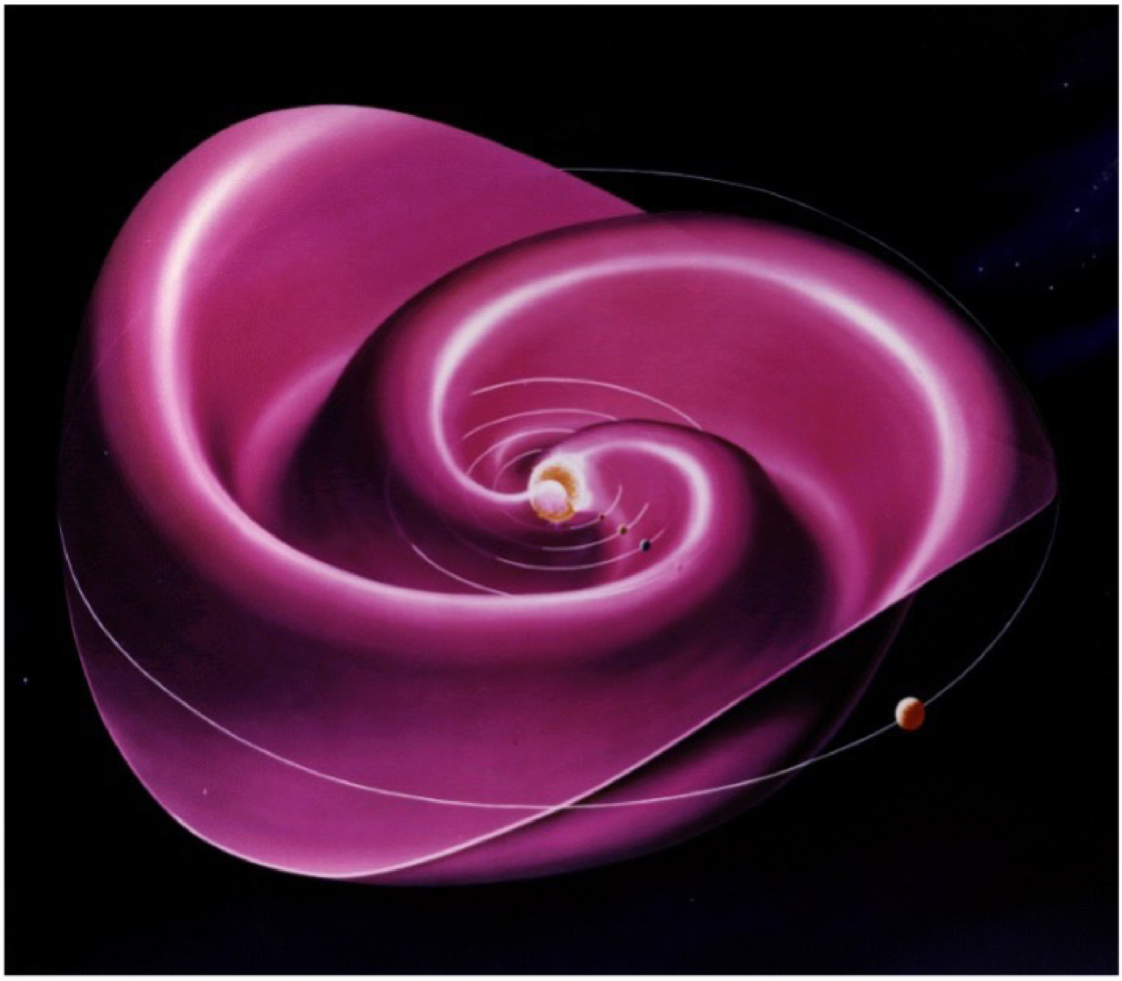

Figure 14. Graphic depiction of the system of Parker spirals composing the heliosphere.
https://upload.wikimedia.org/wikipedia/commons/b/b6/Heliospheric-current-sheet.gif

Radiant celestial bodies thus generate the two opposing fields that define solar systems: planets gestate and are born within the sun-generated accretion disk while the interplanetary MF, the heliosphere, forms the spatial architecture in which planets spin. Dynamically, its accretion field generates the centripetal force that pulls planets inwardly while the heliosphere represents the medium that simultaneously repels planetary bodies not only from the sun but from each other. How could gravity acting through empty space mediate such interactions? We need only examine two sets of relationships, one between the earth and sun and the other between the earth and moon, to see the inescapable reality of such a cosmologic proposition.

The solar wind flows around the geomagnetic field in a manner analogous to how water flows around a rock in a river. Flowing plasma streams impinge upon the magnetosphere by exerting force and pressure. The points of contact where the solar wind and earth's MF exert equal and opposite pressures define the boundary of earth's magnetosphere, aka the magnetopause. Space winds deform earth's MF by compressing it on the day-side and causing it to stretch out on the night-side forming a long comet-like tail (Figure 15). The solar field is held at tenuous bay by the earth's main dipole field thus shielding it from adverse effects. Obviously during large CMEs such as the Carrington event solar winds may breach this barrier with deleterious consequences. This is where magnetic dynamics enter the picture.

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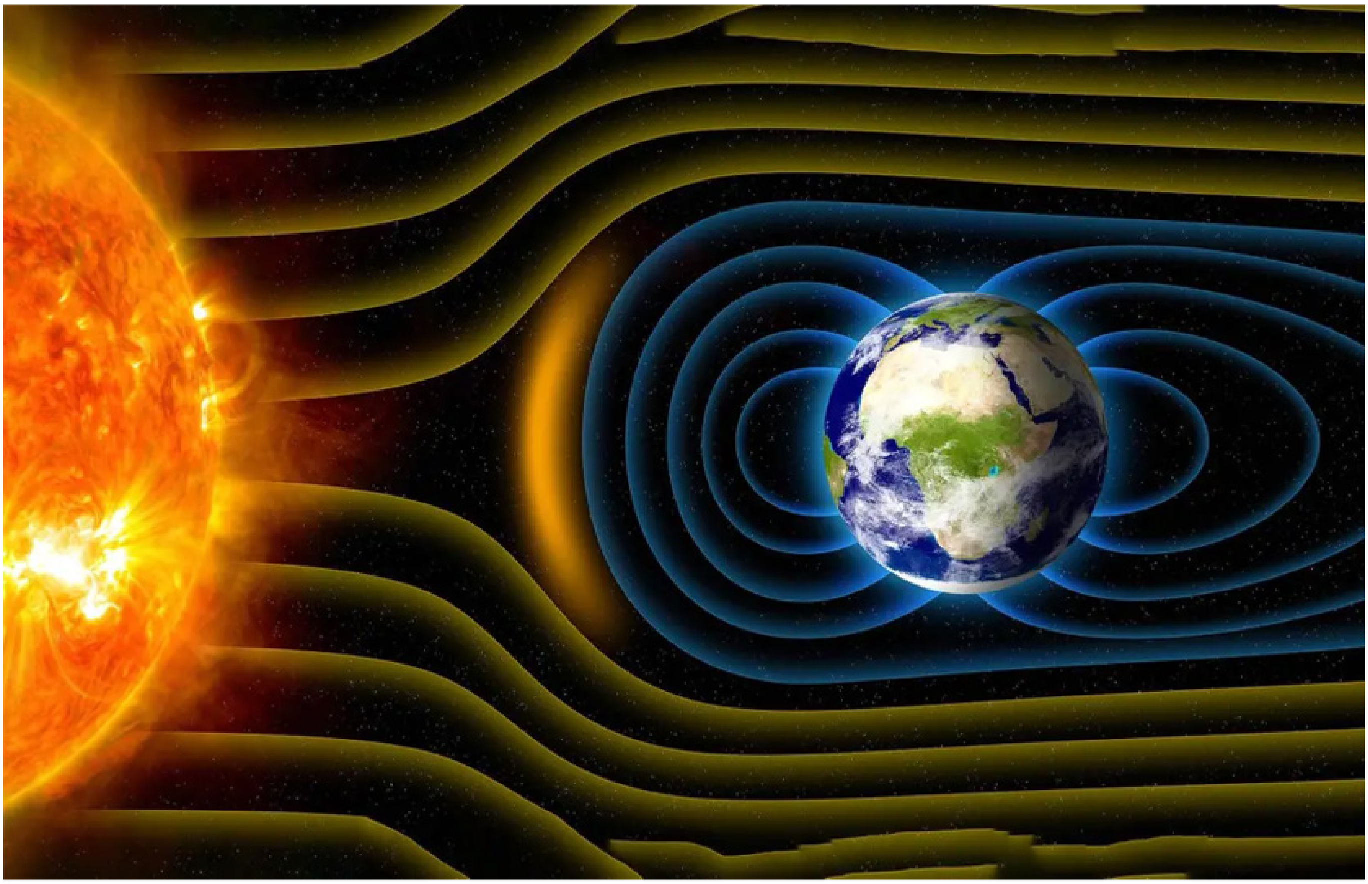

Figure 15. https://www.earth.com/news/earths-magnetic-field-dances-with-solar-wind/

When a dipole magnet breaks apart each piece forms a new whole field complete with N and S poles and an equatorial accretion/dielectric disk. Wheeler goes into great detail on this point. Some of the fragments recombine based on attraction between opposite poles while others may remain separate due to either repulsion between like poles or the sheer distance between pieces. Accordingly, separation of the interplanetary MF and earth's MF can only occur based on like-on-like repulsion. Repulsion between the interplanetary MF and individual planetary MFs is clearly in play throughout the solar system just as it explains the separation between the heliosphere and adjacent interstellar galactic MF. Descartes, once again, was intuitively correct on this matter.

We briefly speculate as to the nature of planetary and solar MFs which, in all cases, possess highly complex field structures, comprising dipole, quadrupole, octupole components. What is the basis for such an organizational scheme? Given that all dipole fields, under appropriate circumstances, spontaneously revert to a single larger field, i.e., re-incorporating into an existing field structure, one must question whether quadrupolarity or octupolarity confer degrees of incommensurability between adjacent fields that resist coalescence into a dominant field.

The relationship between earth and moon must also be considered. Revolution of the moon occurs around earth's ecliptic plane suggesting that the moon is held in orbit not by gravity but by earth's accretion field. Moreover, given that we always see the same side of the moon, it clearly revolves but does not rotate and must somehow be locked into position. This is consistent with observations

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that the moon neither generates its own MF nor possesses an atmosphere. This suggests it is dielectrically/accretionally dominant **(Figure 16).**

Figure 16. https://www.shutterstock.com

Wheeler shows that beneath attraction-repulsion phenomena of magnets lies a more fundamental relationship between magnetism and the accretion/dielectric field. When magnets 'attract' they are, in effect, 'voiding' the space between them and coalescing into a unitary field. MFs attract one another based on affinity, i.e., 'like likes like.' Equally, based on affinity and the centripetal force-field, the accretion disk draws objects into ever tighter spatial proximity. If indeed the moon is fixed in place by such an attractive force, repulsion between earth and moon can only be mediated by the magnetic force of the intervening heliosphere. And as the moon hurtles through not-so-empty space at ~2300 mph it induces electric currents and repels the adjacent heliosphere. This generated force, in turn, impinges on the earth's MF at its outer boundary thus providing a mechanism for the tides that the effete gravitational hypothesis cannot offer.

Evidence from solar storms indicates that heliospheric disturbances rather easily find their way into the earth's atmosphere. The magnetosphere forms the outer shell of the earth's protective envelope which abuts upon the interplanetary MF. The magnetosphere begins ~500 km (310 m) above the earth's surface and, on the day-side extends upward by ~10 earth radii while, on the night-side, for hundreds of earth radii forming a long drawn-out tail. Solar wind variations induce electrical currents in the magnetosphere, aka ring currents, which travel along a system of field lines forming a two-way connection with the ionosphere. The fluctuating field induced by ring currents also

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influences the earth's crust and mantle. All of these dynamic interactions, to gratuitously belabor the point, arise via Faraday's principle of induction, which is to say that moving dielectric, magnetic and electrical fields engender and propagate one another.

The ionosphere, immediately below the magnetosphere, is generated in the upper atmosphere where solar radiation ionizes gaseous substances creating a layer of electrically charged particles. Beginning ~80 km (50 m) above earth's surface and extending to ~600km (400 m) the ionosphere is a complex system of electric currents that generate MFs and thus represents a second active dynamo. The ionosphere is organized vertically in a concentric shell-like fashion with three distinct strata, i.e., the D, E and F layers, in increasing order of height above earth's surface. The D & E layers appear on the day side where sunlight is most intense and almost disappear at night as ionization wanes. The magnetically dominant F layer forms a double layer, the F1 and F2 strata, on the day side that reverts to a single layer at night. These two outer ionospheric layers play a crucial role in translating solar and lunar influences into tidal phenomena [31,32].

Bearing in mind these relationships, we now examine evidence regarding the tides that surfaced during the 19th and 20th centuries to decide for ourselves whether Newton's universal gravitational hypothesis explains the tides or whether they are due to interactions between the magnetic and dielectric fields. Only one of the two propositions can be correct.

STATIONARY WAVES

Perhaps the most important realization concerning the tides, cited by various ancient writers, is the inability to explain their origin based on the bulk movement of water. In the 17th century Galileo argued that the tides resulted from planetary rotation. Given that earth rotates at speeds of ~1000 mph this would engender a swell of rapidly moving water, literally a tidal wave, that would continuously circle the globe. Clearly this does not happen. Such a mechanism also mandates that tides move in a single direction which is not at all the case.

A second confounding factor, raised by the Venerable Bede, is that even along the same coastline tides do not occur simultaneously and their tidal ranges, i.e., differences between high and low levels, are not necessarily equal. Such were the challenges confronting 19th century scientists in their attempts to explain tidal phenomena and which, from the onset, should have raised red flags regarding Newton's gravitational hypothesis.

By 1800 tide tables had been developed from across the world revealing significant variations and incongruities. Based on the unique patterns seen in each locale it was apparent that tides were strongly influenced by coastal topography. Bent on making sense of things, William Whewell gathered published tables from around the world and charted locations where high-water levels peaked at the same time. Upon assembling the data, he was taken aback to observe a system of curvilinear, undulating lines, aka cotidal lines, extending throughout the oceans and seas **(Figure 17).** One must admit that the similarities between cotidal line maps and geomagnetic flux lines are rather striking **(Figure 18).** One is further led to question how gravitational influences could produce such peculiarities.

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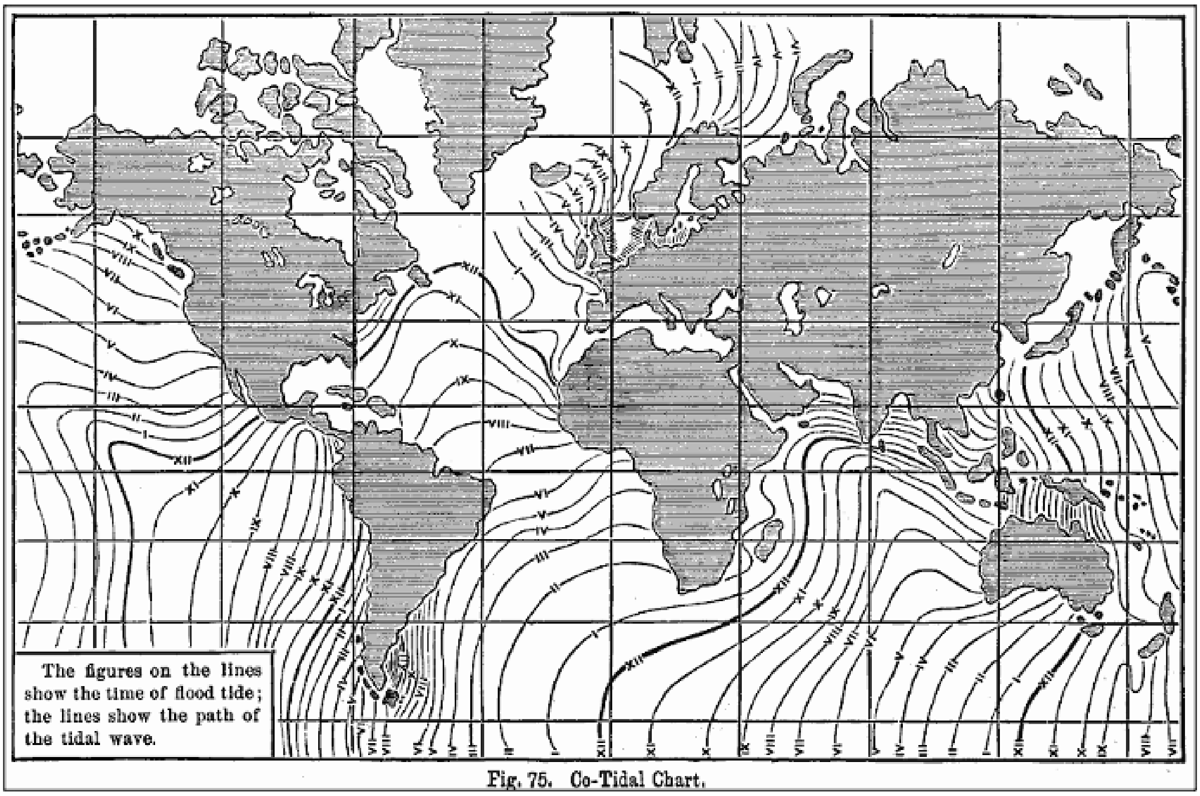

Figure 17. Circa 1890s map of cotidal from
The Elements of Physical Geography

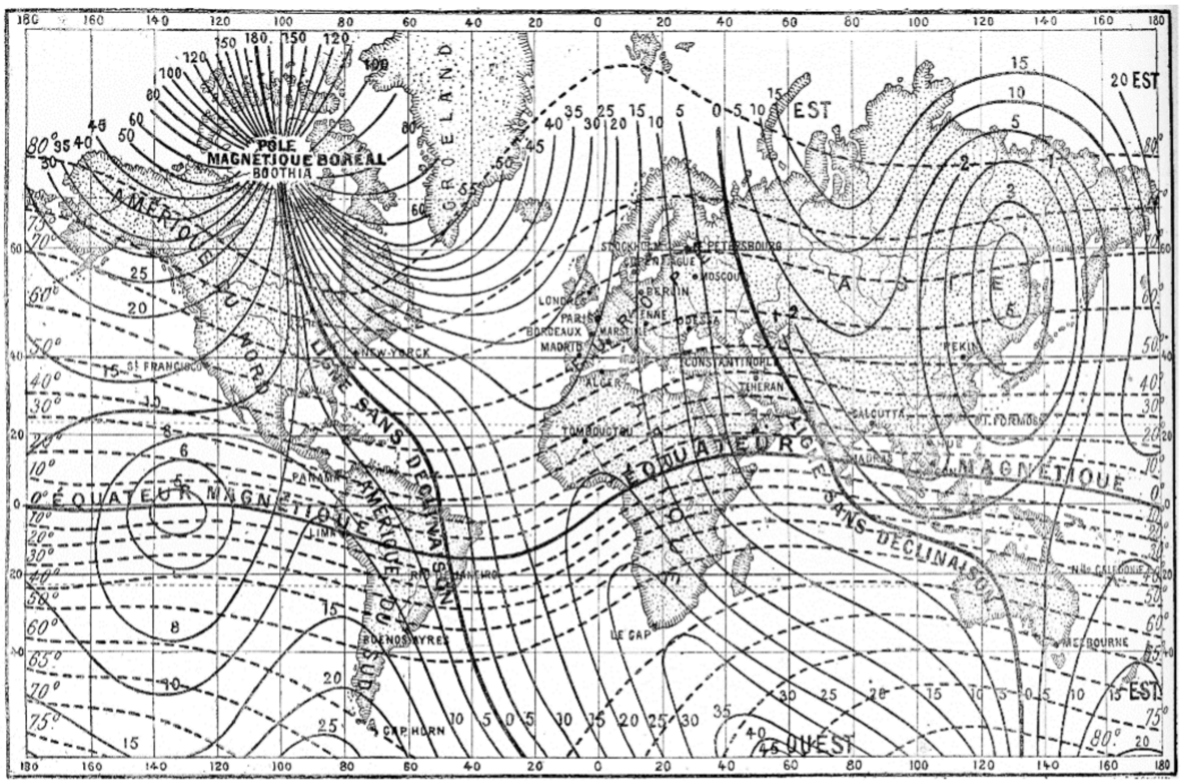

Figure 18. Global magnetic contour line map from 1895

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Based on tidal patterns in the English Channel and North Sea, and the seeming northward progression of tide lines along the western coasts of Africa and Spain, Whewell hypothesized that the tides originated in the south Atlantic and moved north as progressive wave fronts. Unfortunately, this pattern was not observed along the east coast of the US and could not explain complex tide patterns in the Pacific and Indian Oceans. Whewell's progressive wave theory, like that of Galileo, implies the bulk movement of water.

Robert Fitzroy, captain of the HMS Beagle, on which Darwin made his legendary journeys in the 1830s, was skeptical of Whewell's theory based on the 'trifling rise of the tide' and slow progression of the wave front along the west coast of Africa. He advanced the radical notion, introduced decades earlier by Thomas Young, that the tides represent 'stationary oscillations' that arose between the east and west sides of ocean basins.

To bolster his claim Fitzroy cited a paper published in 1837 by mathematician Charles Babbage suggesting that if a zonal tide wave had a wavelength equal to twice the width of the basin it could resonate locally to produce a stationary wave of large amplitude with opposite phases at each coast and a nodal point in the middle. Fitzroy cited numerous examples in the Atlantic and Pacific oceans where, in the same zonal strip, the time of high-water was later on the western side than on the eastern side by the equivalent in time of the difference in longitude.

Now called stationary waves this concept refers to waves that remain in place without traveling through a medium. Stationary waves arise based on harmonic resonance with wave formation occurring simultaneously along the entire length of the zonal strip but in opposite phase at each pole. The stationary wave hypothesis obeys our first injunction that there can be no bulk movement of water. The original concept, as advanced by Young and Fitzroy, was based on interference patterns arising between existing waves but did not explain the origin of the waves themselves. The simplest explanation is that water undergoes a conformational change induced by the fluctuating geomagnetic field. This notion had been discarded by 17th-century scientists as it implied action at a distance. As MRI technology affirms, water is a resonant medium **(Figure 19).**

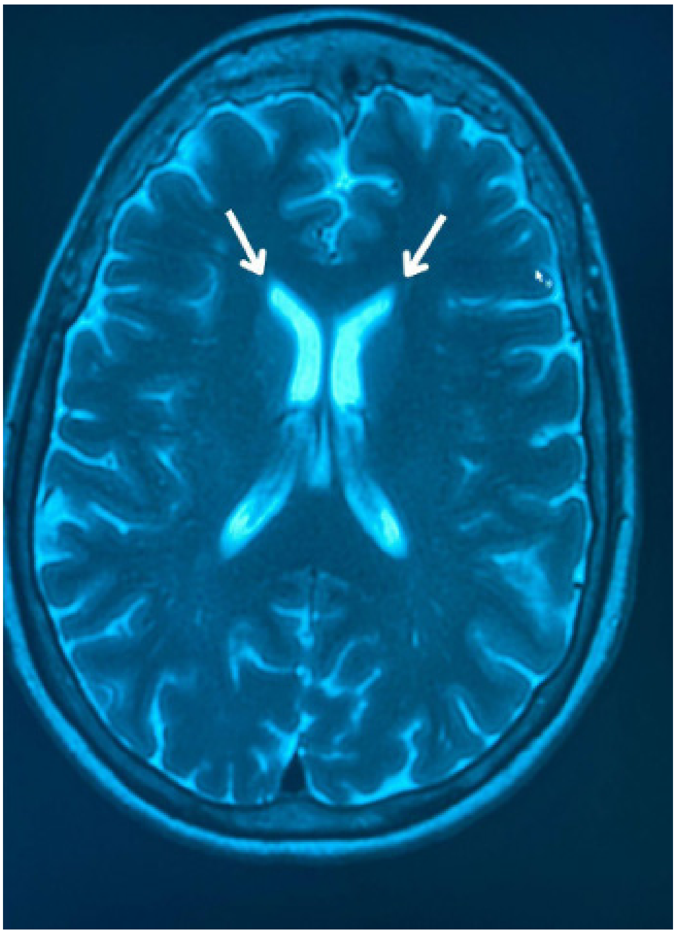

Figure 19. T2-weighted MR image of the brain demonstrating water's ability to undergo resonance. Bright signal (arrows) represents cerebrospinal fluid in the ventricles.

Fitzroy's ideas were largely ignored by scientists for the next half-century until American oceanographer Rollin Harris of the US Coast & Geodetic Survey sought to improve cotidal mapping and to develop further the stationary wave concept. While the mathematics is complicated Harris simplified

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matters by assuming that resonance patterns occur along strips of ocean, may have any orientation, and possess a wavelength (or multiple thereof) related to the distance between coasts. Where cotidal lines intersect there results a 'no-tide point' around which cotidal lines rotate in all directions which Harris called an 'amphidromic system'.

Over time Harris developed a cotidal line map for all the oceans and had found multiple amphidromic systems spread across the globe: one on the equator of the Indian Ocean, two in the North Atlantic, and three in the Pacific. Such amphidromic systems with their rotatory movement have been widely substantiated and today about a dozen such systems have been identified.

In 1928 two Austrian researchers, Albert Defant and Robert von Sterneck, showed the presence of an amphidromic system in the Arctic Ocean which, once again, bears eerie resemblance to magnetic flux line patterns in the northern polar region **(Figure 20).** Not only do the cotidal lines rotate in counterclockwise fashion like earth, but at the central amphidromic point the tidal range is almost non-existent which one might expect near the polar regions where magnetic flux lines dip vertically. Scientists claim the counterclockwise rotation of this amphidromic system is due to the Coriolis force but undoubtedly planetary rotation and the geomagnetic field directly induce this phenomenon. Certainly we can exclude gravity as a proximate cause.

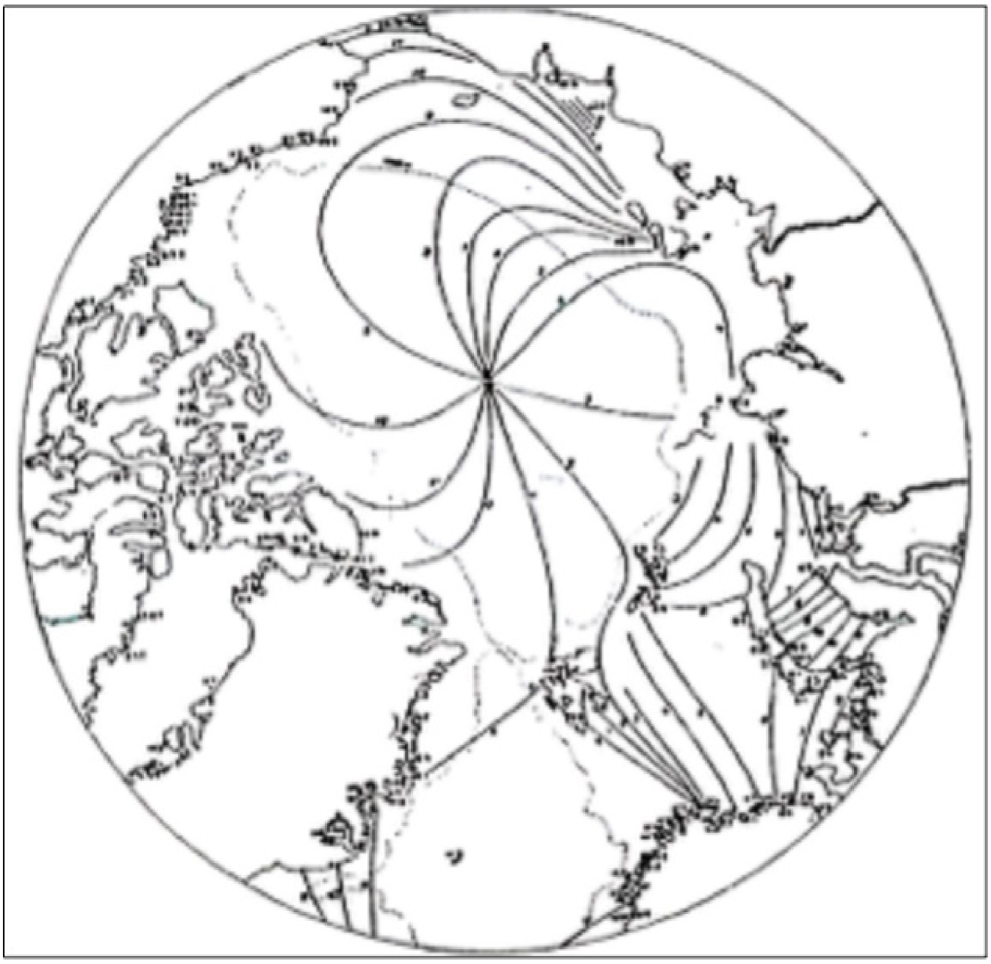

Figure 20. Illustration of the amphidromic tidal system over the Arctic Ocean published in 1928 by Defant and von Sterneck showing striking resemblance to expected magnetic flux line patterns.

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ATMOSPHERIC TIDES

Nestled between the ocean surface and the magneto-ionospheric strata dwells the atmosphere, a gaseous envelope surrounding earth, and particularly, its sub-layer the troposphere in which arise weather, tides, and seasonal phenomena and which sustains all life on the planet. It is known that the F1 and F2 layers of the ionosphere influence the tides and weather and that these effects in large measure are mediated by solar-induced phenomena like heating and cooling in conjunction with the 24h day-night cycle. Tidal oscillations in a medium other than seawater were first observed in tropospheric air pressures during the 18th century.

Within decades of Torricelli's invention of the mercury barometer in the mid-17th century it was discovered that barometric pressures fluctuate on a 12h diurnal basis. The most detailed studies on this phenomenon were undertaken by French naturalist Robert de Paul Chevalier de Lemanon and originally reported to the Académie in 1785. In a later study Lemanon measured pressures continuously over 75h while crossing the Atlantic at the equator and found phasic diurnal fluctuations with peak pressures at 10am and 10pm and low-pressure points at 4am and 4pm independent of longitude. Such effects are greatest at the equator and gradually diminish toward the poles. That the ionospheric F1 and F2 layers also fluctuate on a diurnal basis obviously implicates the solar cycle.

By the 19th century magnetic observatories had been set up in many countries and German physicists Carl Friedrich Gauss and Wilhelm Weber had found daily fluctuations in the geomagnetic field which were eventually shown to be induced by ionospheric electric currents, aka 'air tides'. Similar electric oscillations were also detected in the lithospheric region of the upper mantle and crust. Around the same time small daily lunar variations in the MF were detected which were often drowned out by the dominant solar signals. Such findings were confirmed by 20th century researchers [33, 34]. In spite of these paradigm-shifting discoveries scientists continued to invoke the gravitational hypothesis to explain the tides.

In a 1776 paper *Du systeme du monde* Laplace sought to apply his system of fluid mechanics to 'le flux et le reflux de l'atmosphère' and showed that the atmosphere behaves according to the same dynamic principles as the tides. Laplace noted that the density of air varies with barometric pressure and further deduced the crucial role of atmospheric heat. As we saw with the geodynamo at the earth's core, interactions between the dielectric/accretion field and MF are expressed physically by forces like pressure and heat. Accordingly atmospheric pressure and temperature fluctuations must be ascribed to interactions between solar activity, the heliosphere, and the ionospheric dynamo.

Another striking example of scientists' inability to critically examine their own views and adjust their perspective occurred in the mid-19th century. In 1851 as telegraph cables were being laid across the English Channel Charlton Wollaston measured voltage potentials in the cable that fluctuated synchronously with tidal oscillations in the Dover Strait. When Wollaston later reported this to Faraday he responded, 'Oh, beautiful, beautiful,' and pointed to earlier writings in which he had proposed the same experiment [35]. Faraday regarded this as confirmation of his own dynamo theory.

The same tidally induced fluctuations were 'rediscovered' nearly a century later by two engineers while restoring underwater telephone cables across the Channel in 1946 [36]. Three decades later researchers described 'magnetic effects of sea tides' and 'electromagnetic induction' in the oceans and still failed to make the connection [37-42]. And in the last decade multiple reports describe synchronous tidally-induced voltage

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oscillations and fluctuations in salinity in rivers upstream to large saltwater bodies [43-45]. What has repeatedly kept scientists from drawing the obvious conclusion? Science historian Thomas Kuhn, author of the widely influential work *The Structure of Scientific Revolutions* (1962), called it paradigm-induced blindness. We only 'see' what our conceptual framework permits us to see. More to the point, how do such voltage fluctuations affect seawater?

In *Biologically Closed Electric Circuits: Clinical, Experimental and Theoretical Evidence for an Additional Circulatory System* (1983), Swedish radiologist Björn Nordenström advances arguments in support of an organized energy field in the human body. In one experiment intended to demonstrate the effects of electric fields in water Nordenström packed a U-shaped glass tube with cotton wool in its lower curved portion to simulate capillary resistance **(Figure 21).** Both limbs of the tube were filled with water and metallic electrodes connected to a DC power source were placed on each side. After a while he observed differential water levels in the two limbs of the tube with the left (cathodic) side higher than the right (anodic) pole. How to explain this?

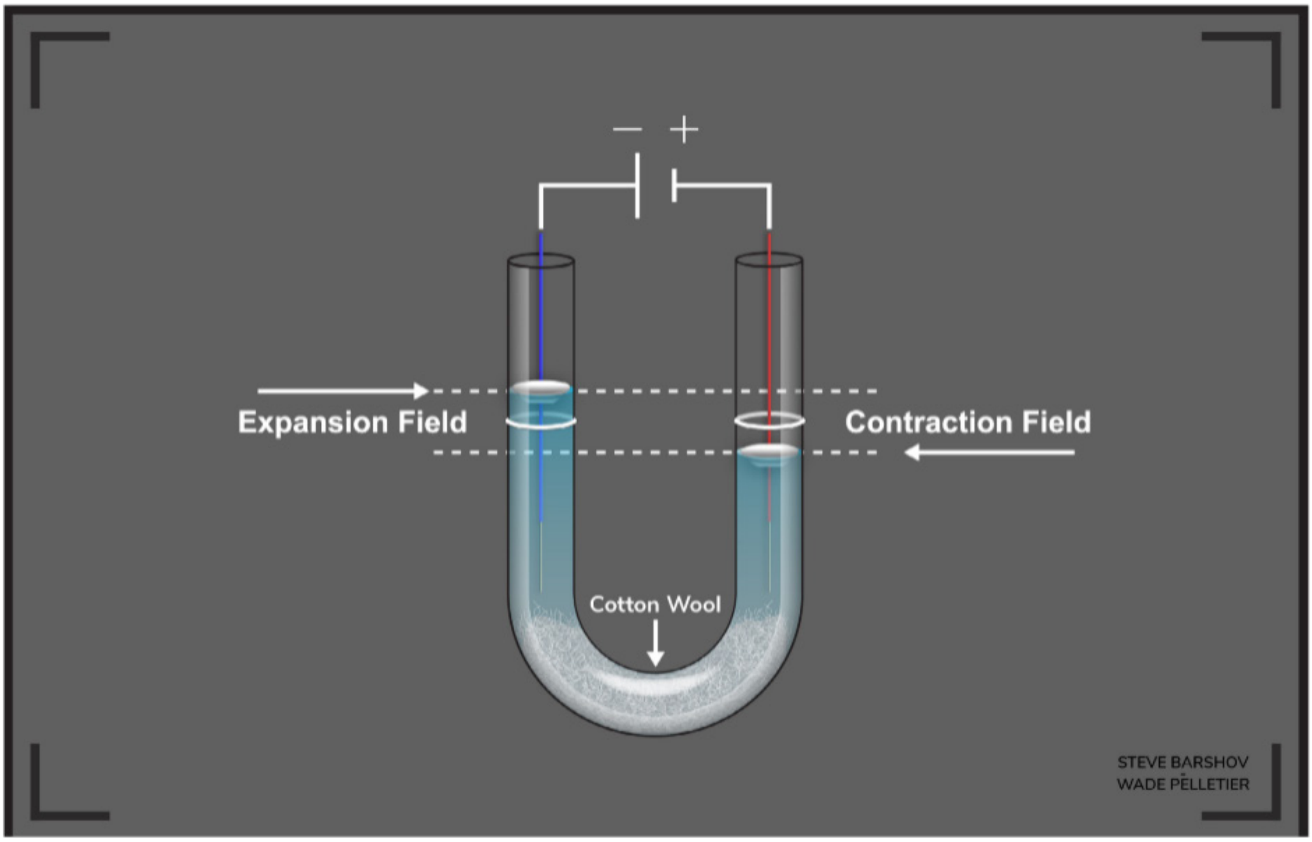

Figure 21. Nordenström's experiment demonstrating the effects of electric fields in water.

At the cathodic terminal hydrogen gas is released into the air leaving an excess of negatively charged (alkaline) hydroxyl ions (OH^-) in the fluid while at the anode oxygen is released resulting in an excess of positively charged (acidic) hydronium ions (H_3O^+). This is a downstream effect of EM induction in water and illustrates why the term 'dielectric' is inappropriate to designate cause. Water has among the highest dielectric constants indicating its capacity to absorb electric currents. Its ability to

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undergo electrolytic decomposition and dissociate into ionic species with opposing charge is related to its 'dielectric polarizability' but this does not explain the disparate fluid levels. Differential movements of water between the two poles are equally untenable: OH^- at the cathode would theoretically be drawn toward the positively charged anode while H_3O^+ at the anode would migrate toward the cathode. At some point in between the two species would recombine resulting in no net movement of water.

The spatial reorganization of water is a field-mediated effect. Electric currents streaming through the electrode at the cathode generate a MF around the wire causing expansion of water mediated by repulsion of negatively-charged ions. Conversely, currents drawn out of the water at the anode enhance the dielectric field inducing contraction and lower water levels. When one says that water is polarizable, it means that electrical induction causes the expansionary magnetic and contractionary dielectric fields to separate and repel each other. No action at a distance is involved. This exact same field effect induces the periodic waxing and waning of oceanic tides.

As we saw earlier, high tides occur when the moon is directly overhead (0°) and at 180° on the opposite side of the globe while low tides occur simultaneously at 90° and 270°. Here we see the inadequacy of a single universal force to explain such phenomena. Newton's calculations were based on the mass of the involved bodies and the distance between them: gravitational effects diminish by the square of the distance. While this has been experimentally verified many times, given what we now know, it would be impossible for scientists to state with certainty whether such interactions were actually caused by gravity. It's an unprovable hypothesis. Pure smoke and mirrors.

The question arises as to why the tide at 180° should be of equal magnitude to the 0° tide given that it is ~8000m further away from the moon with the gravitational force pointed in the opposite direction. The only way this hypothesis makes sense is if the entire gravitational field of earth were somehow affected in which case all objects, not just water, should be affected by the moon's transit.

Even more problematic is explaining the low tides at 90° and 270°. If the gravitational force acts only at 0° and 180° then high tides must involve the bulk movement of water from low tide areas. If the entire field were affected, then it must somehow act differently at 90° and 270° than it does at 0° and 180°. Clearly two forces, one expansionary and the other contractionary, are necessary to mediate tidal phenomena.

The correct explanation is that the tides are caused by interactions between the dielectric/accretion field and the geomagnetic field which, as we know, assert their effects simultaneously through resonance and act at 90° angles to each other. The rise of the tides at 0° and 180° is counterbalanced by contraction at 90° and 270°. No other explanation is needed. When the sun-earth-moon axis is in 180° alignment the magnetic forces compound one another and produce higher tides while the aligned accretional forces cause enhanced contraction and thus greater tidal range. And when the sun-earth-moon axis is in quadrature (90°) these opposing forces mitigate each other producing lower high-tides, higher low-tides and diminished tidal range. Newton's universal gravitation hypothesis is dead in the water.

THE GRAVITY OF ERROR

In seeking to avoid the specter of action at a distance in supposed empty space, Newton advanced the most egregious form of action at a distance imaginable, one which not only was unprovable but entirely divorced from reality. The historical scope of Newton's error rivals that of Ptolemy's geocentric astronomy. His static analysis of tidal phenomena

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was far off the mark and yet, rather than questioning whether the Great One might have fundamentally erred, his heirs spent the next two centuries endeavoring to develop more accurate and dynamic mathematical models.

It is axiomatic that no scientific theory is provable. The corollary to this is that science advances only by refutation of opposing theories and in fact, like democracy, demands such communal dynamics. Much of the confusion surrounding the nature of the tides could have been avoided had scientists simply compared the gravitational and magnetic theories side by side. More was known about magnetism at that time than what scientists currently know about gravity. There is no indication that such dialogue ever occurred and, quite to the contrary, most scientists either uncritically accepted Newton's hypothesis or were swayed by the arguments of authority figures.

Certainly, by the mid-19th century with Faraday and the stream of evidence that was emerging scientists should have made proper adjudications. And yet to this day, centuries later, not a single scientist has had the temerity to call into question what is regarded as established law or principle. The failure of Newton's universal gravitational attraction hypothesis is the mother of all paradigm collapses, one that even Kuhn could not have anticipated.

In *New Organon* (1620) Francis Bacon extolls experimental science as a means of cultivating insight into the inner workings of nature and of developing the power of inductive reasoning. On both counts we must judge the 350-year science odyssey an abject failure. From the early 18th century onward scientists instead embraced Bacon's decree 'knowledge is power' and directed their collective efforts toward gaining illusory power over nature while never suspecting that their science had been built on shifting sands and, like religion, based largely on belief.

What is the take-home lesson here? Once a scientific theory is shown to be wrong it means that it was wrong from the beginning. There is no incrementalism in a worldview. No matter how many facts, laws or principles are amassed over time to 'prove' a given perspective in the end its universality always remains open to question. As 20th century science philosopher Karl Popper notes in *The Logic of Scientific Discovery* (1934), rather than attempting to prove hypotheses scientists should direct their efforts toward disproving them. Knowledge itself is an obstacle. Stubbornly clinging to one's beliefs or excluding hypotheses before they have been properly vetted violates the spirit of scientific inquiry and impedes advancement of knowledge. Plain and simple.

In uncritically accepting Newton's gravitational hypothesis scientists stepped into an abstract, non-existent world which, in any case, amounts to a delusion. As the collapse of Ptolemy's geocentric framework centuries earlier teaches us, the way one perceives things through the senses may not be the way they really are. And by promulgating their fictive construct over three centuries scientists set into motion a broad cultural delusion that will forever be emblematic of the flawed rational perspective. How many other errors and misinterpretations lay buried in the scientific corpus of knowledge?

In Part II of this series, we extend our inquiry into planetary energy dynamics by examining the role of magnetism and the accretion field in the origins of the four elements - Earth, Water, Air and Fire. A widely held notion in the ancient world summarily rejected by early scientists, this cosmological perspective has gained traction in recent decades in the Gaia Hypothesis. A large body of evidence now points in this direction.

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