The Fundamental Question of Physics

The question posed by James Clerk Maxwell which went unnoticed, ignored, undermined, trivialized, misstated and which has been repeatedly wrongly answered

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Our Universe has promised us neither temporal nor spatial symmetry. Yet, "the principle of spatial symmetry" has gradually emerged as the ultimate dogma of Physics, replacing the doctrine (held unquestioned for millennia and dismantled by Giordano Bruno) of a "centralized Universe". Thrice-stricken, this "principle" born in the cradle of the scientific revolution has found refuge in "the CPT theorem", whose "proof" rests on axioms not quite fully stated, though believed to be exhaustive.

An introduction: A question which failed the answer

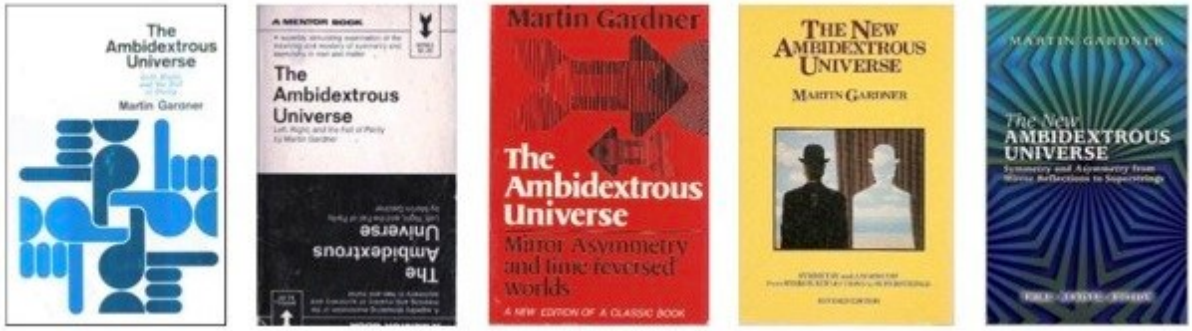
In [24, The 7 Percent Solution], Richard Feynman recounts how he was prompted (by J. Robert Oppenheimer), during the 1956 Rochester Conference, to get up and say:

> I'm asking this question for Martin Block: What would be the consequences if the parity rule was wrong?[1]

Martin Gardner went on to popularize in [25] what Feynman maintained in his Lectures on Physics as impossible to convey "right" and "left" upon our two-way radio communication with a "Martian" in any way other than involving parity violation in weak interactions [22, Chapter 52: Symmetry in physical laws (6/1/1962)]. In the Preface to the second edition [26], Gardner wrote:

> In 1952, intrigued by what in this book I call the Ozma problem, I wrote a paper, "Is Nature Ambidextrous?," that appeared in the Journal of Philosophy and Phenomenological Research (December 1952). In it I considered the possibility that someday a basic law of nature might prove to be left-right asymmetric. I ruled this out as unthinkable. Five years later, the unthinkable occurred. It was the shock of this discovery, the fall of parity, that prodded me into writing an entire book about mirror-reflection symmetry.

[1] The awkward framing of the question – "What would be the consequences" – signaled to Murray Gell-Mann a fear of asking; he repeatedly ridiculed Feynman for not daring to raise the question as his own. Feynman and his apologist Lawrence Krauss, in [35], attempted to dress up the fear of dissent (which Gell-Mann exposed) as Feynman's pure (almost noble) desire to give due credit. The desire is not in doubt — its purity is. It fits too well into Feynman's own striving to conform and to distance himself from a "heretical" question he was not supposed to ask.



A third and a further revised edition followed [27], and even more recently further discussion was prompted by a question: "I was wondering if something has changed since then and if there are some other experiments (maybe some thought experiments) and theories that can solve the Ozma Problem" [54].

Feynman, Gardner and many others have been taught "too well" to not notice that, in our Universe, a compass needle would be deflected by a directed current, flowing in a parallel wire, independently of our (or an alien's) convention.[2] The deflection, of course, is not altered by a decision made by either Feynman or Gardner to bring a mirror.[3]

Thereby, the question, which Feynman and Gardner invented and explicitly posed, sharply revealed that they implicitly "resolved" another question with a certainty as great as not to pose it.[4] Yet, neither their explicit question, nor the question they implicitly answered without stating, is the question that Maxwell raised which we much hope to bring to wide attention.

The three fundamental symmetries that never were

The three "fundamental" discrete symmetries of Physics are those acted upon by the three binary operators:

C – Charge conjugation,
P – Parity reversal, that is, the odd-dimensional spatial inversion,
T – Time reversal.

We shall refer to the assigned (by our or some other Universe) symmetries (before the action of any of the operators C, P or T is exerted) as an orientation. The three symmetries acted upon by the three operators will be denoted with the same letters. The context will make the designation clear.

Before moving on, one must keep in mind that Newton's second law $\boldsymbol{f} = m\, d^2\boldsymbol{x}/dt^2$ is invariant under the action of either P or T, as well as it obeys, as noted by Appell [13],

[2] On the other hand and most evidently, Feynman and Gardner were deprived of learning basic Astronomy, or else they would have been told that, according to "the right-hand rule", the angular momentum of the orbital motion of the Earth around the Sun is directed towards the North Pole of the ecliptic (rather than the ecliptic South Pole). Our convention of orienting the orbital angular momentum towards the ecliptic North Pole (with the Cat's Eye Nebula as a convenient landmark "nearby") would tell the alien what we call "the right hand".

[3] We would recommend, however, keeping the mirror away so as not to be tempted to conflate our Universe with its mirror image.

[4] We are alluding to the symmetry principle as the principle which they believed to apply to electromagnetism.

the coupled transformation $t \to it$ and $\boldsymbol{f} \to -\boldsymbol{f}$, where i is the imaginary unit. We must further note that the lack of a canonical choice of the imaginary unit i as a particular square root of -1 implies that the square root which we labeled as i could have been alternatively labeled as $-i$. In fact, this seemingly insignificant, commonly dismissed, ambiguity will keep arising at the core of the fundamental question of Physics.[5]

The concept of imaginary time was most spectacularly exploited by Sophia Kowalevskaya [33].

Backward in time: Three faces of complex conjugation

- If $\boldsymbol{\Psi}$ is a spinor residing in the kernel of the Dirac operator

$$\mathcal{D} := i\hbar\gamma^\mu\partial_\mu - mc^2, \qquad \partial_\mu := (\partial_t,\ c\nabla)\,,$$

$$\gamma^0 := \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{pmatrix},\ \gamma^1 := \begin{pmatrix} 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & -1 & 0 & 0 \\ -1 & 0 & 0 & 0 \end{pmatrix},\ \gamma^2 := \begin{pmatrix} 0 & 0 & 0 & -i \\ 0 & 0 & i & 0 \\ 0 & i & 0 & 0 \\ -i & 0 & 0 & 0 \end{pmatrix},\ \gamma^3 := \begin{pmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 \\ -1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \end{pmatrix},$$

  where $\hbar$ is the reduced Planck constant, m is the mass and c is the constant speed of light [1], then the (charge-conjugated) spinor $C\boldsymbol{\Psi}^*$ is also a resident in the same kernel of the same operator $\mathcal{D}$, where C is the (charge conjugation) operator satisfying $C(\gamma^\mu)^*C^{-1} = -\gamma^\mu$ and the superscript $(\cdot)^*$ denotes complex conjugation.[6]

- If $\boldsymbol{\Psi}$ is a wave function (not necessarily scalar) residing in the right kernel of the Schrödinger operator

$$\mathcal{S} := \hbar J\partial_t - \mathcal{H}$$

  in the Pauli representation, where J is "the multiplication by i" operator and $\mathcal{H}$ is Hermitian, then the transpose of $K\boldsymbol{\Psi}$, where K is "the complex conjugation" operator, resides in the left kernel of the same Schrödinger operator $\mathcal{S}$.

- The vacuum Maxwell-Heaviside equations imply that the electromagnetic spinor

$$\boldsymbol{\Psi}_\pm := \mathbf{E} \pm ic\mathbf{B} \tag{1}$$

  lies in the kernel of the Riemann–Silberstein operator

$$\mathcal{R}_\pm := \pm\, i\, c^{-1}\, \partial_t - \nabla_+\times,$$

  where the subscript in ∇_+ emphasizes the "right-handedness" of the curl operator and distinguishes it from the "left-handed" curl operator $\nabla_-\times$.

  The two complex-conjugate electromagnetic spinors (1) correspond to two distinct chiral orientations, so they remain ambiguous until we impose a conventional interpretation which would distinguish them. However, once our convention is chosen to represent the actual chirality of our Universe we may no longer declare the Maxwell equations spatially symmetric.[7]

[5] Physics in our context must be interpreted in its broadest, most inclusive, sense as the (only) Science of Nature. Thereby the issue of the three discrete fundamental symmetries is not restricted to any particular branch of Physics such as Quantum Field Theory.

[6] Unless we have encountered a Majorana fermion [40], the inequality $C\boldsymbol{\Psi}^* \neq \boldsymbol{\Psi}$ holds.

[7] The attentive reader might notice here that we have not named Heaviside. Apparently, the chirality so emphatically emphasized by Maxwell was somehow reduced to a mere convention with Heaviside making the first step towards that reduction, as we shall soon clarify.

In fact, since

$$\mathcal{S}_\pm \, \mathbf{\Psi}_\mp = \mathbf{0} = \mathcal{R}_\pm \, \mathbf{\Psi}_\pm,$$

where

$$\mathcal{S}_\pm := \pm i c^{-1} \partial_t - \nabla_- \times,$$

complex conjugation has disguised a parity reversal.

Indeed, applying complex conjugation to $\mathcal{R}_+ \, \mathbf{\Psi}_+$ yields $-\mathcal{S}_+ \, \mathbf{\Psi}_-$, and so flipping the sign of i corresponds to flipping the handedness of the curl, that is, performing a parity reversal, as we have just claimed.[8]

Maxwell, Wu, and Dzhanibekov: Three strikes on a dogma

1. The chiral theory of electromagnetism

Maxwell, in his most monumental Treatise on Electricity and Magnetism, emphasized that the distinction between the right-handed and the left-handed screw does not depend on a chosen convention. He clarified this independence by addressing the natural phenomenon of enantiomorphism, noting, for instance, that the tendrils of the hop are left-handed [41, Volume 1, Chapter I, Article 23: On Right-handed and Left-handed Relations in Space].[9]

Thereby, the law governing the deflection of a compass in a magnetic field does not depend on the convention chosen to describe it.[10]

Nevertheless, the myth of spatial symmetry was "reinstated" (after Maxwell) in three steps. The first step "removed" the emphasis on chirality, so emphatically stressed by Maxwell, in pursuit of the laudable mission of Oliver Heaviside to simplify the electromagnetic theory [28].[11] The second step (which Heaviside most certainly did not anticipate) brought "an evil of considerable magnitude", named "an axial vector" by Woldemar Voigt [66, p. 418], and later named "pseudovector" by Arthur Eddington [21]. It was subsequently and systematically invoked in order to "prove" that the Maxwell-Heaviside equations were spatially symmetric.[12] The third and "the final" step was carried out by Eugene Wigner who transformed the surviving assumption that all natural laws are

[8] The language of Geometric Algebra, beautifully developed by David Hestenes [29], provides an ultimate clarification. Both E and cB are vectors (neither is a pseudovector) whereas i is pseudoscalar, so icB is a bivector (but not B nor cB). The two Riemann–Silberstein spinors $F_\pm = E \pm icB$ possess two opposing orientations, that is, the ambiguity of the sign of i, which we earlier emphasized, is the ambiguity of the orientation of an orthonormal basis in a three-dimensional space.

[9] Note that Maxwell, unlike Feynman and Gardner, would need neither electricity nor magnetism in order to convey to a space alien what a right-handed and a left-handed screw is. The right-handed screw is tightened according to the right-hand rule away from its cap; recall that we already told the space alien, in footnote 2, what the right-hand rule is.

[10] Once driven by Maxwell's natural analogy one would never confuse an orientation with a convention encoding it, much like never confusing a wild beast with one of its "equivalent" descriptions in textbooks.

[11] The simplification eliminated the 3-dimensional sphere of unit quaternions which constitutes a double cover to the special orthogonal group (of "proper" rotations). Thereby, Heaviside relieved us from the burden of excessively contemplating a choice of two orientations of an orthonormal basis, as he wrote "I came later to see that, as far as the vector analysis I required was concerned, the quaternion was not only not required, but was a positive evil of no inconsiderable magnitude". Yet, suppressing that "evil" turned out to be an invitation for another of a truly great magnitude.

[12] It formally concealed a conflation of an orientation of space with the orientation of its mirror image, and, thereby, reduced the actual orientation of space to a mere convention.

mirror-symmetric into a conservation law of quantum mechanics [70].[13] In doing so, our choice of a convention to describe a chirality, assigned by our Universe, was ultimately and conclusively confused with a lack of any choice for reassigning it.

2. The cobalt-60 experiment that was not mirrored

The legendary 1956 Christmas Experiment, led by Chien-Shiung Wu [71], was therefore perceived as no less than devastating. In Wu's words in celebration of the event on January 9, 1957: "We finally drank to the overthrow of the law of parity" [45].

Wolfgang Pauli, being the founding coauthor of the "CPT theorem" which is alternatively called "the Lüders–Pauli theorem" [39, 49], responded exceptionally honorably — he fully conceded and never recovered.[14] Less courageous physicists opted to contain the stunning discovery with their "revelations" which they presented as "deep theories" aimed, in fact, at nothing more than patching the "violated symmetry".[15]. They were unwilling to concede that their cherished "law of parity" had been "overthrown" – as demolishingly precisely declared by Wu. And, moreover, there was yet another principle, noted by Max Planck in [53], which was not about to be violated – new scientific truth does not triumph before its opponents die.

Never before had "the scientific authority" had to respond as urgently as it did. Unlike the "Supreme Sacred Congregation of the Roman and Universal Inquisition",[16] which had been known for acting punitively bluntly, the Swedish Royal Academy thrives on assigning ceremonially awarded prizes with highly debated exclusions. Oskar Klein led the Nobel prize committee's efforts to expeditiously marginalize the marvelous achievement of "Mrs. C.S. Wu and her collaborators", describing it "very schematically" in his lecture at the "Konserthuset" in Stockholm, Sweden, on December 10, 1957 [31], where he declared:

> In fact, most of us were inclined to regard the symmetry of elementary particles with respect to right and left as a necessary consequence of the general principle of right-left symmetry of Nature. Thanks to Lee and Yang and the experimental discoveries inspired by them we now know that this was a mistake.

In other words, Klein is telling us that the inference of "the symmetry of elementary particles with respect to right and left" as "a necessary consequence of the general principle of right-left symmetry of Nature" was "a mistake" of which we learned "thanks to Lee and Yang".[17] He is not doubting "the general principle of right-left symmetry of Nature".[18]

[13] The biographer Helge Kragh notes in [34, p. 184] that the only pre-1957 book on quantum mechanics that did not assume parity conservation in physical laws was "The Principles of Quantum Mechanics" by Paul Dirac.

[14] Werner Heisenberg had to present his "Weltformel" alone on April 25, 1958 (at the Congress Hall in West Berlin) after Pauli denounced his "Reklamerummel", in his letters [51].

[15] So the "symmetry principle" would still somehow be preserved!

[16] It was renamed in 1908 by Pope Pius X into the "Sacred Congregation of the Holy Office"

[17] The reader might easily suspect that the attribution to Lee and Yang of this recognition of "a mistake" was made up entirely by Klein alone.

[18] No less confusingly, Feynman "summarized" in [22, Section 52-7 Parity is not conserved]:

> However, it was possible to prove (and we cannot here explain at all how), from the principle of reflection symmetry in quantum mechanics, that it was impossible to have these both come from the same particle—the same particle could not disintegrate in both of these ways.

In his next paragraph he begins his explanation of right and left to an alien with a statement loaded with unstated assumptions:[19]

> Let us assume that the magnetic field is created by means of a coil placed like a spool of thread on a table, and that the electric current is flowing counterclockwise in the wire. Then the north poles of the cobalt nuclei will be directed upwards. The experiment, now, gave the result that the electrons from the radioactive process with this arrangement were preferentially thrown downwards towards the floor. From this it follows unambiguously that the process lacks that right-left symmetry, which one had earlier assumed. Thus, by means of this experiment it could be explained to a person, who did not know it – let us say an inhabitant of a distant stellar system – what we mean by right and left. In fact, it would be sufficient to ask him to arrange the experiment so as to make the preferential direction of the electrons point downwards. The current will then have the same direction as that in which he has to turn at the command "left face".

Klein neglects to inform the alien of our convention for directing an electric current.[20] So, upon rushing to the "next step of the utmost importance", where he would "reestablish right-left symmetry for elementary particles", while the alien is winding a current-carrying wire into a coil, placing cobalt-60 inside, and observing the direction of the beta emission,[21] he stumbles — he "discovers" that he cannot unambiguously convey our current convention without verifying what kind of matter the alien is made of:

> The conservation law corresponding to the principle of reflection symmetry is something which has no classical analog, and so this kind of quantum-mechanical conservation was called the conservation of parity.

But who are "we", who "cannot here explain at all how"? The dogma holders? And why would we trust "them" to tell us of an "impossibility", alleged "possible to prove"? Why would "conservation of parity" need to be a "principle" in quantum-mechanics?

[19] One has to keep in mind that the most unexpected launch of "Sputnik" on October 4, 1957 left the public, including Feynman, Gardner and Klein, preoccupied with discussing "space aliens" for many years to come. Technically speaking, "Project Ozma" as a search for extraterrestrial intelligence was initiated by Frank Drake on April 1959 at the National Radio Astronomy Observatory in Green Bank, West Virginia [18].

[20] He will wrongly dismiss this omission as easily fixable, failing to realize that it is about to become a source of trouble he will never resolve. Meanwhile, he would undoubtedly tell us that the alien might construct a lithium-gold battery in order to be told that the external electric current through a conducting wire will flow (according to our convention) from the gold to the lithium. He is either unaware of the chirality of the coil or wrongly assuming it to be irrelevant — he is all set to fall victim to his own trap from which he will never escape.

[21] Feynman would go on to reproduce this faulty setup in [22, Section 52-7 Parity is not conserved]:

> In short, we can tell a Martian where to put the heart: we say, "Listen, build yourself a magnet, and put the coils in, and put the current on, and then take some cobalt and lower the temperature. Arrange the experiment so the electrons go from the foot to the head, then the direction in which the current goes through the coils is the direction that goes in on what we call the right and comes out on the left." So it is possible to define right and left, now, by doing an experiment of this kind.

He is oblivious to the chirality of the coil. He assumes the Martian can just "put the coils in, and put the current on" without already distinguishing left from right. Not only does he assume, following Klein, that telling the Martian of our convention to direct an electric current is an issue so trivial as to be undermined, but he is now pretending to derive right and left from a current coming "in" and "out", while (no longer consciously) assuming that the Martian employed a right-handed coil.

> However – and this is a thing of the utmost importance for the incorporation of the new discoveries into our edifice of physical laws – the person on the distant planet will be able to follow our prescriptions only if he knows what we mean by the direction of an electric current. And to know this he must know that our atoms and his are made up of the same elementary particles. We know, however, that not only are there double sets of electrons – positive and negative – but that the same holds for protons and neutrons, the building stones of atomic nuclei. It is therefore possible that his atoms contrary to ours would consist of positive electrons and negative nuclei. If they did, he would judge the direction of the current opposite to what we would do, with the result that he would call right left and left right. In stating this we have tacitly made an assumption which is not quite confirmed as yet but which, as far as the experiments go, seems probable, namely that the results of all experiments performed with the opposite kind of elementary particles would be just such as to reestablish the right-left symmetry. With other words, one should be able to regard the antiparticles not only as the electric opposites of the particles but also as their mirror images.[22]

The audience applauds. "The general symmetry principle" was never in doubt and the remedy "to reestablish the right-left symmetry" for elementary particles was announced before Gustaf VI Adolf handed the Nobel prize to two physicists for a discovery they neither made nor could ever have predicted.[23] Feynman would go on, in [22, Section 52-8 Antimatter], to "triumphantly" conclude:

> Therefore, at long last, it is really true that right and left symmetry is still maintained!

The "thing of the utmost importance for the incorporation of the new discoveries into" their "edifice of physical laws" would require regularly deflecting the annual nominations of Wu towards awarding Landau (in 1962), Wigner (in 1963) – "for his contributions to the theory of the atomic nucleus and the elementary particles, particularly through the discovery and application of fundamental symmetry principles" [46] – and Feynman (in 1965), all with speeches delivered by Ivar Waller, who inherited (after Klein) the task of ensuring the exclusion of Wu from the Nobel prize. The committee then assigned Bengt Nagel to evaluate her contributions and "conclude" in [43]:

> I feel somewhat hesitant whether their theoretical importance is a sufficient motivation to render Wu the Nobel Prize.[24]

[22]Klein, attempting to "rescue" spatial symmetry with a CP conservation recipe, as Landau did, is now faced with an anti-current which would flow from the anti-gold to the anti-lithium. The north and the south magnetic poles of the coil are then swapped, and the direction of the anti-beta emission from anti-cobalt-60 is reversed. Klein is "logically" concluding that an alien made of positrons and negative nuclei "would judge the direction of the current opposite to what we would do, with the result that he would call right left and left right." But now, instead of confessing to his own failure to resolve the Ozma problem, he is announcing parity reversal as an implication of charge conjugation.

[23]After their unavoidable and no longer postponable most bitter dispute on April 18, 1962 over who deserved the ultimate recognition, Lee went on to nominate Wu thrice (1964, 1971, 1972), whereas Yang never nominated her among others he chose to nominate.

[24]Delegating such a conclusion to a member of the Royal Swedish Academy is reminiscent of delegating a conclusion to a member of the Holy Office such as Robert Bellarmine – who was beatified (on 13 May 1923), canonized (on June 29, 1930) and declared Doctor of the Church (on September 17, 1931) by the

Consequently, in the very year Nagel became the Secretary of the Nobel Committee (1974), Stig Hjalmars (yet another physicist from the same neighborhood) nominated Klein (alongside Wigner for a second award).[25] It was a moment of opportunity because the committee's primary candidate (Nikolai Bogolyubov) had just been purged for political reasons — an institutional hypocrisy the Nobel Committee is known to consistently perform and simultaneously deny. But Waller was gone, and the loyal guard dog was no longer of use.[26]

3. The striking observation of reversal of a wingnut rotation

The observation of the "flipping wingnut" made by Vladimir Dzhanibekov on June 25, 1985 brought the problem of the spatial orientation to a foundational level, not restricted to Field Theory, and involving a most fundamental problem of Theoretical Mechanics.

The phenomenon witnessed by Dzhanibekov would be best described, in his own words, as a "rotation reversal" [19]. Those who have paid little attention to his precise interpretation and its incredible implication as a spatial reversal (in a rotating frame attached to the wingnut) rushed to dismiss it as a "known phenomenon".[27] Thereby his most incredible observation of critical motion was primitively explained as "perturbed motion".[28] Most unfortunately such "popular ideology" was reinforced by public posts made by Terence Tao [63, 64]. And although his first post (on Google+) was later removed, the damage was done by propagating an "intuitive explanation" of "the Bizarre Behavior of Rotating Bodies".[29]

Oleg Smolyanov marvelled, at his seminar, on December 3, 2018 [5], at the striking analogy between the critical motion of the Dzhanibekov top and the Abrarov solution of

infamous Pope Pius XI. Analogously, Nagel (having successfully sidelined Wu) was elevated to Secretary of the Nobel Committee in 1974, further promoted in 1986 to full Committee Member while still Secretary, and further elevated in 1997 to Chairman of the Nobel Committee. In that capacity, at the December 10, 1997 award ceremony [44], Nagel shamelessly echoed his dismissal of the pioneers [65] — Vladilen Letokhov, Vladimir Minogin and Vitaly Balykin — whose foundational theoretical and experimental work (1968–1981) [36, 37, 38, 12] was cited two days earlier in the Nobel lectures of all three co-laureates [16, 17, 52]. Predictably, he was quietly terminated shortly thereafter, and the Nobel machine went on without him, as if it was never tarnished.

[25] His wife, Inga Fischer-Hjalmars (who succeeded Klein as Professor of Theoretical Physics at Stockholm University), and their collaborator Olof Sandy Gunnar Brulin submitted standalone nominations for Klein in 1974. They were the only three who renewed their nominations the following year (after an attempt for an "80$^{\text{th}}$ birthday celebration" for Klein failed): Hjalmars resubmitted a joint nomination pairing Ernst Pascual Jordan and Klein (dropping Wigner from the previous year's slate), while Fischer-Hjalmars and Brulin resubmitted their standalone nominations for Klein [47].

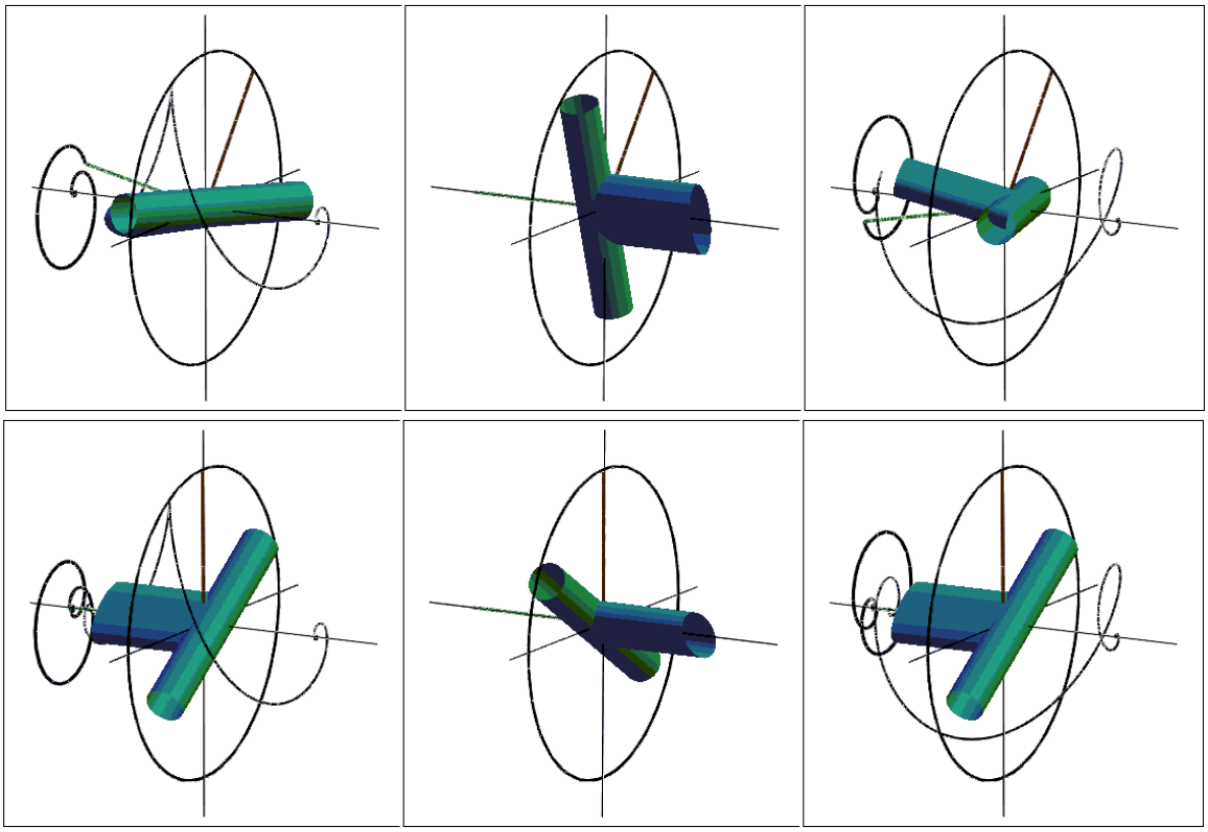
[26] Instead, the 1974 prize was split between two Cavendish colleagues — Martin Ryle and Antony Hewish — who shared a lasting debt of gratitude to the committee for shielding them from the discoverer of pulsars, Jocelyn Bell Burnell, and keeping her away from their prize.

[27] While repeatedly failing to notice that the wingnut has swiftly reversed its rotation, in its own frame of reference!

[28] Dmitry Abrarov emerged among a very few critics who methodically exposed such a widely spread and profoundly erroneous misinterpretation of the Dzhanibekov effect as entirely missing the duality of the "critical motion" which he further emphasized as being "exact" [3, 18:00]. Another, rarely astute and highly relevant, observation of the "geometric incompleteness of the Poinsot construction" was described by Vladimir Zhuravlev in [72].

[29] The conventional sluggish modeling of the Dzhanibekov effect as a motion in a "neighborhood" of a separatrix is nowhere nearly as striking as the "exact" motion, where the "sudden flip" occurs along the separatrix itself.

the "unstable equilibrium" of the simple pendulum [11, 2], after he was presented with [42, a computer animation of a triple motion, sharing a single Galois axis].[30]



A solution to the critical motion of a (right-handed) wingnut is reflected in a mirror, orthogonal to the fixed angular momentum, into another solution to the same critical motion [4]. Two such (mutually mirroring) critical solutions share a common, uniformly rotating, Galois axis[31]

Once we compactify the (complex) time domain with complex infinity we might identify it with a two-dimensional sphere which we might centre at the centre of mass and rigidly attach to a moving frame [10]. The tip of the angular momentum in this rotating frame would then trace a curve on such a sphere which we might call "the momentum polhode", as suggested in [72]. A 15-year struggle of Hanspeter Schaub and John L. Junkins in pursuing the commendable task of orienting the momentum polhodes in their textbook "Analytical Mechanics of Space Systems" spanned two editions [55, 58] and three errata lists [56, 57, 59]. The source of their highly instructive difficulties was identified and discussed in detail in [7].

The lesson still to be learned is the duality of critical motion of the Dzhanibekov top: two critical solutions, sharing a single, uniformly rotating Galois axis, correspond to two coplanar separatrices. Four critical solutions, paired into two dual pairs, each pair sharing a single, uniformly rotating, Galois axis, correspond to four separatrices: $2 + 2 = 4$.

[30] The two traced herpolhodes are mirror images of each other.

[31] The Galois axis never leaves a plane parallel to the mirror (orthogonal to the angular momentum).

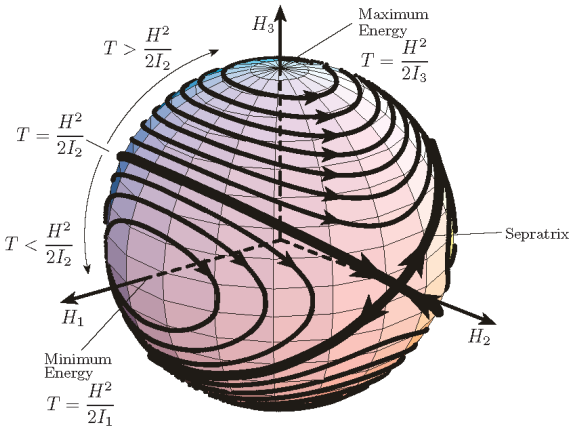


Fig. 4.7 on p.147 as "corrected" in [56, 57]

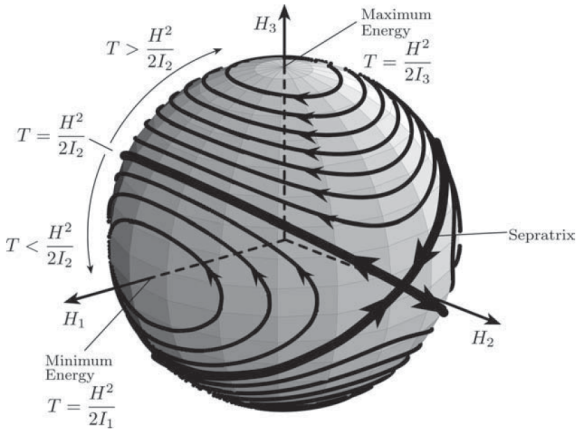
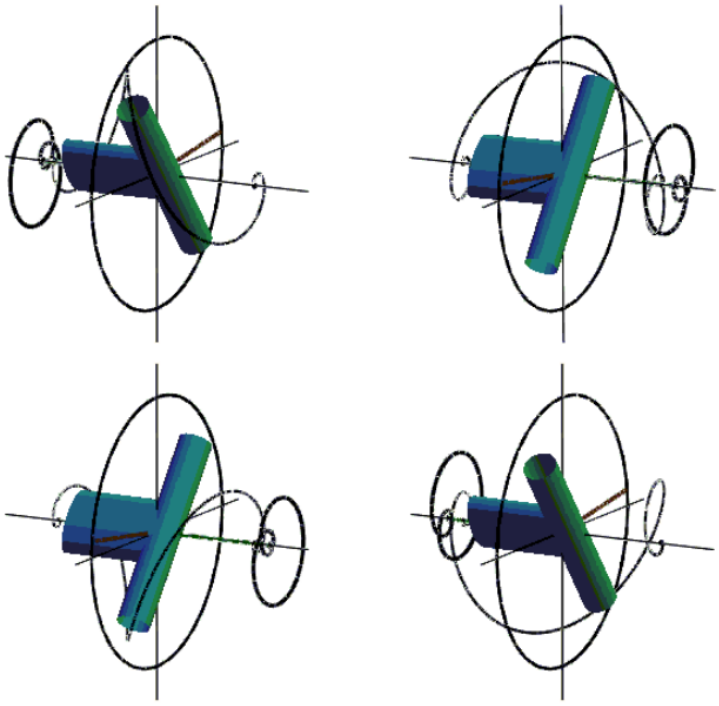


Fig. 4.10 on p.167 as further "corrected" in [58]

Two instances of "correcting" the orientation of the momentum polhodes by Schaub and Junkins[32]

There are three "reasons" which preclude this lesson from being learned:



A snapshot of an animation of four critical solutions [42]

- Firstly, two mutually mirroring, yet distinct, critical solutions, corresponding to two coplanar separatrices, become indistinguishable once the angular velocity is conventionally treated as a "pseudovector". This is the same confusion which leads to conflating a deflection of a compass with its mirror image.

- Secondly, the duality is "excluded" by applying the "local uniqueness theorem" via invoking the "Lipschitz condition" (to the Euler equations, which are representable in normal form locally in real time) while failing to notice that this local condition is irrelevant at critical points for global solutions once the time domain is compactified with complex infinity.

- Thirdly, the exact nontrivial solutions (with a flip) are deemed irrelevant "since" they constitute solutions of "measure zero" in the set of all solutions. Permanent

[32] The seeming irreconcilability of these two "corrections" would cease to exist once they are viewed as "left-handed" (on the left-hand side) and "right-handed" (on the right-hand side) interpretations of the Euler equations for torque-free rigid body motion. In fact, the traditional departure of an ambidextrous interpretation towards insisting on a single "right-handed" interpretation is of consequences as grave as those discussed in [8].

> rotations (without a flip) about the principal axis, corresponding to the intermediate moment of inertia, are regarded as "the only solutions" corresponding to equality of the square of the modulus of the angular momentum and twice the kinetic energy multiplied by the intermediate principal moment of inertia.[33]

Unfathomable to Klein and Feynman is a fact of greater than the proclaimed (by the former) "utmost importance" – the fact that "the right" Galois axis is determined before "the right-handed" wingnut is set in motion. Yet, we cannot overemphasize here that the exact location of the "directed" principal axis, corresponding to the intermediate moment of inertia, in the midst of the flip is predictable (only) up to spatial inversion.[34]

The "left" Galois axis would then be shared by two solutions of the critical motion of a "left-handed" wingnut. We thus have two undetermined flips corresponding to each of the two determined (right and left) Galois axes, once again coming back to the famous identity $2 + 2 = 4$.

Further clarification on "what Galois axis is not" was provided in a response to an initiative by Victor Sazonov [6].

"The CPT theorem" is "not even wrong"

And now three strikes later, the current "scientific establishment" has not abandoned its "symmetry principle". It went on from reducing Maxwell's chiral warning to a mere convention, to patching its shattered "principle" with a failed CP conservation, then to sheltering it with the CPT theorem,[35] and eventually adopting a "broken-symmetry" story, whose popularized version [67] was awarded by the 1979 Nobel committee as if a question yet to be raised (much less answered) was resolved by "a left-handed postulate".[36]

The pattern is clear: dogmatic defense of the "symmetry principle" along with labeling evidence refuting it as a "violation" — an anomaly to be fixed rather than a clue that the "symmetry" was never established to begin "the three minutes" with.[37]

So the CPT theorem is now restricted to answering whether the combined operation of charge conjugation, parity reversal, and time reversal is a symmetry of any local, Lorentz-invariant quantum field theory with a Hermitian Hamiltonian [14, 30, 62]. It does not answer the question whether the spatial orientation is predictable before being observable, as it is accustomed to conflating formalized empirical observations with "theories".[38]

[33]The third "argument", although it seems to be the funniest, is a last-ditch argument – its holders share the belief that no flip is possible without "perturbations". These are the same people who are much inclined to declare "chaos" as a "solution".

[34]Dzhanibekov, after repeatedly experimenting with the flipping wingnut, was able to predict the midst of the flip when the principal axis, corresponding to the intermediate moment of inertia, becomes orthogonal to the angular momentum, with baffling precision. He told us the story in [20], where Georgy Grechko, who joined him on September 17, 1985 after docking Soyuz T-14 with the Salyut 7, had only a single sentence to state – "но ты даёшь"!

[35]The CPT theorem, which had not been much more than mathematical curiosity before 1964, was urgently elevated by the establishment to a sacred dogma of the current paradigm.

[36]Pauli would have recognized the distasteful genre — the advertising frenzy which he wholeheartedly despised just kept going on [68]. Unlike Pauli, who was so aware of the question as to exclaim "I do not believe that God is a weak left-hander" [50], Steven Weinberg jumped to answering without either stating or even noticing the question.

[37]The inclusion of Weinberg for the Nobel prize was consistent with the exclusion of Wu from it.

[38]The CPT theorem became a refuge for the three symmetries held together after CP preservation

Emmy Noether exposed the three (believed to be) "conservation laws" (of energy, momentum and angular momentum) to be, in fact, consequences of preassumed continuous symmetries (translational in time and space, and rotational) [48]. In other words, the continuous symmetries turned out to be the axioms whereas the said "laws" are the testable consequences. Likewise, the discrete symmetries or a combination thereof were never theorems derived from any set of axioms, unless the set is "the Wightman axioms" for a relativistic quantum field theory in Minkowski spacetime [62], where the underlying assumption of symmetry went unrecognized and so has never been explicitly stated.[39]

Much like Giordano Bruno who dismantled the dogma of a "centralized Universe", exposing the debate on whether it was geocentric or heliocentric as being based on a faulty premise,[40] so did Chien-Shiung Wu refute the dogma of a "spatially symmetric Universe", exposing the discussion of "parity violation" as fundamentally flawed.

Just as there has never been a candidate for a centre of our Universe to be determined, there has never been a spatial symmetry to be "violated".[41]

Yet, Lev Landau rushed with a "CP conservation" proposal in order to restore a symmetry principle he could not bear to lose. Unsurprisingly, Tsung-Dao Lee & Chen-Ning Yang, who were hastily awarded (in record time) the 1957 Nobel prize, were among those to make the same proposal. Wu, by contrast, needed neither such a proposal nor that forever tainted Nobel prize.[42]

Feynman went on to pride himself on "the first time, and the only time, in my career that I knew a law of nature that nobody else knew", conflating an empirical description with what he later called a "$V-A$ theory" [24].[43] Feynman remained oblivious to the fact that neither that "theory" nor an alternative "$V+A$ theory" could have been invented by him or anyone else without the cobalt-60 experiment led by Wu, as he failed to notice that neither his nor anyone else's "theory" could have deduced which of the two Weyl spinors our Universe would choose [69].

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failed – a far cry from the assumption that the three symmetries held separately.

[39]The Minkowski space is symmetric, by construction, unlike our Universe whose chirality was not constructed by us, and it never owed us an "initial symmetry" to be then "broken".

[40]The "scientific establishment" which replaced the discredited Roman inquisition was too quick to replace the dogma of a centralized Universe with a dogma of spatial symmetry. Yet, the Roman inquisition is still to be shamed of its abhorrent crime against Bruno [9], and no less surprisingly the principle of spatial symmetry is still believed to hold aside from "violations", known to have been "patched", where the chirality of a compass deflection was reduced early on into becoming a convention not even "violating" the "principle".

[41]As there has been neither temporal nor charge symmetry.

[42]The Nobel prize committee has been repeatedly accused by many of dishonesty, but the case of undermining the Christmas 1956 experiment led by Wu is a demonstration of something else it has never been accused of — incompetence. The Nobel prize committee not merely disgracefully excluded Wu but failed to understand that it was rewarding an interpretation of a phenomenon so deep as to be irreplaceable by any amount of theoretical work. By so stubbornly ignoring Wu, it most stupidly elevated the description above the discovery of a particular chirality no theory could ever have predicted. Metaphorically speaking, the Nobel prize committee rewarded the words (incapable of) describing magnificent music, not the music. Unsurprisingly, the committee was not sufficiently qualified to notice Feynman's glaring error that "came out of a complicated equation", which he never corrected [15], before awarding him a 1965 Nobel prize, as he revealed it to us [24, The Dignified Professor]. That Nobel prize has proven itself to be unworthy of Wu.

[43]And, along the way, irritating Gell-Mann enough to tell us that Feynman's "preoccupation with himself began to get on my nerve"; "he spent a great deal of his effort on generating anecdotes about himself"; "whenever we did anything together he would somehow think of it as his work" and "he could not keep his ego out of the reasoning".

Much worse, Feynman failed to notice that he employed the same "axial-vector ideology" to arrive at an opposite conclusion, that is, the "spatial symmetry" which he desired for an electromagnetic field in his Lectures on Physics [23, Section 13-1 The magnetic field].[44] Such glaring logical inconsistency, driven by a desire to "prove" a belief, went further unnoticed by many subsequent recipients of the Nobel prize. Cibelle Celestino Silva and Roberto de Andrade Martins recounted the traditional interpretation of the history behind such "teaching" in [60]. They argued that Gibbs and Heaviside misidentified a pure quaternion as a polar vector, and that Hamilton and Tait used i, j, k for both versors (axial) and unit vectors (polar), whereas the distinct notation for polar and axial vectors, later proposed by Voigt and Langevin, was never adopted. So they concluded:

> The traditional notation of arrows to represent the polar and axial vectors makes it difficult for students to realize that the electric field is a physical quantity with polar symmetry whereas the magnetic field has axial symmetry.

Their "standard" conclusion fell short of noticing that Geometric Algebra "makes the awkward distinction between polar and axial vectors unnecessary", as Hestenes pointed out [29, p. 16].[45] So we must seize the opportunity here to say decisively more – the said "distinction" is indeed both "awkward and unnecessary" – and it is disastrously wrong.

With this paper we aim at nothing less than to consign the dogma of spatial symmetry to the garbage bin of history, as we much hope that it would not be replaced by another dogma.

The Fundamental Question

Is the spatial orientation computable? Is it predictable before being observable?

This fundamental question is well-posed as we might, in particular, have in mind the critical dual motion of the Dzhanibekov wingnut.

We have no tools to predict the choice of our Universe and we are yet to trace the uniformly rotating Galois axis of the critical motion of the Dzhanibekov top in outer space in order to discover the chirality which our Universe would impose on the flip of the axis, corresponding to the intermediate principal moment of inertia.

Furthermore two distinct (clockwise and counterclockwise) rotations of a wingnut, as demonstrated by Natalia Misyura and Evgeny Mityushov [42, four critical solutions], must be tested for another discovery yet to be made.

The CPT theorem is unlikely to evolve so as to admit that the well-posed fundamental question might remain unanswerable. Even more humbling to mankind is the admission

[44] Feynman, already in [22, Section 52-5 Polar and axial vectors], interpreted the term "pseudovector" to literally mean that angular momenta and angular velocities are "not really vectors at all":

> As a matter of fact, if we go back and look at where the vectors came from, we know that the "right-hand rule" was merely a convention; it was a trick. The original quantities, like the angular momenta and the angular velocities, and things of this kind, were not really vectors at all!

[45] Silva and Martins did not seize the opportunity, in their next paper [61], to "realize" that the "difficulty for students" was no more than artificially constructed.

that it was never guaranteed to acquire the tools to know whether the answer to the fundamental question of Physics is decidable, that is, we might never know whether or not the question is answerable.

Maxwell, highly likely, upon repeatedly raising the fundamental question in [41], neither anticipated it to be ignored nor hastily answered. His question, most certainly, had better forever remain rhetorical than consensually wrongly resolved.

Coda

Nothing seems to preclude us from imagining an alternative Universe, where the charge of a proton and the charge of an electron, right and left, future and past, are interchanged. But such an imaginable Universe is not obliged to exist, nor ought it be declared "indistinguishable" from our Universe.

The belief of those who still insist on telling us that right and left are indistinguishable without invoking weak interactions must remain their own – not a fact to further propagate in Physics textbooks. The solution to the Ozma problem neither requires beta-decay observation nor is attained by it alone. In fact, we have seen that the Ozma problem was an artificial invention based on confusing the charge of an electron with our convention of designating it with a negative sign. Yet, nothing precludes us from unambiguously communicating our convention of labeling an electric charge. So, although several too prominent people had done their best to convince us that we must fail, as they did, to solve the Ozma problem upon encountering an alien made of antimatter, we can easily disprove them all by doing even more – we can unambiguously communicate our charge convention. The communication protocol is clear:

- We begin with locating the magnetic poles of asymmetric stars such as HD 57372; the pole where the magnetic field is highly concentrated is what we call the south magnetic pole, while the pole where the magnetic field is diffuse is what we call the north magnetic pole [32].[46]
- We proceed with telling the aliens of our "right-handed" coil (defined via directed orbital motion or Maxwell's enantiomorphism).
- We define the direction of the electric current in a "right-handed" coil via our "right-hand rule" (with the right thumb pointing towards the north magnetic pole of such a current-carrying coil).
- We inform the aliens that, according to our convention, the current flows towards the negative charge (which is the charge of an electron).[47]

Our Universe did make the distinction that many physicists were mutually hypnotized to unsee (confusing the artificial symmetry they imposed on paper with a natural symmetry they could not impose but could have repeatedly mistakenly declared) long before exhibiting it in the weak force, and we would be far better off noticing it literally everywhere (rather than seeing it nowhere but in weak force).

[46] Alternatively, we might inform the alien that the south magnetic pole of our planet is, unlike the north magnetic pole, visited by polar bears.

[47] Note that no space aliens are left confused no matter what they are made of.

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