Why Bergson was Right
Part 2
Did Einstein Erase Maxwell's Ether?

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Abstract

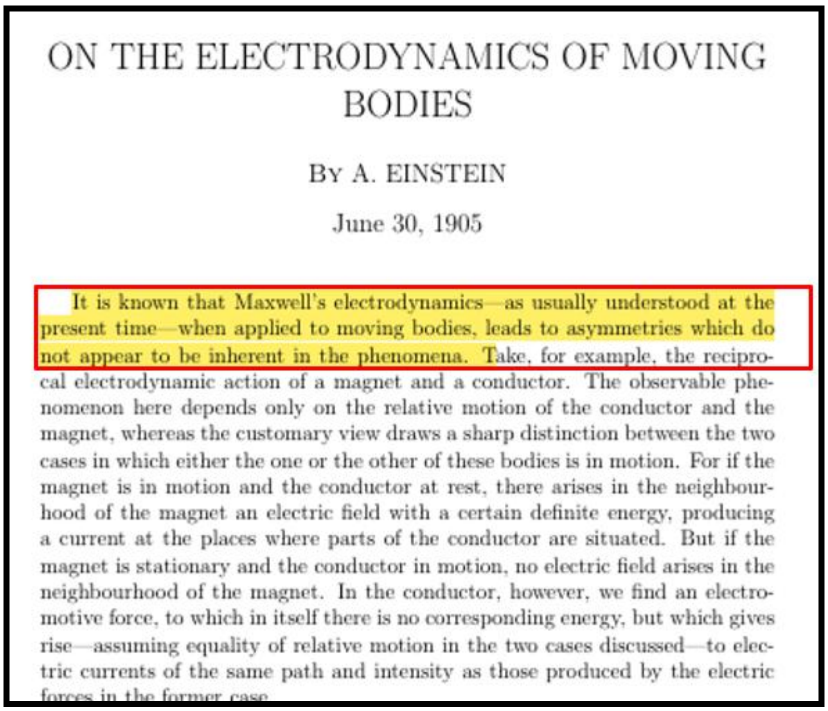
It is universally held that Einstein's paper of 1905 (creating Special Relativity) explained a certain asymmetry in the motion of magnets and conductors via its framework of the relative motions of coordinate systems. In doing so, it removed the need for the concept of an *electromotive force* and the need for an ether medium in which, for Maxwell, this force was based. The difficulty is that the logical structure of Special Relativity allows it to explain *measurement* effects, not physical, real, *ontological* effects, and given the effects of the electromotive force as described by Maxwell are indeed very physical, very real, the paper of 1905 cannot possibly have done what is claimed.

Why Bergson was Right, Part 2:
Did Einstein Erase Maxwell's Ether?

Introduction

> "We see that *electromotive force plays in the developed theory merely the part of an auxiliary concept* which owes its introduction to the circumstance that electric and magnetic forces do not exist independently of the state of motion of the system of coordinates." (Einstein, 1905, Section 6, p. 15, emphasis added)

So concluded Einstein in Section 6 (Transformation of the Maxwell-Hertz Equations…) of his 1905 (Special Relativity) paper. It was his delivery on his promise at the opening sentence of his paper, namely:



ON THE ELECTRODYNAMICS OF MOVING BODIES

By A. EINSTEIN

June 30, 1905

It is known that Maxwell's electrodynamics—as usually understood at the present time—when applied to moving bodies, leads to asymmetries which do not appear to be inherent in the phenomena. Take, for example, the reciprocal electrodynamic action of a magnet and a conductor. The observable phenomenon here depends only on the relative motion of the conductor and the magnet, whereas the customary view draws a sharp distinction between the two cases in which either the one or the other of these bodies is in motion. For if the magnet is in motion and the conductor at rest, there arises in the neighbourhood of the magnet an electric field with a certain definite energy, producing a current at the places where parts of the conductor are situated. But if the magnet is stationary and the conductor in motion, no electric field arises in the neighbourhood of the magnet. In the conductor, however, we find an electromotive force, to which in itself there is no corresponding energy, but which gives rise—assuming equality of relative motion in the two cases discussed—to electric currents of the same path and intensity as those produced by the electric forces in the former case.

Figure 1. First page, 1905.

The "assymetries" that he noted referred to this case (Figure 2) where, 1) a magnet in motion through a conductor creates an electric field around the magnet, whereas, 2) a conductor in motion across the magnet creates an electric field around the conductor. As he notes in the opening paragraph:

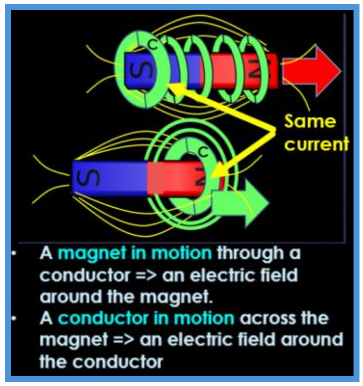
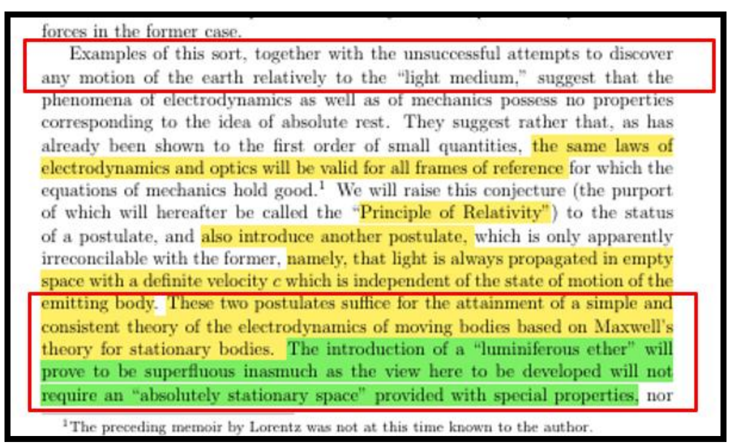


Figure 2: A magnet in motion through a conductor versus a conductor in motion across the magnet.

> "For *if the magnet is in motion and the conductor at rest*, there arises in the neighbour hood of the magnet an electric field with a certain definite energy, producing a current at the places where parts of the conductor are situated. But *if the magnet is stationary and the conductor in motion*, no electric field arises in the neighbourhood of the magnet. In the conductor, however, we find an electro motive force, to which in itself there is no corresponding energy, but which gives rise—assuming equality of relative motion in the two cases discussed—*to elec tric currents of the same path and intensity as those produced by the electric forces in the former case*." (1905, p. 1, emphasis added)

To be noted in the above, Einstein has characterized the two cases as having this commonality: they produce *the same current*, i.e., currents "of the same path and intensity" (also, Figure 2).

A bit further down (Figure 3, bottom red box) in the first page, he will summarize his two principles – the constancy of light velocity and his principle of relativity, noting that this system will make the "luminiferous ether" (Maxwell's framework) "superfluous."



forces in the former case.

Examples of this sort, together with the unsuccessful attempts to discover any motion of the earth relatively to the "light medium," suggest that the phenomena of electrodynamics as well as of mechanics possess no properties corresponding to the idea of absolute rest. They suggest rather that, as has already been shown to the first order of small quantities, the same laws of electrodynamics and optics will be valid for all frames of reference for which the equations of mechanics hold good.[1] We will raise this conjecture (the purport of which will hereafter be called the "Principle of Relativity") to the status of a postulate, and also introduce another postulate, which is only apparently irreconcilable with the former, namely, that light is always propagated in empty space with a definite velocity c which is independent of the state of motion of the emitting body. These two postulates suffice for the attainment of a simple and consistent theory of the electrodynamics of moving bodies based on Maxwell's theory for stationary bodies. The introduction of a "luminiferous ether" will prove to be superfluous inasmuch as the view here to be developed will not require an "absolutely stationary space" provided with special properties, nor

[1]The preceding memoir by Lorentz was not at this time known to the author.

Figure 3. First page, lower on, 1905.

The first sentence of this paragraph, I suspect ("Examples of this sort…"), especially given that opening sentence of 1905 referencing Maxwell, has always been taken to suggest that Maxwell's "asymmetries" were his primary motivation for SR, Michelson-Morley's "null result" a bit secondary, though it is curious to note his later statement that this was the inverse of reality:

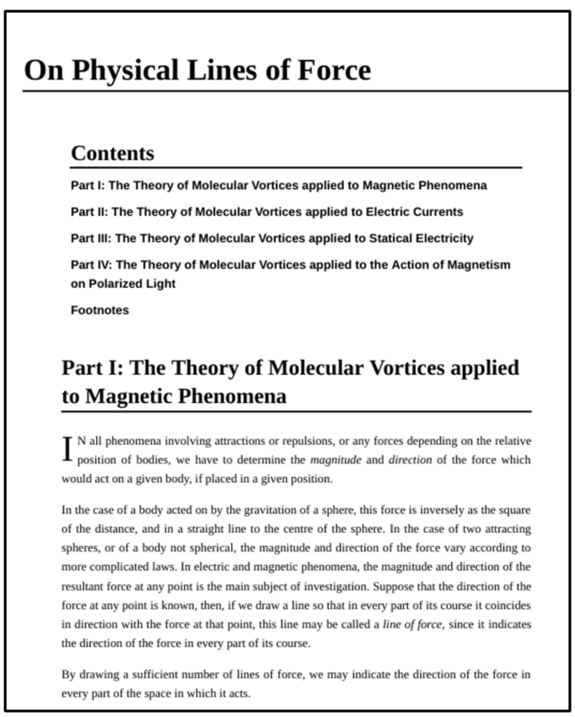
> "Soon I came to the conclusion that our idea about the motion of the Earth with respect to the ether is incorrect, if we admit Michelson's null result as a fact. *This was the first path which led me to the special theory of relativity*." (Einstein at Kyoto, 1922; Cf. Ono, 1982, emphasis added)

In any case, it is generally held that Einstein of 1905 "made the ether irrelevant," i.e., the ether in which Maxwell felt his equations embedded, which gave them concrete meaning (hence, on to QM). This is the standard theme – unquestioned, unanalyzed. But can Einstein possibly have achieved this? That is, does Special Relativity even have the logical structure required to achieve Einstein's claim re EM?

This paper is the continuation of the same structural analysis of SR given in an earlier paper, "Why Bergson was right: The Einstein-Bergson debate on Special Relativity," applied in that paper to the twin-paradox and various relativistic subjects such as Michelson-Morley and time-retardation experiments, but applied now in the context of Einstein's treatment of Maxwell and EM.

Maxwell, 1861

Maxwell's 1861 paper ("On Physical Lines of Force," Figure 4) featured an attempt at an explicit model of the electric and magnetic components (as *conjugates*) of the ether. "Conjugates" here implies two intrinsically implicated components that are distinct – mirrors – and one cannot be transformed into the other (or vice versa). In the current framework of SR's "explanation" of EM we should note, this distinction no longer exists. If one looks at the Wiki section ("The moving magnet") on the subject, one will see, "The Electric Field transforms (partially) to the Magnetic field. The Magnetic field transforms (partially) to the Electric field." For Maxwell, given his physical model, this "transformation" could not possibly be the case. We shall see why.



On Physical Lines of Force

Contents

Part I: The Theory of Molecular Vortices applied to Magnetic Phenomena

IN all phenomena involving attractions or repulsions, or any forces depending on the relative position of bodies, we have to determine the *magnitude* and *direction* of the force which would act on a given body, if placed in a given position.

In the case of a body acted on by the gravitation of a sphere, this force is inversely as the square of the distance, and in a straight line to the centre of the sphere. In the case of two attracting spheres, or of a body not spherical, the magnitude and direction of the force vary according to more complicated laws. In electric and magnetic phenomena, the magnitude and direction of the resultant force at any point is the main subject of investigation. Suppose that the direction of the force at any point is known, then, if we draw a line so that in every part of its course it coincides in direction with the force at that point, this line may be called a *line of force*, since it indicates the direction of the force in every part of its course.

By drawing a sufficient number of lines of force, we may indicate the direction of the force in every part of the space in which it acts.

Figure 4. Maxwell, 1861

There's an opinion that Maxwell himself had abandoned – given up on – the ether. This is far from the case. There was a transition – from an explicit, concrete model in 1861 to a more abstract discussion in 1865 with misgivings noted re 1861 – but 1865, we'll see, in no way abandons the ether. Even in 1861 he notes that his vortices model: "…may appear awkward…or [not] even as that which I would willingly assent to as an electrical hypothesis…It is, however, a mode of connexion which is mechanically conceivable [and testable]."

After describing the mathematics of lines of force, he is at pains to differentiate the model from then-current attempts that employed *action at a distance* in the explanatory mechanism:

> "Such a state of stress, if assumed to exist in the medium, and to be arranged according to the known laws regulating lines of force, will act upon the magnets, currents, &c. in the field with precisely the same resultant forces as those calculated *on the ordinary hypothesis of direct action at a distance*. We have therefore a satisfactory answer to the question, 'Is there any *mechanical hypothesis* as to the condition of the medium indicated by lines of force, by which the observed resultant forces may be accounted for?'" (Part 2, start)

And he adds:

> "What is the mechanical cause of this difference of pressure in different directions? We have supposed, in the first part of this paper, that this difference of pressures is caused by molecular vortices, having their axes parallel to the lines of force." (Figure 5, for a rough visualization.)

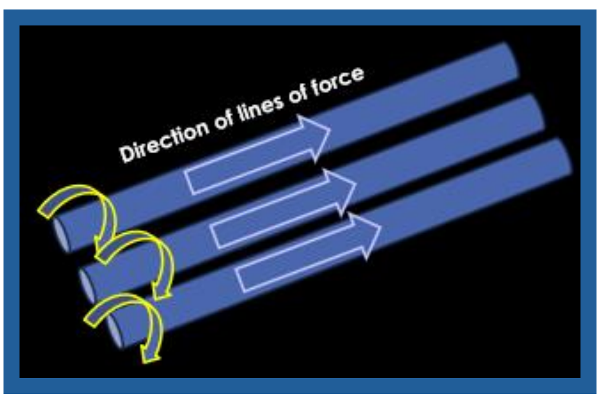


Figure 5. Rotating molecular vortices/lines of force.

Continuing:

> "How are these vortices set in rotation? …Why are they arranged according to the known laws of lines of force about magnets and currents?"

And he notes this difficulty (Figure 6):

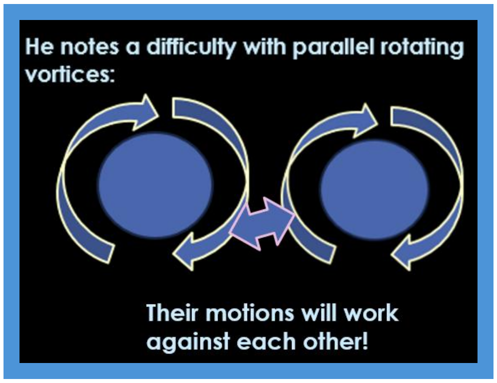


Figure 6: Rotating vortex tubes work against each other.

Continuing:

> "Why does a particular distribution of vortices indicate an electric current? A satisfactory answer…would lead us a long way towards…'What is an electric current?'"

His answer (with picture of Figure 7):

> "The only conception which has at all aided me in conceiving of this kind of motion is that of the vortices being separated by a layer of particles, revolving each on its own axis in the opposite direction to that of the vortices, so that the contiguous surfaces of the particles and of the vortices have the same motion."

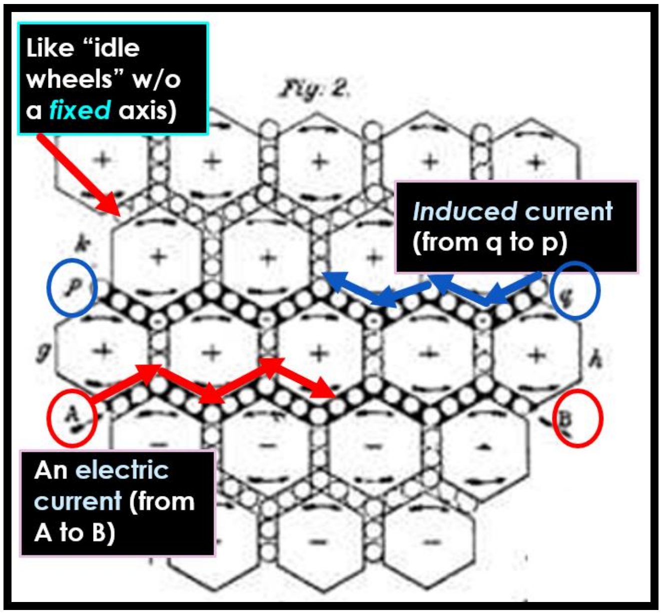


Figure 7. Maxwell's rotating vortices (as the hexagons).

The particles (like idle wheels with no fixed axis) are "electric particles." Note the primary current (red) from A to B, and the secondary, induced current (blue) from q to p.

> "It appears therefore that, according to our hypothesis, *an electric current* is represented by the transference of the moveable particles interposed between the neighbouring vortices."

The model is thoroughly mechanical (no action at a distance is involved). There could be no "partial transforming" of the electric component to the magentic component. He notes, "…so the effect of the connexion between the current and the electromagnetic field surrounding it, is to endow the current with a kind of *momentum*, just as the connexion between a machine and the driving point of a flywheel endows the driving point with additional momentum…" The electromotive force, then, is the force *behind* the current, *not* the current. The model supports the [multitudinous] equations he works out for the phenomena of electromagnetism.

Was he satisfied? As already noted, no. Within 1861 are implications for the electromotive force (the force Einstein will make "come and go" via relative motion). But some are more obviously found in his 1865.

Maxwell, 1865

He is still concerned with action-at-a-distance theories (such as Weber's). Note the red-box highlights of Figure 8. And he will note:

> "I have therefore preferred to seek an explanation of the fact in another direction, by supposing them *to be produced by actions which go on in the surrounding medium as well as in the excited bodi*es, and endeavouring to explain the action between distant bodies without assuming the existence of forces capable of acting directly at sensible distances." (Emphasis added)

In other words, the ether is far from abandoned.

A Dynamical Theory of the Electromagnetic Field

By James Clerk Maxwell

INTRODUCTION.

(1) THE most obvious mechanical phenomenon in electrical and magnetic experiments is the mutual action by which bodies in certain states set each other in motion while still at a sensible distance from each other. The first step, therefore, in reducing these phenomena into scientific form, is to ascertain the magnitude and direction of the force acting between the bodies, and when it is found that this force depends in a certain way upon the relative position of the bodies and on their electric or magnetic condition, it seems at first sight natural to explain the facts by assuming the existence of something either at rest or in motion in each body, constituting its electric or magnetic state, and capable of acting at a distance according to mathematical laws.

In this way mathematical theories of static electricity, of magnetism, of the mechanical action between conductors carrying currents, and of the induction of currents have been formed. In these theories the force acting between the two bodies is treated with reference only to the condition of the bodies and their relative position, and without any express consideration of the surrounding medium.

These theories assume, more or less explicitly, the existence of substances the particles of which have the property of acting on one another at a distance by attraction or repulsion. The most complete development of a theory of this kind is that of M.W. WEBER[1], who has made the same theory include electrostatic and electromagnetic phenomena.

In doing so, however, he has found it necessary to assume that the force between two particles depends on their relative velocity, as well as on their distance.

Figure 8. Maxwell, 1865

This is the paper that holds his twenty equations for EM, reduced to only four (with what has to be loss of information) by Heaviside. Now, some of his comments on the electromotive force;

> "(9) We may now consider another phenomenon observed in the electromagnetic field. When a body is moved across the lines of magnetic force it experiences what is called an electromotive force; the two extremities of the body tend to become oppositely Electrified [polarized], and an electric current tends to flow through the body. When the electromotive force is sufficiently powerful, and is made to act on certain compound bodies, *it decomposes them, and causes one of their components to pass towards on extremity of the body*, and the other in the opposite direction." (Emphasis added)

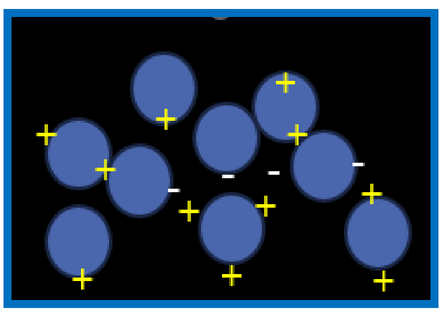
And note this:

> "Here we have evidence of a force…if strong enough, *tearing to pieces chemical compounds and carrying their components in opposite directions…*" (Emphasis added)

Continuing:

> "(11) But when electromotive force acts on a dielectric it produces a state of Polarization…In a dielectric under the action of electromotive force, we may conceive that the electricity in each molecule is so displaced that one side is rendered positively and the other negatively electrical, but that the electricity remains entirely connected with the molecule...*The effect of this action on the whole dielectric mass is to produce a general displacement of electricity in a certain direction.* This displacement does not amount to a current, because when it has attained to a certain value it remains constant…" (Emphasis added)

And (with rough visualization, Figure 9):



> "In the interior of the dielectric there is no indication of electrification, because the electrification of the surface of any molecule is neutralized by the opposite electrification of the surface of the molecules in contact with it; but at the bounding surface of the dielectric, where the electrification is not neutralized, we find the phenomena which indicate positive or negative electrification."

There's more, but this is enough. Let us look at Einstein.

Einstein, 1904, Section 4

Sections 1-4 of 1905 describe his relativistic transformations, while Section 6 is devoted to these transformations as applied to Maxwell – removing those "asymmetries." In Sect. 4, the implications of the transformations are concretely explained (Figure 10), to be discussed below.

§ 4. Physical Meaning of the Equations Obtained in Respect to Moving Rigid Bodies and Moving Clocks

We envisage a rigid sphere[6] of radius R, at rest relatively to the moving system k, and with its centre at the origin of co-ordinates of k. The equation of the surface of this sphere moving relatively to the system K with velocity v is

$$\xi^2 + \eta^2 + \zeta^2 = \mathrm{R}^2.$$

The equation of this surface expressed in x, y, z at the time $t = 0$ is

$$\frac{x^2}{(\sqrt{1 - v^2/c^2})^2} + y^2 + z^2 = \mathrm{R}^2.$$

A rigid body which, measured in a state of rest, has the form of a sphere, therefore has in a state of motion—viewed from the stationary system—the form of an ellipsoid of revolution with the axes

$$\boxed{\mathrm{R}\sqrt{1 - v^2/c^2},\ \mathrm{R},\ \mathrm{R}.}$$

Thus, whereas the Y and Z dimensions of the sphere (and therefore of every rigid body of no matter what form) do not appear modified by the motion, the X dimension appears shortened in the ratio $1 : \sqrt{1 - v^2/c^2}$, i.e. the greater the value of v, the greater the shortening. For $v = c$ all moving objects—viewed from the "stationary" system—shrivel up into plane figures.[†] For velocities greater than that of light our deliberations become meaningless; we shall, however, find in what follows, that the velocity of light in our theory plays the part, physically, of an infinitely great velocity.

It is clear that the same results hold good of bodies at rest in the "stationary" system, viewed from a system in uniform motion.

Figure 10. 1905, Section 4, beginning

Above, Einstein describes an observer (Observer 1) at rest, and with a sphere in his reference system (Figure 11, right). Observer 1 sees Observer 2 in motion (per O1), where the sphere is now in "the form of an ellipsoid" with radius R given by an equation with Einstein's factor $(1 - v^2/c^2)^{1/2}$ (see the first red box of Figure 10). And he notes nearly immediately (bottom red box), "the same results hold good of bodies in the 'stationary' system, viewed from the system in motion." In other words, Observer 2, equally legimately, per relativity, considering himself stationary, holds Observer 1 in motion, O1's "sphere" as that compressed to an ellipsoid (Figure 11, left). *The "compression" of the sphere comes and goes depending on the motion of the observer*. The two cases are fully *reciprocal*. Neither observer can say who is in motion, who is at rest, therefore who is "correct" about the sphere/ellipsoid.

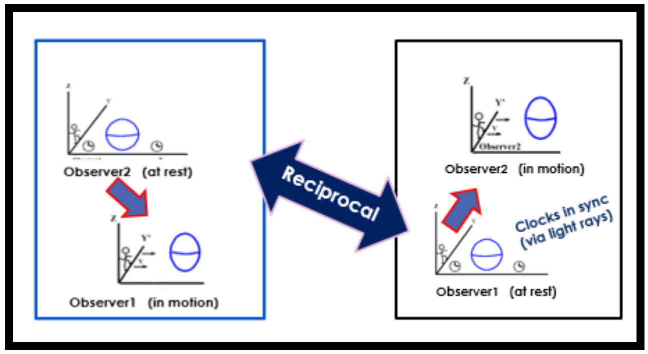


Figure 11. The reciprocity of Special Relativity. Each observer can claim that he is *at rest*, the other in motion, and the "effects" of motion can be ascribed (like the sphere shortening) – fully legimately, without any possible appeal as to who is "correct" – to the other.

Hence, the *logical structure of Special Relativity*:

- SR can only explain *measurement* effects. (See A. P. French, *Special Relativity*, 1968, p. 114, for this terminology: *"…not a property of matter…something inherent in the measurement process."*)
- A measurement effect:
  - We have two rulers of the same physical length, one marked 6", one 9", We measure a toaster. The toaster "expands" (from 6" to 9") or "contracts" depending on the screwy ruler (Figure 12, left).
  - SR: *The "rulers" are light rays and clocks* (the clocks are "synchronized" if the observer is considered at rest, unsynchronized if "in motion").
  - Michelson-Morley is considered to be explained by SR as *a measurement effect* – like the toaster, there is no actual, physical contraction of the apparatus arm which is parallel to the flow of the ether. (Figure 12, right).
- SR does not have the logical structure to explain *real, physical, ontological* effects – actual, physical shortenings of apparatus arms, real compression of "spheres" that might in fact be physical bowling balls (requiring massive forces for true compression), or actual retardation of physical clocks.
  - SR is being used *invalidly* as an explanation of such effects.
  - The effects (e.g., clock slowings) are indeed very real; *some other model* is needed as explanation.

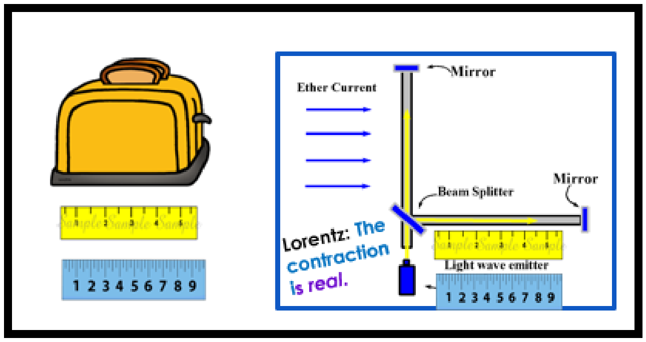


Figure 12. Left: The "toaster" expands/contracts depending on the rulers. Right: Michelson-Morley – the "contraction" of the apparatus arm parallel to the ether current is equally just a measurement effect per SR.

There are two major thought *constraints* here, the first as already noted:

1. SR only "explained" Michelson-Morley via a measurement effect (*not* by a physical, real contraction).
    i. Note: Lorentz proposed an electrodynamical model of the arm's contraction – as a real, physical contraction. This was supposedly seen as ad hoc and rejected – in favor of SR's "explanation" as *measurement*.
2. The Lorentz transformations are *compensatory: Time units expand in exact proportion as space units contract.*
    i. Thus, all SR's effects (of length, of time) must be of the *same order: measurement.*
    ii. Hence, *SR cannot be used to explain real "time-retardations"* – the real, physical slowing of clocks (say, carried on jets, e.g., Hafele-Keating), or yes, the physical lack of aging of Langevin's rocket-riding twin – a very physical, ontological effect – youthful skin, brown hair versus the very physical wrinkles, grey hair and arthritis of the earth-twin.
    iii. Again, some other theory, some other model is needed to explain these real effects, e.g., something like Lorentz's earlier proposal (purely as a possible example).
    iv. If one thinks SR is explaning time retardation (of clocks) as a real effect, see thought constraint #1: *you have just given up SR as an explanation of Michelson-Morley* (for the length contraction is of the same order; it would be equally physical, real).

Logical Structure of 1905 Destroyed by/in 1905

In Section 4, we come across the following paragraph (Figure 13, with illustration, Figure 14):

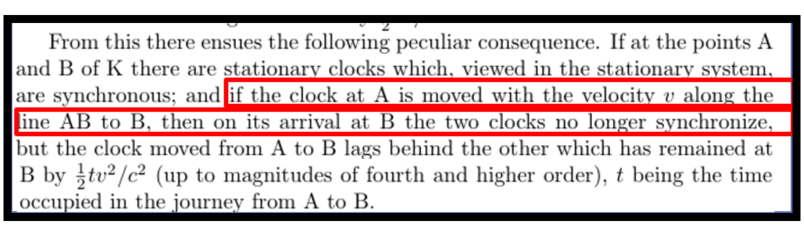

From this there ensues the following peculiar consequence. If at the points A and B of K there are stationary clocks which, viewed in the stationary system, are synchronous; and if the clock at A is moved with the velocity v along the line AB to B, then on its arrival at B the two clocks no longer synchronize, but the clock moved from A to B lags behind the other which has remained at B by $\frac{1}{2}tv^2/c^2$ (up to magnitudes of fourth and higher order), t being the time occupied in the journey from A to B.

Figure 13. Moving the clock in the stationary system

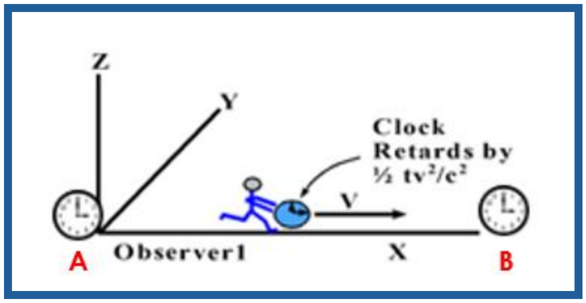


Figure 14. Moving the clock in the stationary system (in which the clocks at each end, A/B, would already, intially, be synchronized).

Einstein intends this as a real effect. O1, he is certain, will find the clock slowed at B. But Einstein has simply voided SR's logical structure here – the reciprocity of O1 and O2. He only refers to O1. This is nothing more than a cheap form of Lorentz (who at least had an electrodynamical model of the contractions). Velocity/motion, per Einstein, is all that is required for the "effect" – the reciprocal structure that actually makes SR – that which differentiates it from Lorentz – has been thrown away. Yet how does O1 *know* he is moving, rather than B moving towards him? (The physical act of walking – sensing fatigue, muscles straining, toes hurting – all this means precisely *zero* in the abtract, geometrical framework of Einstein and SR – no more than the forces required to actually compress a bowling ball.) But the fact that Einstein does not care here about the reciprocity of two reference systems is evident in the next paragraph (Figure 15, and see Figure 16).

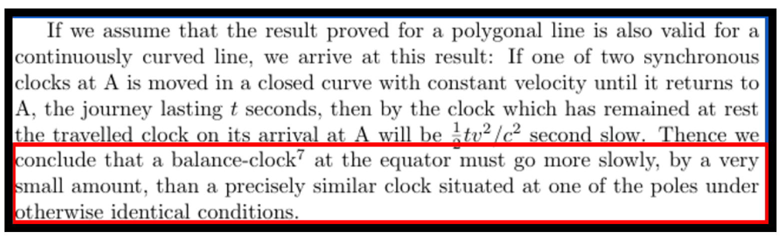

If we assume that the result proved for a polygonal line is also valid for a continuously curved line, we arrive at this result: If one of two synchronous clocks at A is moved in a closed curve with constant velocity until it returns to A, the journey lasting t seconds, then by the clock which has remained at rest the travelled clock on its arrival at A will be $\frac{1}{2}tv^2/c^2$ second slow. Thence we conclude that a balance-clock[7] at the equator must go more slowly, by a very small amount, than a precisely similar clock situated at one of the poles under otherwise identical conditions.

Figure 15. On the equator clock versus pole clock.

Figure 16. Clocks at the equator and the pole – in the same (earth) system!

The "Equator-gal" is not going to tell the Pole-guy that the she is stationary, the Pole-guy is moving, thus it is, rather, the Pole-guy's clock that has slowed – no more than the folks at the airport in the Hafele-Keating experiment are going to be willing to step forward when the jet carrying the clock lands, invoke reciprocity, and say that the jet carrying the clocks was actually stationary, the earth moving under the jet, therefore, the airport clocks are the clocks that slowed, not those on the jet.

This "structure-wrecking" of SR – the voiding of reciprocity, i.e., the very relativity principle which makes SR distinct from Lorentz – plays its role in Einstein's treatment of Maxwell in Section 6.

Einstein, 1905, Section 6

Section 6 starts with the Maxwell-Hertz equations for the stationary system (Figure 17, red box), where he notes the X, Y, Z are the vectors of electric force (blue ellipse), the L, M, N are the vectors of magnetic force (green ellipse) – this for the *stationary* system.

§ 6. Transformation of the Maxwell-Hertz Equations for Empty Space. On the Nature of the Electromotive Forces Occurring in a Magnetic Field During Motion

Let the Maxwell-Hertz equations for empty space hold good for the stationary system K, so that we have

$$\begin{aligned}
\frac{1}{c}\frac{\partial \mathrm{X}}{\partial t} &= \frac{\partial \mathrm{N}}{\partial y} - \frac{\partial \mathrm{M}}{\partial z}, & \frac{1}{c}\frac{\partial \mathrm{L}}{\partial t} &= \frac{\partial \mathrm{Y}}{\partial z} - \frac{\partial \mathrm{Z}}{\partial y},\\
\frac{1}{c}\frac{\partial \mathrm{Y}}{\partial t} &= \frac{\partial \mathrm{L}}{\partial z} - \frac{\partial \mathrm{N}}{\partial x}, & \frac{1}{c}\frac{\partial \mathrm{M}}{\partial t} &= \frac{\partial \mathrm{Z}}{\partial x} - \frac{\partial \mathrm{X}}{\partial z},\\
\frac{1}{c}\frac{\partial \mathrm{Z}}{\partial t} &= \frac{\partial \mathrm{M}}{\partial x} - \frac{\partial \mathrm{L}}{\partial y}, & \frac{1}{c}\frac{\partial \mathrm{N}}{\partial t} &= \frac{\partial \mathrm{X}}{\partial y} - \frac{\partial \mathrm{Y}}{\partial x},
\end{aligned}$$

where (X, Y, Z) denotes the vector of the electric force, and (L, M, N) that of the magnetic force.

Figure 17. Start of Section 6.

And he modifies these (Figure 18), for the *moving* system, with his transformation factor, β, $1/(1 - v^2/c^2)^{1/2}$ (in red circle, bottom), i.e., as he notes, using the transformations derived in Sections 1-4.

If we apply to these equations the transformation developed in § 3, by referring the electromagnetic processes to the system of co-ordinates there introduced, moving with the velocity v, we obtain the equations

$$\begin{aligned}
\frac{1}{c}\frac{\partial \mathrm{X}}{\partial \tau} &= \frac{\partial}{\partial \eta}\left\{\beta\left(\mathrm{N} - \frac{v}{c}\mathrm{Y}\right)\right\} - \frac{\partial}{\partial \zeta}\left\{\beta\left(\mathrm{M} + \frac{v}{c}\mathrm{Z}\right)\right\},\\
\frac{1}{c}\frac{\partial}{\partial \tau}\left\{\beta\left(\mathrm{Y} - \frac{v}{c}\mathrm{N}\right)\right\} &= \frac{\partial \mathrm{L}}{\partial \xi} - \frac{\partial}{\partial \zeta}\left\{\beta\left(\mathrm{N} - \frac{v}{c}\mathrm{Y}\right)\right\},\\
\frac{1}{c}\frac{\partial}{\partial \tau}\left\{\beta\left(\mathrm{Z} + \frac{v}{c}\mathrm{M}\right)\right\} &= \frac{\partial}{\partial \xi}\left\{\beta\left(\mathrm{M} + \frac{v}{c}\mathrm{Z}\right)\right\} - \frac{\partial \mathrm{L}}{\partial \eta},\\
\frac{1}{c}\frac{\partial \mathrm{L}}{\partial \tau} &= \frac{\partial}{\partial \zeta}\left\{\beta\left(\mathrm{Y} - \frac{v}{c}\mathrm{N}\right)\right\} - \frac{\partial}{\partial \eta}\left\{\beta\left(\mathrm{Z} + \frac{v}{c}\mathrm{M}\right)\right\},\\
\frac{1}{c}\frac{\partial}{\partial \tau}\left\{\beta\left(\mathrm{M} + \frac{v}{c}\mathrm{Z}\right)\right\} &= \frac{\partial}{\partial \xi}\left\{\beta\left(\mathrm{Z} + \frac{v}{c}\mathrm{M}\right)\right\} - \frac{\partial \mathrm{X}}{\partial \zeta},\\
\frac{1}{c}\frac{\partial}{\partial \tau}\left\{\beta\left(\mathrm{N} - \frac{v}{c}\mathrm{Y}\right)\right\} &= \frac{\partial \mathrm{X}}{\partial \eta} - \frac{\partial}{\partial \xi}\left\{\beta\left(\mathrm{Y} - \frac{v}{c}\mathrm{N}\right)\right\},
\end{aligned}$$

where

$$\beta = 1/\sqrt{1 - v^2/c^2}.$$

Figure 18. Electric and magnetic vectors transformed by β.

With a bit more manipulation, he shows the equations' final form (Figure 19).

and our equations assume the form

$$
\begin{aligned}
X' &= X, & L' &= L, \\
Y' &= \beta\left(Y - \tfrac{v}{c}N\right), & M' &= \beta\left(M + \tfrac{v}{c}Z\right), \\
Z' &= \beta\left(Z + \tfrac{v}{c}M\right), & N' &= \beta\left(N - \tfrac{v}{c}Y\right).
\end{aligned}
$$

Figure 19. Transformed vectors for the moving system.

Now Einstein has us imagine an observer at rest (Observer 1, Figure 20, right), with an element of charge in his system. O1 assigns it a force of "one" (1 dyne at a distance of 1 cm). Then he has us imagine an observer in motion (Observer 2, Figure 20, top left), observing the charge in O1's stationary system. Einstein says, "by relativity" this observer will apply his transformations and also get a force of "one" (for the charge in the stationary system). Then he has us imagine a charge in O2's moving system (Figure 20, bottom left). O2 will obtain a force of X',Y', Z' (the transformed vector shown in Figure 19), i.e., the Lorentz transformations are applied.

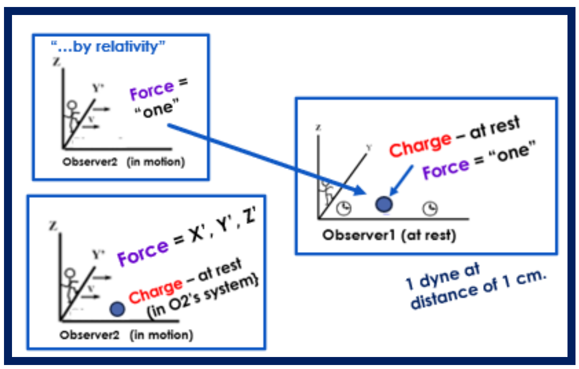


Figure 20. Charge force value – moving vs. rest

Now he makes two interesting statements. First (Figure 21), for the "*old manner of expression,*" where we still see the presence of an *electromotive force.*

1. If a unit electric point charge is in motion in an electromagnetic field, there acts upon it, in addition to the electric force, an "electromotive force" which, if we neglect the terms multiplied by the second and higher powers of v/c, is equal to the vector-product of the velocity of the charge and the magnetic force, divided by the velocity of light. (Old manner of expression.)

Figure 21: "Old manner of expression"

Then (Figure 22), for the "new manner of expression," where all is taken as a function of the state of motion of a coordinate system.

2. If a unit electric point charge is in motion in an electromagnetic field, the force acting upon it is equal to the electric force which is present at the locality of the charge, and which we ascertain by transformation of the field to a system of co-ordinates at rest relatively to the electrical charge. (New manner of expression.)

Figure 22. "New manner of expression"

And then we see the claim made (Figure 23), i.e., the quote at the very start of this paper, namely, that electromotive force has been removed; it is merely an "auxiliary concept."

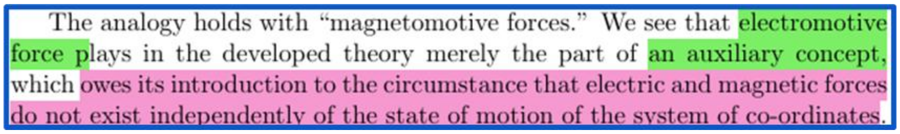

The analogy holds with "magnetomotive forces." We see that electromotive force plays in the developed theory merely the part of an auxiliary concept, which owes its introduction to the circumstance that electric and magnetic forces do not exist independently of the state of motion of the system of co-ordinates.

Figure 23. EMF reduced to an auxiliary concept.

So, the EMF "goes away" when we transform the stationary system to a moving system. This is to say that we are back again to his example in Section 4 (Figure 24). There is a substitution: for the *compression* into an *ellipsoid* (computed via the Lorentz transform) which is simply removed by viewing the ellipsoid as in a stationary system (thus, in "reality" – though no one can say for sure –a sphere), we have now substituted the EMF.

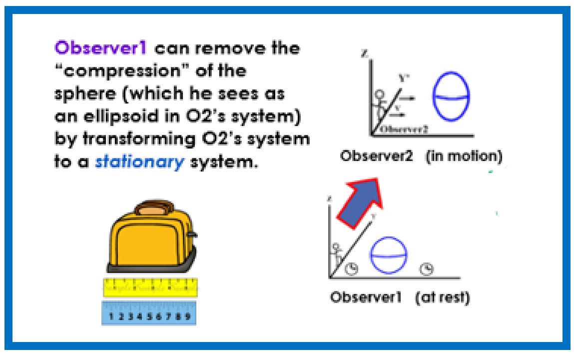


Figure 24. The reciprocal scheme of Section 4.

But Sections 1-4, as we saw, only describe *measurement effects*! They are not and cannot be dealing with actual, real, physical changes, i.e., *ontological* effects. Can Einstein's claim possibly hold true for Maxwell's (very physical) EMF?

Maxwell vs. Einstein

Start with this (already noted from 1865):

> "When a body is moved across the lines of magnetic force it experiences what is called an electromotive force... When…sufficiently powerful, and is made to act on certain compound bodies, it decomposes them…Here we have evidence of a force…if strong enough, tearing to pieces chemical compounds and carrying their components in opposite directions…"

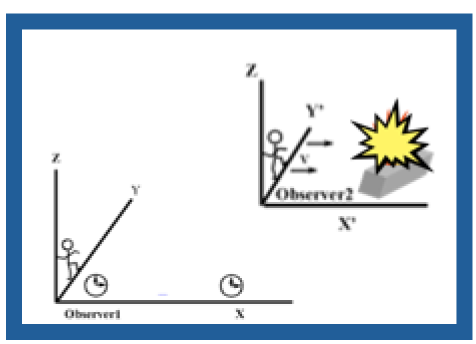


Figure 25. The EMF tears the block (a compound body) in O2's system to pieces.

If the body is decomposed, *torn to pieces*, we are not going to put it back again; it is a *real, physical effect* that cannot be made to "go away" by transforming the coordinate system.

And consider this:

> "But when electromotive force acts on a dielectric it produces a state of Polarization …at the bounding surface of the dielectric, where the electrification is not neutralized, we find the phenomena which indicate positive or negative electrification."

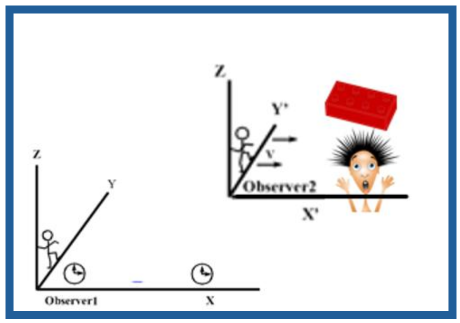


Figure 26. The electrification has its effect.

The hair standing up (Figure 26) is not "going away" by transforming the coordinate system. The same problem, as noted in Part 1 (and mentioned earlier above re the "structure of SR"), is endemic to Langevin's "twin paradox" (Figure 27) which, while remembering 1905's own distortion (e.g., the clocks at the pole/equator), can still be taken as the definitive destruction of SR's logical consistency (and which caused Bergson (1923) to enter the subject, conscerned to correct the distortion of our theory of time all this implied). Again, remember "thought constraint #1," namely, *SR only "explained" Michelson-Morley via a measurement effect* (*not* as a physical, real contraction of the apparatus arm). If you assign real physicality – ontological status – to these "effects," whether of length or of time – *physics no longer has an "explanation" of Michelson-Morley*. This is a consequence, a constraint, that simply cannot be ignored.

Figure 27. Langevin's distortion of the logical structure and consistency of SR.

Einstein's move here (Figures 28, 29), namely, to only consider that there's an *electric current* created in each case, ignores the character of Maxwell's ether-embedded EMF.

Furthermore it is clear that the asymmetry mentioned in the introduction as arising when we consider the currents produced by the relative motion of a magnet and a conductor, now disappears. Moreover, questions as to the "seat"

Figure 28. From Section 6.

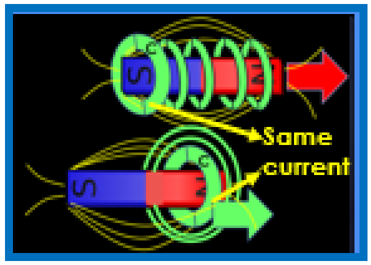


Figure 29. The assymetry

This (the 2nd-to-last) sentence (on "the assymetry disappearance") of Section 6 (Figure 28, above) – simply cannot be true.

Maxwell on the Ether

In 1865, Maxwell derives the *total energy of the field* (Figure 30):

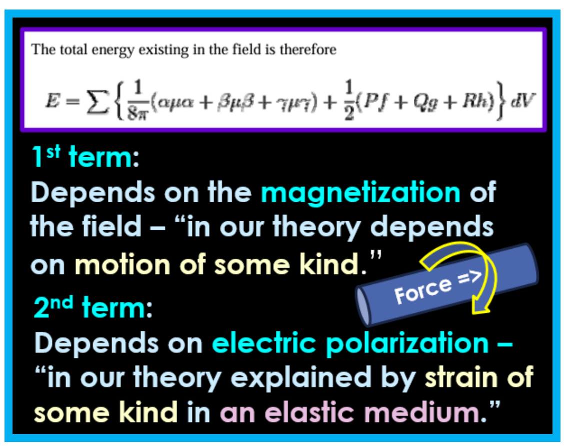


Figure 30. The total energy of the field, 1865.

Then he notes the following (Figure 31):

(73) I have on a former occasion[1] attempted to describe a particular kind of motion and a particular kind of strain, so arranged as to account for the phenomena. In the present paper I avoid any hypothesis of this kind; and in using such words as electric momentum and electric elasticity in reference to the known phenomena of the induction of currents and the polarization of dielectrics, I wish merely to direct the mind of the reader to mechanical phenomena which will assist him in understanding the electrical ones. All such phrases in the present paper are to be considered as illustrative, not as explanatory.

Figure 31. From 1865, his model is *illustrative* (the former occasion" refers to the 1861 paper).

He changes his tone (Figure 32) when speaking of the "Energy of the field," defined in his equation (Figure 30):

> (74) In speaking of the Energy of the field, however, I wish to be understood literally. All energy is the same as mechanical energy, whether it exists in the form of motion or in that of elasticity, or in any other form. The energy in electromagnetic phenomena is mechanical energy. The only question is, Where does it reside? On the old theories it resides in the electrified bodies, conducting circuits, and magnets, in the form of an unknown quality called potential energy, or the power of producing certain effects at a distance. On our theory it resides in the electromagnetic field, in the space surrounding the electrified and magnetic bodies, as well as in those bodies themselves, and is in two different forms, which may be described without hypothesis as magnetic polarization and electric polarization, or, according to a very probable hypothesis, as the motion and the strain of one and the same medium.

Figure 32. The Energy of the field is to be taken literally.

The "unknown quality called *potential energy*" to which Maxwell refers, we might note, is the core of the *Lagrangian* – itself a generalization (allowing the description of the motion of an object through a gravitational field) – a generalization on Newton's basic gravitational equation ($F = G (m_1 m_2)/r^2$) and an equation (i.e., the Lagrangian) which Einstein would later essentially and simply *geometrize* (Cf. Carrol, 2022). All this continued mathematization be considered by physics as explanation did nothing to improve Newton's position/frustration re any concrete, physical meaning for his gravitational equation and its own mysterious action at a distance (thus his famous, "Hypotheses non fingo."),

And equally here, in the realm of EM, do we have "action at a distance," or, rather, a comprehensible, mechanical model? This fundamental question has not gone away. Whatever the deficiencies of Maxwell's concrete model, and he was certainly aware of these, the common theme that Maxwell's position has been destroyed based on the notion of a supposed erasure by Einstein and Special Relativity is simply elementary failure to understand the logical structure of SR – what it can and cannot explain – and to look more deeply.[1]

[1] Though the great Maxwell is viewed as failing in his vortex model, and this seems to have had its discouraging effect on physics efforts to continue on these lines, in fact, currently with a mindset to virtually deny a mechanical model can exist or can be a form of explanation, it obviously does not follow from Maxwell's inadequacy, in fact it is absurd, to say that there is no mechanical model.

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(This book has a version of Part 1's arguments, for reference purposes.)

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