History of $E=mc^2$

Claim from Guy

- $E=mc^2$ has physically manifested itself and was utilized to create atomic bombs.

J. J. Thomson 1897

of energy which is proportional to the square of the velocity. This causes the charged body to behave as if its mass were increased by a quantity, which for a charged sphere is $\frac{1}{5} e^2/\mu a$ ('Recent Researches in Electricity and Magnetism'), where e is the charge and a the radius of the sphere. If we assume

Calculated the mass of an electron based off its charge potential

Thomson, J. J. (1897). Cathode Rays, Academic Reprints.

- By using electric and magnetic fields to direct and deflect charge potential of cathode rays, J. J. Thomson was able to mathematically extrapolate a charge-to-mass ratio based on the degree of deflection.

- Does this mean that a tiny charged particle had its mass physically increased?

- No. The accelerating charge potential changes when the impedance (ε) (μ) changes. The "behavior", as described by J. J. Thomsons of mass increase is a kinematic. Dynamically, the change in (ε) (μ) are is responsible for the deflection and an apparent charge-to-mass ratio relationship.

Thomson, J. J. (1897). Cathode Rays, Academic Reprints.

its neighbourhood; moving the body involves the production of a varying electric field, and, therefore, of a certain amount of energy which is proportional to the square of the velocity. This causes the charged body to behave as if its mass were increased by a quantity, which for a charged sphere is $\frac{1}{5} e^2/\mu a$ ('Recent Researches in Electricity and Magnetism'), where e is the charge and a the radius of the sphere. If we assume that it is this mass which we are concerned with in the cathode rays, since m/e would vary as e/a, it affords no clue to the explanation of either of the properties (1 and 2) of these rays. This is not by any means the only objection to this hypothesis, which I only mention to show that it has not been overlooked.

Ives, H. E. (1952). "Derivation of the Mass-Energy Relation." JOSA **42(8): 540-543.**

in question had been established by other, more intricate derivations. The first explicit statement that the heat energy of a body increases its "mechanical" mass was made by F. Hasenöhrl in 1904. Hasenöhrl studied the problem of a hollow enclosure filled with radiation, to determine the effect of the pressure due to the radiation.[4] He showed that "to the mechanical mass of our system must be added an apparent mass $\mu = 8E/3c^2$." This he later recalculated as $4E/3c^2$.[5] On the ground that the internal energy of a body must consist in part of radiation Hasenöhrl stated that in general the mass of a body will depend on its temperature.

Ives, H. E. (1952). "Derivation of the Mass-Energy Relation." JOSA **42(8): 540-543.**

No momentum, no logical meaning behind the derivation provided by Big Ein.

universal law." This comment is incorrect; Einstein, in the work referred to (1905), did not give this derivation; he did not use the momentum of radiation, which is an essential element of this "example," and his derivation was actually incompetent to give the result he announced. This is brought out in the Appendix to the present paper.

Thomson, D. and J. Bourassa (2004). Secrets of the Aether.

E does not equal m

Energy is a unit. Mass is a dimension. Energy is composed of the dimensions of mass times length squared times frequency squared.

$$E = M \cdot L^2 \cdot F^2 \tag{5.3}$$

Mass is not converted to energy and energy is not converted to mass. Mass is merely a dimension from which the units are constructed. This is repetitive, but understanding mass as merely a dimension is perhaps the greatest intellectual physics challenge for most people coming out of the 20th Century.

Thomson, D. and J. Bourassa (2004). Secrets of the Aether.

Conversation Factor for E=mc^2

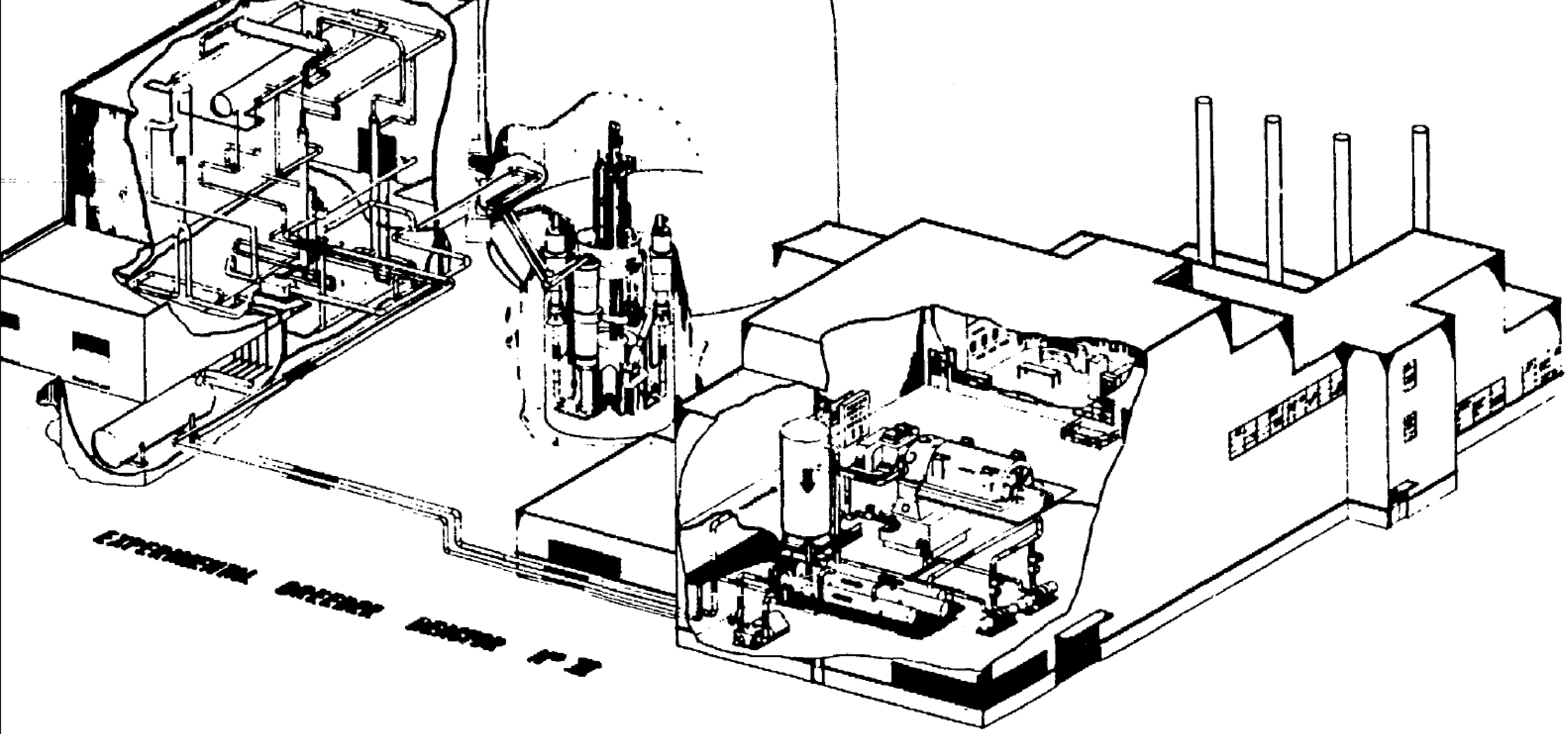
We often refer to nuclear reactions on the Sun, nuclear power plants, and nuclear bombs as examples of mass to energy conversion. In the nuclear power plants the United States has been operating for 60 years, a high degree of precision applies to the measured amount of energy and material mass passed through the reactor. And yet, there is not one report available anywhere (that this writer was able to obtain) that presents the data from a nuclear power plant and shows that the mass of the fuel was exactly converted to energy according to $E = mc^2$. One would think that to prove Special Relativity Theory, the data from a precisely monitored nuclear power plant would provide an abundance of evidence. Nevertheless, such data apparently does not exist.

Violation of Energy Conservation

In fact, there is evidence to suggest that more energy comes out of a nuclear power plant than the mass of fuel that goes in. A Liquid Metal Fast Breeder Reactor once operated for 25 years and produced more fuel in its byproducts than it consumed during its operation[81]. A violation of

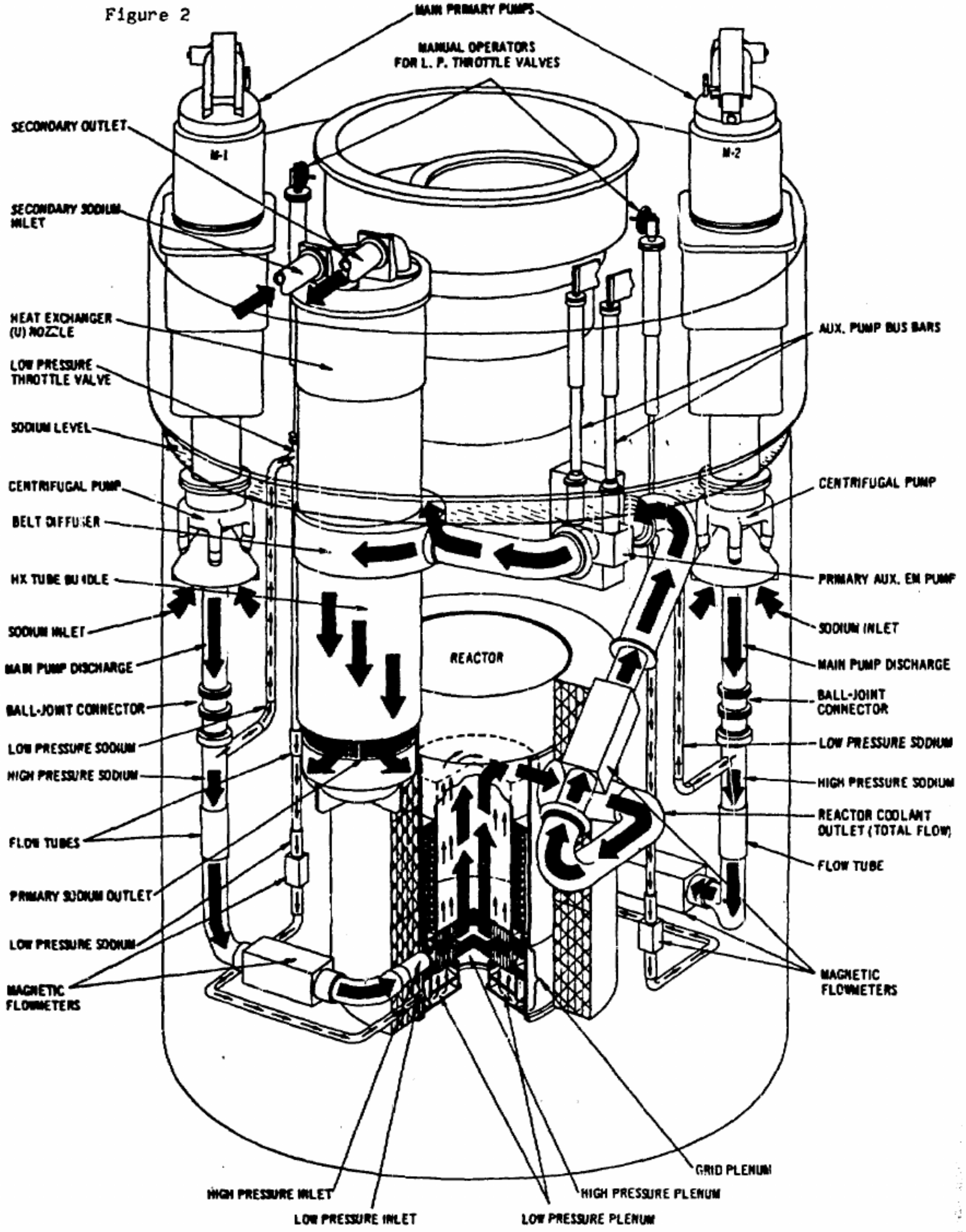
[81] "EBR-II is, by definition, a Liquid-Metal-Cooled Fast Breeder Reactor (LMFBR). It is cooled with molten sodium metal, its chain reaction is perpetuated with extremely energetic (fast) neutrons, and it was designed with the potential for breeding more fuel than it consumes." Argonne National Laboratory – West EBR-II: Sixteen Years of Operation (Idaho Falls, ID, Argonne National Laboratory, May 1980) 1

Thomson, D. and J. Bourassa (2004). Secrets of the Aether.



Principal EBR—II facilities. Shown from left to right are the sodium boiler building, the reactor and its containment building, and the power plant building

Figure 2


MAIN PRIMARY PUMPS
MANUAL OPERATORS
FOR L. P. THROTTLE VALVES
SECONDARY OUTLET
M-1
M-2
SECONDARY SODIUM
INLET
HEAT EXCHANGER
(U) NOZZLE
LOW PRESSURE
THROTTLE VALVE
SODIUM LEVEL
CENTRIFUGAL PUMP
BELT DIFFUSER
HX TUBE BUNDLE
SODIUM INLET
MAIN PUMP DISCHARGE
BALL-JOINT CONNECTOR
LOW PRESSURE SODIUM
HIGH PRESSURE SODIUM
FLOW TUBES
PRIMARY SODIUM OUTLET
LOW PRESSURE SODIUM
MAGNETIC
FLOWMETERS
AUX. PUMP BUS BARS
CENTRIFUGAL PUMP
PRIMARY AUX. EM PUMP
SODIUM INLET
MAIN PUMP DISCHARGE
BALL-JOINT
CONNECTOR
LOW PRESSURE SODIUM
HIGH PRESSURE SODIUM
REACTOR COOLANT
OUTLET (TOTAL FLOW)
FLOW TUBE
MAGNETIC
FLOWMETERS
REACTOR
GRID PLENUM
HIGH PRESSURE INLET
HIGH PRESSURE PLENUM
LOW PRESSURE INLET
LOW PRESSURE PLENUM

Ohanian, H. C. (2009). "Did Einstein Prove E= mc^2?" Studies in History and Philosophy of Science Part B: Studies in History and Philosophy of Modern Physics **40(2): 167-173.**

A B S T R A C T

Although Einstein's name is closely linked with the celebrated relation $E = mc^2$ between mass and energy, a critical examination of the more than half dozen "proofs" of this relation that Einstein produced over a span of forty years reveals that *all* these proofs suffer from mistakes. Einstein introduced unjustified assumptions, committed fatal errors in logic, or adopted low-speed, restrictive approximations. He never succeeded in producing a valid general proof applicable to a realistic system with arbitrarily large internal speeds. The first such general proof was produced by Max Laue in 1911 (for "closed" systems with a time-independent energy–momentum tensor) and it was generalized by Felix Klein in 1918 (for arbitrary time-dependent "closed" systems).

Ohanian, H. C. (2009). "Did Einstein Prove E= mc^2?"
Studies in History and Philosophy of Science Part B: Studies in History and Philosophy of Modern Physics **40(2): 167-173.**

Einstein's 1905 derivation (Einstein, 1905) of the celebrated relation between mass and energy is widely regarded as one of his seminal contributions to modern physics. But he cannot be awarded priority in proposing such a relation. Some years earlier, J. J. Thomson, Abraham, Poincaré, and Lorentz had recognized that the electrostatic energy of a charge distribution is endowed with mass, and they had proposed that most or all of the mass of the electron arises from its electric self-energy; and Hasenöhrl had shown that electromagnetic radiation enclosed in a cavity contributes to the inertia of the cavity (Jammer, 1961, pp. 175–177; Rohrlich, 1965, chap. 2; Whittaker, 1960, Vol. I, pp. 309, 310 and Vol. II, pp. 51, 52[1]).

Ohanian, H. C. (2009). "Did Einstein Prove E= mc^2?" Studies in History and Philosophy of Science Part B: Studies in History and Philosophy of Modern Physics **40(2): 167-173.**

3. Who proved $E = mc^2$?

Einstein returned to the mass–energy problem in six other papers: one in 1906, two in 1907, an unpublished paper in 1912, and, much later, two more papers in 1935 and 1946 (Einstein, 1906, 1907a, 1907b, 1912, 1935, 1946). These reprises are in themselves an indication that Einstein had some suspicions that his proofs were unsatisfactory—didn't Feynman say that one good proof is sufficient?

Ohanian, H. C. (2009). "Did Einstein Prove E= mc^2?" Studies in History and Philosophy of Science Part B: Studies in History and Philosophy of Modern Physics **40(2): 167-173.**

The general proof of $E = mc^2$ remained elusive until 1911, when Laue finally derived the mass–energy relation for an arbitrary closed "static" system, that is, a system with a time-independent energy–momentum tensor containing any electric, mechanical, elastic, chemical, thermal, etc. energies and stresses whatsoever (Laue, 1911). His proof exploited Minkowski's tensor formalism; it was concise and elegant, and avoided the tedious dynamical details that had frustrated Einstein. Laue integrated the $T^{0\mu}$ components of the energy–momentum tensor over the volume of the system to obtain the total energy and momentum; he also showed that for a closed static system the conservation law $\partial_k T^{k\mu} = 0$ implies that the volume integrals of the stresses T^{kl} are zero in the rest frame (the rest frame is defined by the condition of zero total momentum). From the Lorentz-transformation properties of the components of the energy–momentum tensor he was then able to prove that the volume integrals of the $T^{0\mu}$ components of the energy–momentum tensor transform as a four vector, that is, the total energy and the total momentum of the system transform as a four vector. This implies that the energy

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In the two last papers on $E = mc^2$ in 1935 and 1946, Einstein reverted to the mistakes of his earliest papers. In the 1935 paper—which is the published version of the Josiah Willard Gibbs lecture he delivered in Philadelphia in 1934—he again assumed, without any justification, that the energy and momentum of a system have a particle-like dependence on velocity.[14]

And in the 1946 paper he repeated exactly the same mistake as in 1905, that is, he again dealt only with a low-speed approximation, but he now performed the calculation with the momentum change produced by the emission of two light pulses, rather than with the energy change, as in 1905.

In view of all these mistakes, Einstein does not have a solid claim on the mass–energy relation, neither in terms of priority nor in terms of proof. Einstein himself thought otherwise. In 1907 he

1906

- Einstein analyzes the motion of the center of mass of a system containing several small bodies and electric fields.
- Includes electric field energy in his definition of the center of mass but treats the contribution from the moving bodies as nonrelativistic and only considers their rest masses.
- Einstein fails to examine the contribution of the detailed velocity dependence of the kinetic energy, and his result is only approximate.

1907a

- Einstein analyzes extended systems consisting of electric fields and electric charges held in static equilibrium by a rigid mechanical framework.
- He recognizes that the presence of mechanical stress increases the kinetic energy of the system.
- However, he makes a mistake by assuming that the kinetic energy of the extended system has the same simple particle-like form as that of a single particle.

1907b

- Einstein modifies his 1905 work by changing the energy of the system with the action of an external electric field.

- Similar to the 1907a paper, he again assumes that the kinetic energy of the system has a simple particle-like form.

- These assumptions are criticized as they lack a rigorous basis.

1912

- This unpublished manuscript, written in 1912, but not published until much later, attempts to explain the theory of relativity.
- The critique is that it includes the same mistake as in the 1907 papers, assuming that the kinetic energy of the system has a simple particle-like form without proper justification.

1935

- In the 1935 paper, Einstein once again assumes that the energy and momentum of a system have a particle-like dependence on velocity.
- Again, assumptions lacking a proper justification or proof

1946

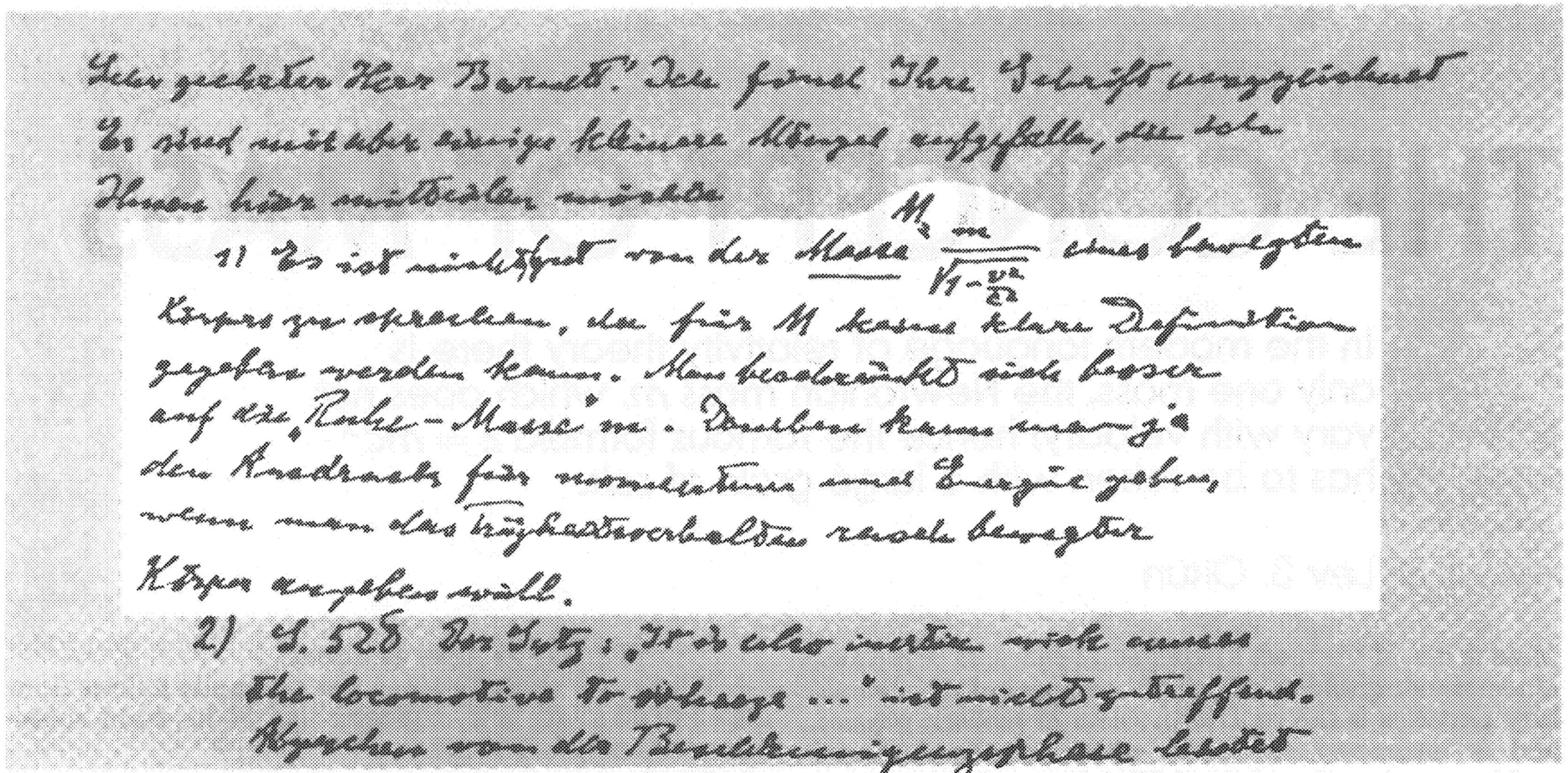
- In this paper, Einstein repeats the same mistake as in 1905 by dealing only with a low-speed approximation and performing the calculation with the momentum change produced by the emission of two light pulses.
- The critique is that this approach is limited and does not provide a complete and accurate derivation of the mass-energy equivalence.

Wrong for 40 Years

Ohanian, H. C. (2009). "Did Einstein Prove E= mc^2?" Studies in History and Philosophy of Science Part B: Studies in History and Philosophy of Modern Physics **40(2): 167-173.**

This is an astonishing mistake, all the more so because Einstein was aware of it, but refused to recognize it for what it was. In a footnote in the 1912 manuscript, he highlighted this mistake: "To be sure, this is not rigorous, because additive constants might be present that do not have the character of a vector; but this seems so artificial that we will not dwell on this possibility at all." (Einstein, 1996, p. 158). Despite this admission, he persisted in this mistake in all the revisions and republications of this argument, over a span of more than forty years (he first wrote down this argument in the 1912 manuscript, included it in several papers on general relativity and in his 1921 book *The Meaning of Relativity*, and revised this book in four subsequent editions, with the last of these in 1955—and he never corrected his mistake.)[13]

By 1948 in a letter to Lincoln Barnett, Einstein denounced the use of relativistic mass as it was being used in Special Relativity.. The hand written letter is published in part.



Sehr geehrter Herr Barnett! Ich finde Ihre Schrift ausgezeichnet. Es sind mir aber einige kleinere Mängel aufgefallen, die ich Ihnen hier mitteilen möchte.

1) Es ist nicht gut von der Masse $M = \frac{m}{\sqrt{1-\frac{v^2}{c^2}}}$ eines bewegten Körpers zu sprechen, da für M keine klare Definition gegeben werden kann. Man beschränkt sich besser auf die „Ruhe-Masse" m. Daneben kann man ja den Ausdruck für momentum und Energie geben, wenn man das Trägheitsverhalten rasch bewegter Körper angeben will.

2) S. 528 Der Satz: „It is also inertia [illegible] the locomotive [illegible] ..." ist nicht zutreffend. Abgesehen von der Beschleunigungsphase leistet

Letter from Albert Einstein to Lincoln Barnett, 19 June 1948. Einstein wrote in German; the letter was typed and sent in English. The highlighted passage in this excerpt says: "It is not good to introduce the concept of the mass $M = m/(1 - v^2/c^2)^{1/2}$ of a moving body for which no clear definition can be given. It is better to introduce no other mass concept than the 'rest mass' m. Instead of introducing M it is better to mention the expression for the momentum and energy of a body in motion." (Reprinted by permission of the Hebrew University of Jerusalem, Israel.)

Why was Big Ein Opting Out of Relativistic Mass?

Relativity requires different values for the inertial mass of a moving object: in its direction of motion, and perpendicular to that direction. This contradicts the Principle of Relativity; that the laws of physics are the same in all reference frames.

E=mc^2 produces noninvariant transformation for inertial mass and energy, which renders it untenable to satisify conservation laws on the Relativistic scale without supplemental stress tensors*.

On the surface, E=mc^2 gives the appearance that the conservation of energy is satisfied by redefining energy as a function of mass to supplement logical inconsistencies in the theory itself.

After 40 years what did Einstein bring to the table for deriving E=mc^2 as a Relativistic effect?

In his "proofs," the main contention is that while total energy, comprising both kinetic and potential energy, remains constant, potential energy can be interpreted as contributing to an augmented resting mass. This interpretation implicitly alters the definition of mass to align with the desired conclusion.

Induction and Atomism are incompatible: you have to divorce all your notions of photons, electrons as particles and with it the entire fantasy particle-zoo CERN is producing. Take a handful of spaghetti and break it in half: what you see is a bunch of terminal ends of spaghetti, so you clearly see something which you can name ans describe, but a terminal end is not a thing in itself - that’s how it works with “particles”: they are the terminal ends of lines of induction, not something with an autonomous existence. CERN is doing nothing but breaking spaghetties and giving the terminal ends names, and the more energy they pump into into their apparatus, the more spaghetti they break. But one wouldn't call that a path of discovery, would one?

Summary:

Einstein made assumptions about the kinetic energy of extended systems having the same form as that of a single particle without providing a solid justification or proof for these assumptions.

Laue and Klein, using conservation laws and the stress tensor* (T_{uv}) to satisify them, $E=mc^2$ was mathematically proven*. Einstein never proved his assertion about $E=mc^2$ without circular reasoning trying to derive the solution for what he already assumed to be true.

*First-order Intrinsic Invariant Differential

If E=m then how is Energy Conserved in Relativity Theory?

https://youtu.be/0CSL702JSdY

Examples of Tensors:
Einstein Tensor: $G_{\mu\nu}$
Ricci Tensor: $R_{\mu\nu}$
Pseudotensor: $T_{\mu\nu}$

Covariant: Used to describe a tensor that transforms in accordance with the rules of covariant transformation by maintaining their geometric properties when transferred to a new coordinate system, defining them as independent of the coordinate system. Maintaining covariance is a good way to mathematically show that your theory is in alignment known laws and the postulates in which your theory itself is built upon .e.g., that the laws of physics are the same in all reference frames.

Invariant: A quantity that remains unchanged under a given transformation. Example: *c*, the speed of light

Transformation: A mathematical operation that maps a set of objects to another set of objects while preserving certain properties of the original system.

Tensor: A mathematical object that represents a linear relationship between sets of vectors, scalars, and other tensors.

Pseudotensor: A tensor-like object that transforms like a tensor under some transformations but not under others.

First order intrinsic invariant differential: A type of invariant tensor that is coordinate dependent and changes under transformations; it is composed solely of the components of a tensor and its first derivatives. It is not derived from the field equations themselves and cannot be obtained from second-order field equations, which violates the mathematical structure of the theory based on the principle of covariance and the idea that physical laws should be independent of the choice of coordinate system.

Contraction: A mathematical operation that involves summing over the components of a tensor in a specific way to extract information about the state of the system the tensor is describing.

Conservation of energy and momentum: A physical principle that states that the total energy and momentum in a closed system are conserved over time. In relativity theory, gravitational fields and spacetime curvature tend to infinity, which violates the conservation of energy and momentum.

Second-order differential equation: A second-order differential equation is a mathematical equation that involves a function, its derivatives, and its second derivatives. Einstein's field equations are second-order differential equations that describe the relationship between spacetime curvature and the distribution of matter and energy within it. The curvature of spacetime is affected by the presence of matter and energy, and the field equations provide a framework for understanding this relationship.

Covariance and pseudotensor (cont’d)

- The issue with the Einstein pseudotensor is that it produces an invariant that is a first-order intrinsic differential invariant, which violates the mathematical structure of general relativity. This is because the equations of general relativity are second-order differential equations, and the use of a first-order invariant is inconsistent with this mathematical framework. In 1900, Ricci-Curbastro and Levi-Civita proved that invariants composed solely of the components of the metric tensor and their first derivatives do not exist. Since the Einstein pseudotensor is an invariant constructed solely from these components, its existence is shown to be invalid and violates the mathematical structure of the theory.
- Additionally, the use of the pseudotensor to define the gravitational energy-momentum tensor is not consistent with the mathematical structure of the theory. As there are no invariants that can be constructed using only the metric tensor and its first derivatives that can be used to define the gravitational energy-momentum tensor. While several attempts have been made to rectify this issue, including the Landau-Lifshitz, Bel-Robinson, and Bergmann-Thomson tensors, to date, no tensor exists that satisfies the covariance issue with the Newtonian framework or the violation of the conservation laws.
- Finally, the conservation of energy and momentum is a fundamental principle in physics, and any theory that fails to account for it adequately would be considered incomplete or inconsistent. In general relativity, the gravitational field extends infinitely, making it impossible to define and conserve energy and momentum in a fixed region of space. The ad-hoc use of the pseudotensor to address this issue further invalidates the theory and any derived explanations, including orbital explanations, black holes, gravitational waves, physical or apparent contractions, and spacetime curvature.