$E = mc^2$ — Not Einstein's Invention

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Contrary to popular opinion, $E = mc^2$ did not originate with Einstein. As van der Kamp reveals:

> And then that hackneyed combination of Einstein and the "$E = mc^2$," endlessly bandied about in popular-scientific Western folklore! True, it can be deduced from the theory, but it does not prove STR [Special Theory of Relativity], and does not depend on it, as Einstein himself has admitted. That formula has been derived in at least three non-relativistic ways, and abandonment of STR will leave that Bomb-equation unharmed. Even in a vague manner, to think that somehow Hiroshima in a most horrible way has confirmed the theory to be right is unwarranted.[1]

As for the origin of the formula, it wasn't until five years before his death (1955) that Einstein publicly attributed the basis of $E = mc^2$ to the 1862 charge-momentum field equations of James Clerk Maxwell.[2] Previous to Maxwell was the work of J. Soldner who assigned mass to light and thus could calculate its deflection in a gravitational field.[3] Michael Faraday's 1831 experiments with electricity and induction coils had already introduced the energy/mass relationship, and Maxwell put

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[1] *De Labore Solis*, p. 51. Van der Kamp cites Carl A. Zappfe's *A Reminder on $E = mc^2$* for the "three non-relativistic ways," but there are actually a half dozen or more paths to the formula. See text and footnotes.

[2] Albert Einstein, *Out of My Later Years*, Philosophical Library, New York, viii, 282, 1950. Also Edward Schilpp's, *Albert Einstein, Philosopher Scientist*, Library of Living Philosophers, 1949, p. 62, has Einstein quoted as saying: "The special theory of relativity owes its origin to Maxwell's Equations of the electromagnetic field."

[3] J. Soldner, *Berliner Astronomisches Jahrbuch*, 1804, p. 161. Also cited in *Annalen der Physik*, 65:593, 1921.

this in the reciprocal $m = E/c^2$ equation.[4] In fact, one can go back as far as Isaac Newton in 1704 for the theoretical relationship between mass and energy.[5] Samuel Tolver Preston used the formula in 1875.[6] Julius Robert Mayer put the formula in terms of ether pressure.[7]

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[4] The derivation of $E = mc^2$ originates from Maxwell's formula [$f = \delta E/c\delta t$] which equates the force exerted on an absorbing body at the rate energy is received by the body. Since force is also the rate of the change of momentum of the body, which, by the conservation of momentum, is also the rate of change in the momentum of the radiation, the momentum lost by the radiation is equal to 1/c times the energy delivered to the body, or $M = E/c$. If the momentum of the radiation of a mass is M times the velocity c of the radiation, the equation $m = E/c^2$ is derived.

[5] In Newton's Query 30 he writes: "Gross bodies and light are convertible into one another…" (*Opticks*, Dover Publications, Inc., New York, p. cxv). Newton's *Opticks* also reveal that he believed gravity would bend light. This is further evidence that many of Einstein's ideas are not original. Stephen Hawking adds that "a Cambridge don, John Michell, wrote a paper in 1783 in the *Philosophical Transactions of the Royal Society of London* in which he pointed out that a star that was sufficiently massive and compact would have such a strong gravitational field that light could not escape…A similar suggestion was made a few years later by the French scientist the Marquis de Laplace…" (*A Brief History of Time*, pp. 81-82).

[6] Preston's purpose in the paper *Physics of the Ether* was to dispel Newton's spiritualistic notion of "action-at-a-distance" and replace it with the mechanical concept of ether. The total force required in Preston's following example is said to be equivalent to $E = mc^2$.

> To give an idea, first, of the enormous intensity of the store of energy attainable by means of that extensive state of subdivision of matter which renders a high normal speed practicable, it may be computed that a quantity of matter representing a total mass of only one grain, and possessing the normal velocity of the ether particles (that of a wave of light), encloses a store of energy represented by upwards of one thousand millions of foot-tons, or the mass of one single grain contains an energy not less than that possessed by a mass of forty thousand tons, moving at the speed of a cannon ball (1200 feet per second); or other wise, a quantity of matter representing a mass of one grain endued with the velocity of the ether particles, encloses an amount of energy which, if entirely utilized, would be competent to project a weight of one hundred thousand tons to a height of nearly two miles (1.9 miles)." (S. T. Preston, *Physics of the Ether*, E. & F. N. Spon, London, 1875, #165).

[7] "If a mass M, originally at rest, while traversing the effective space *s*, under the influence and in the direction of the pressure *p*, acquires the velocity *c*, we have $ps = Mc^2$. Since, however, every production of motion implies the existence of a pressure (or of a pull) and an effective space, and also the exhaustion of one at least of these factors, the effective space, it follows that motion can never come into existence except at the cost of this product, $ps = Mc^2$. And this it is which for shortness I call 'force'" (J. R. Mayer, translated by J. C. Foster, "Remarks on

A curious twist in this saga occurs in 1881 with J. J. Thomson in his work with charged spherical conductors in motion, since he derived a slightly higher coefficient, $E = 4/3mc^2$.[8] The same $E = 4/3mc^2$ was found by F. Hasenöhrl in 1904 when he published the first explicit statement that the heat energy of a body increases its "mechanical" mass.[9] The 1905 Nobel Prize winner, Philipp Lenard, a stauch opponent of Einstein, was one of the first to reveal this fact in his 1921 book *Ether and Paraether*.[10] In the book, Lenard demonstrated how simple it was to arrive at $E = mc^2$ without any reference to Relativity theory – something Einstein would also admit a few years prior to his death. In his 1929 book *Energy and Gravitation*, Lenard honored Hasenöhrl as "the first to demonstrate that energy possesses mass (inertia)."[11]

The history of the 4/3 coefficient is intriguing. Arthur Miller shows both its origin and how Einstein sought to remove it. Although Einstein purports to have legitimately removed it, Miller shows he did not succeed. Einstein had attributed the excess 1/3 to mechanical constraints, but Poincaré had demonstrated earlier that it was due to forces that avoid the explosion of the electron.[12] Engrossed in his General Relativity

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the Mechanical Equivalent of Heat," *The Correlation and Conservation of Forces*, 1867, pp. 331, 336.)

[8] Thomson's use of the formula has not escaped the notice of at least some modern physics textbooks. In *Fundamentals of Physics* by Halliday, et al, they state: "A decade before Einstein published his theory of relativity, J. J. Thomson proposed that the electron might be made up of small parts and that its mass is due to the electrical interaction of the parts. Furthermore, he suggested that the energy equals mc^2" (John Wiley, fourth edition, p. 735).

[9] Cunningham, *The Principle of Relativity*, 1914, p. 189. N. M. Gwynne, *Einstein and Modern Physics*, p. 36; F. Hasenöhrl in *Annalen der Physik*, 4, 16, 589, 1905, and Wien. Sitzungen IIa, 113, 1039, 1904. Hasenöhrl's original equation was $8E/3c^3$, which was then changed to $4E/2c^3$. Some sources have ¾ $E=mc^2$; Kostro has $E = ¾\ mc^2$ (*Einstein and the Ether*, p. 135).

[10] Philip Lenard, *Über Äther und Uräther*, Leipzig, Verlag von S. Kirzel, 1921, cited in Kostro's *Einstein and the Ether*, p. 135.

[11] Philip Lenard, *Über Energie und Gravitation*, Berlin/Leipzig, Walter de Gruyter und Co., 1929, cited in Kostro's *Einstein and the Ether*, p. 136.

[12] Arthur I. Miller, *The Special Theory of Relativity: Emergence and Early Interpretation*, 1998, pp. 338-339. Miller writes: "But where is the 4/3-factor? It is reasonable to conjecture that by May 1907, when Einstein submitted…for

theory, Einstein did not visit the problem again. Max Von Laue demonstrated that to obtain the final formula $E = mc^2$ "one type of energy…the new physics must eliminate from its list…is kinetic energy."[13] The reason is that if mass is based on energy, as $E = mc^2$ shows, then there cannot be a kinetic energy, $K = ½mv^2$, which, in turn, depends on the mass. In other words, to obtain $E = mc^2$ one must abandon the most obvious and primary form of energy, kinetic energy.[14] Prior to this, in 1889 Oliver Heaviside used the $E = mc^2$ principle in his work with capacitors.[15] Henri Poincaré used the rudiments of the $E = mc^2$ formula long before Einstein commandeered it for his Special and General Relativity theories.[16] In 1903 the Italian scientist Olinto De

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publication, he knew full well that the electron's mass occurred in kinematical quantities deduced from its self-fields as 4/3 times its electrostatic mass – for example…the role of Poincaré's stress and very probably of Abraham's (1905) which contained a detailed discussion of the necessity for an extra energy to correct the Lorentz-electron's total energy. In fact, Einstein may well have avoided the particular example of Lorentz's electron because of his having been unable to deduce the 4/3-factor from the relativistic kinematics."

[13] Max von Laue in *Albert Einstein: Philosopher Scientist*, ed., P. A. Schlipp, 1988, p. 529. He continues: "…we must explain why Abraham's model of the electron as well as cavity radiation yield the different relationship $m = (4/3) (E_o/c^2)$. The reason is the same in both cases. The electromagnetic field is not capable of existing by itself alone, it requires certain supports of a different nature. Cavity radiation can exist only within an envelope, and the charged sphere would fly apart if it were not for certain cohesive forces. In both cases, motion will give rise to an energy current within the material supports which is directed opposite to the motion. It contributes to the total momentum a negative amount and reduces the factor 4/3 to 1" (*ibid*., pp. 528-529).

[14] This discrepancy can be seen, for example, in the kinetic energy of the electron in the hydrogen atom compared to the speed of light. The ionization energy of the electron is 13.6 eV or 2.17×10^{-18} joules. Transposing $K = ½mv^2$ to $v = (2K/m)^{½}$, and then making the binding energy of the electron equal to the ionization energy, we have $v = (2 \times 2.17 \times 10^{-18}\ J / 9.1 \times 10^{-31}\ kg)^{½} = 2.18 \times 10^6$ meter/second as the velocity of the electron, but this value is 137.6 times slower than *c*, the speed of light.

[15] *The Flash of the Cathode Rays: J. J. Thomson and His Contemporaries*, 1998, by Per F. Dahl: "...not only did Thomson anticipate Einstein's mass-energy equivalence by 24 years...the expression was also anticipated by Oliver Heaviside in 1889." See also David Bodanis' book, *$E=mc^2$: A Biography of the World's Most Famous Equation*. See a critique of Bodanis' book by Hans Melberg, *How Much Gossip is Required Before Science Becomes Interesting*, Walker Publishing, 2000.

[16] In his 1900 paper "The Theory of Lorentz and the Principle of Reaction," Poincaré derived the expression $M = S/c^2$, representing M as the momentum of

Pretto had already published $E = mc^2$ two years before Einstein did, but Einstein did not mention De Pretto in his 1905 paper on Special

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radiation, S as its flux, and c as the velocity of light. Poincaré reasoned that, since electromagnetic energy behaved like a fluid with inertia, if it is discharged from a source there must be a recoil, just as there is a recoil when a ball is shot from a cannon. Using μ for the mass of the recoiling body, and v for its velocity, the equation is $\mu v = S/c^2$. Since $S = Ec$, we have $\mu v = Ec/c^2 = E/c^2$ times c, where the E/c^2 represents the role of mass. When $v = c$, the equation reduces to $E = mc^2$. Poincaré also developed the concepts of relativity and the limit of light's velocity. Einstein makes no reference to Poincaré in his famous 1905 paper, or anyone else. This is all the more significant since Poincaré wrote 30 books and 500 papers, none of which Einstein claimed to have read. Perhaps Poincaré returned the favor to Einstein since, until his death in 1912, he only mentioned Einstein's name in print once, and that was to register an objection (Holton, *Thematic Orgins of Scientific Thought*, p. 249). Regarding the 1905 paper, Clark, an admirer of Einstein, states: "…it was in many ways one of the most remarkable scientific papers that had ever been written. Even in form and style it was unusual, lacking the notes and references which give weight to most serious expositions and merely noting, in its closing paragraph, that the author was indebted for a number of valuable suggestions to his friend and colleague, M. Besso" (*Einstein: The Life and Times*, p. 101). Later, however, Einstein eliminated Besso's name from a paper he submitted to the Berlin Academy in 1915 regarding the perihelion of Mercury, even though the equations were "simply to redo the calculation he had done with Besso in June 1913" (Michel Janssen, "The Einstein-Besso Manuscript," p. 15). As for the 1905 paper, how it is that a 9,000 word paper on one of the most controversial ideas ever presented to mankind made it past the editor of *Annalen der Physik*, the world's leading physics periodical, is anyone's guess. The most likely reason is that Max Planck, the chief editor of *Annalen* in 1905, published it due to his total acceptance of Special Relativity, which he demonstrated by defending it against Kaufmann in 1906. In any case, an editor of a prestigious physics journal should want to know whether anyone prior to Einstein had written about the ideas being presented, especially since the editors themselves were very familiar with the work of Lorentz and Poincaré. When asked about whether his 1905 paper was guilty of plagiarism, Einstein retorted in his 1907 paper: "It appears to me that it is the nature of the business that what follows has already been partly solved by others. Despite that fact, since the issues of concern are here addressed from a new point of view, I am entitled to leave out a thoroughly pedantic survey of the literature…" (Über die vom Relativitätspringzip geforderte Trägheit der Energie," *Annalen der Physik* 23 (4), p. 373). Yet in a 1935 paper Einstein admitted: "…because the *Lorentz transformation, the real basis of special relativity theory*…" ("Elementary Derivation of the Equivalence of Mass and Energy," *Bulletin of the American Mathematical Society* 61:223-230; first delivered as The Eleventh Josiah Willard Gibbs Lecture at a joint meeting of the American Physical Society and Section A of the AAAS, Pittsburgh, December 28, 1934, emphasis Einstein's). There was hardly any way to avoid this realization, since Lorentz's Transformation equation is identical to the equation for Einstein's Special Relativity. My thanks to Richard Moody in *Nexus Magazine*, vol. 11, no. 1, Dec.-Jan. 2004 for many of the above quotes. Against all this is Gerald Holton's view that Einstein never read Lorentz and Poincaré before 1905; that Einstein showed "painful honesty," and that "the so-called revolution which Einstein is commonly said to have introduced into the physics in 1905 turns out to be at bottom an effort to return to a classical purity" (*Thematic Origins of Scientific Thought*, pp. 199, 200, 195 in order of ellipses).

Relativity, which is odd considering that he spoke fluent Italian and, by his own admission, read all the Italian physics journals.[17] In 1907, Max Planck, expanding the work of Hasenöhrl and using Poincaré's momentum of radiation formula, gave the final derivation of the $E = mc^2$ formula.[18] All in all, $E = mc^2$ is readily derivable apart from the theory of Relativity, as both Joseph Larmor in 1912; Wolfgang Pauli in 1920, Philipp Lenard in 1921, and M. Simhony in 1994, demonstrated independently.[19]

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[17] Umberto Bartocci, Professor of Mathematics at the University of Perugia, Italy, in his book, *Albert Einstein E Olinto De Pretto: la vera storia della formula piu' famosa del mondo* (translated: "Albert Einstein and Olinto De Pretto, the true history of the most famous formula in the world," Societa Editrice Andromeda, via S. Allende1, 40139) provides documentation that De Pretto published an article in which he gave, in its final form, the equation $E = mc^2$. This article was published on June 16, 1903, and published again in February 27, 1904, the second time in the Atti of the Reale Instituto Veneto di Scienze. De Pretto thereby preceded Einstein's famous 1905 $E = mc^2$ paper by at least a year and half. Could Einstein have copied from De Pretto? No one can prove definitively that Einstein saw De Pretto's article, but Professor Bartocci offers some intriguing speculation. Professor Bartocci traced a link between De Pretto and Einstein, through Einstein's best friend, Michele Besso. As we noted, Besso is the only person credited in the famous $E = mc^2$ paper of 1905. See also R. Carroll's, "Einstein's $E = mc^2$ 'was Italian's idea,'" (*The Guardian*, Nov. 11, 1999, cited in Moody).

[18] Planck writes: "…through every absorption or emission of heat the inertial mass of a body alters, and the increment of mass is always equal to the quantity of heat…divided by the square of the velocity of light *in vacuo*" (M. Planck, Sitz. der preuss. Akademie der Wissenschaften (Berlin), Physik. Math. Klasse. 13 (June, 1907), p. 566. Regarding Einstein's 1905 paper (*Annalen der Physik* 18, 639), Planck shows that, although Einstein came to "essentially the same conclusion by application of the relativity principle to a special radiation process," he did so *by assuming* the existence of one of the mathematical components. Thus Planck continues, "however under the assumption permissible only as a first approximation, that the total energy of a body is composed additively of its kinetic energy and its energy referred to a system with which it is at rest" (cited in *The Einstein Myth and the Ives Papers*, Part II, p. 185).

[19] Larmor in "On the dynamics of radiation," *Proc. Intern. Congr. Math.*, Cambridge, 1912, p. 213; W. Pauli, Jr., "Relativitätstheorie," Encyclopedia Math. Wiss. V-2, hft 4, 19, 679, 1920, as reported by Herbert Ives in *Journal of the Optical Society of America* 42: 540-543, 1952, and cited in *The Einstein Myth*, pp. 84, 109, 184.