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Origin and Escalation of the Mass-Energy Equation Δ E=Δ mc^2

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Einstein's 27 Sep 1905 paper available at http://www.fourmilab.ch/etexts/einstein/E_mc2/www/

Abstract
E=Δ mc^2 existed before Einstein's derivation in Sep. 1905. Isaac Newton, S**.** Tolver Preston, Poincaré , De Pretto and F. Hasenöhrl are the philosophers and physicists who have given idea of E =Δ mc^2. Einstein derived existing E =Δ mc^2 starting with the result of relativistic variation of light energy, but finally obtained L =Δ mc^2 under applying classical conditions (v<<c). After Einstein, Max Plank also derived the same independently. Max Born has expressed surprise over non-inclusion of previous references by Einstein in the derivation of E=Δ mc^2.

Contributors to Equation E =Δ mc^2
Before Einstein, among other physicists, Isaac Newton **[1],** English S. T. Preston **[2]** in 1875, French Poincaré **[3,4]** in 1900, Italian De Pretto **[5]** in 1903, German F. Hasenöhrl **[6,7]** made significant contributions in speculations and derivations of E =Δ mc^2 . After Einstein Planck **[8]** has also derived E =mc2 independently. J J Thomson in 1888 is also believed to have anticipated E= Δ mc^2 from Maxwell's equations.

Issac Newton (1642-1727)
The Great Sir Isaac Newton **[1]** has quoted "Gross bodies and light are convertible into one another...", 1704). In 1704 Newton wrote the book "Optiks". Newton also put forth Corpuscular Theory of Light

S. Tolver Preston
S. Tolver Preston **[2],** who made predictions which are based essentially upon E =Δ mc^2. Preston in his book *Physics of the Ether* proposed in 1875 that vast amount of energy can be produced from matter. Preston determined that one grain could lift a 100,000-ton object up to a height of 1.9 miles. This deduction yields the essence of equation E = Δ mc^2.

Jules Henri Poincaré (1854-1912)
Poincaré in 1900 **[3,4]** put forth an expression for what he called the "momentum of radiation" M_R. It is M_R = S/c^2, where S represents the flux of radiation and c is the usual velocity of light. Poincaré applied the calculation in a recoil process and reached at the conclusion in the form mv = (E/c^2)c. From the viewpoint of unit analysis, E/c^2 takes on the role of a "mass" number associated with radiation. It yields E =mc^2.

Olinto De Pretto
An Italian Industrialist Olinto De Pretto **[5]** suggested E =Δ mc^2, in concrete way. Firstly this article was published on June 16, 1903. Second time on February 27, 1904 the same was published in the Atti of the Reale Instituto Veneto di Scienze. Thus De Pretto published E =Δ mc^2 about one and half year before. In 1921 De Pretto was shot dead by a woman over a business dispute. When De Pretto was killed he was trying to publish the complete book of his scientific ideas. This paper is in Italian; hence it remained away from accessibility of wider scientific community. However Einstein was affluent in Italian language also.

F. Hasenöhrl
In 1904 F. Hasenöhrl **[6,7],** gave first derived expression for mass-energy conversion. He investigated a system composed of a hollow enclosure filled with "heat" radiations and wanted to determine the effect of pressure due to radiations. His calculations lead him to conclude that
"to the mechanical mass of our system must be added an apparent mass which is given by

$m = (8/3)E/c^2$"

where E is the energy of the radiation. Further in later paper he maintained that improve result for mass exchanged is

$m = (4/3)E/ c^2$,"

Ebenezer Cunningham **[9]** in 1914 in his book *The Principles of Relativity* showed that F. Hasenöhrl, has made a slight error in his calculations. F. Hasenöhrl, did not take characteristics of the shell properly. If errors are removed then

m (mass exchanged) = E/c^2
or E = (mass exchanged) c^2

This is the same result as quoted by Einstein. It implies that $E=mc^2$ is contained in F. Hasenöhrl's, analysis. Moreover Hasenöhrl's work was published in the same journal in which Einstein's method to derive $E =\Delta mc^2$was published one year later.

Albert Einstein
In 1905, Einstein **[10]** derived $L = \Delta mc^2$, and then speculated from here $E =\Delta mc^2$, analogously without actual proof. Einstein derived already existing $E =\Delta mc^2$, strangely did not acknowledge his predecessors like de Pretto and Hasnholtz. Both have suggested $E =\Delta mc^2$ just one and half year before Einstein's derivation. However two years after i.e. 1907 when Max Plank **[8]** derived $E =\Delta mc^2$ independently, Planck acknowledged derivation of Einstein. Planck even pointed out the conceptual and mathematical limitations of Einstein's method of derivation. In derivation Einstein used result of relativistic variation of light energy

$$l^* = l\left[1 - \frac{v}{c}\cos\phi\right] / \sqrt{1-\frac{v^2}{c^2}} \quad (2)$$

where l is light energy of plane wave of light in co-ordinate system (x,y,z)., which is at rest. The ray direction i.e. wave normal makes angle ϕ with the x-axis of the system (x,y,z). This light energy as measured in system (X,Y,Z), which is in uniform translation w.r.t. (x,y,z) along x-axis with velocity v is l^*. But while deriving final result i.e. $L =\Delta mc^2$ Einstein interpreted the equation under classical conditions (v<<c) as below.

a. Although Einstein started to derive $L =\Delta mc^2$ using relativistic variation of light energy as in Eq.(2), yet he derived final results under classical condition. Einstein interpreted the results using *Binomial Theorem* which is applicable if v<<c.

b. Einstein never considered any relativistic increase in mass of body as given by

   $m_{motion} = m_{rest}/(1-v^2/c^2)^{1/2}$

This equation was first justified by Kaufman **[11]** in 1900. Further, Einstein speculated $E =\Delta mc^2$ for all energies from $L=\Delta mc^2$ without justifying that eq.(2) in essence holds good for sound, heat, chemical , electrical energy etc. If eq.(2) holds good for sound and heat energies, then $L =\Delta mc^2$ will be analogously transformed as

Sound energy = Δmc^2 (3)
or Every type of energy = Δmc^2 (4)

The results from eq.(3) are exciting as sound energy can be converted in mass. Einstein did not justify that how eq. (2) holds good quantitatively for heat energy, sound energy etc, but regarded it as is true for all. In nuclear Physics $E =\Delta mc^2$ is used as standard and all data is consistent with this. Also Einstein derived rest mass energy ($E_o= m_{rest}c^2$) from relativistic form of kinetic energy [1]

Total Kinetic Energy = m_{motion} c^2 = KE +$m_o c^2$ as E_o= $m_{rest}c^2$

Max Planck
In 1907, Planck **[8]** made an in-depth investigation of the energy "confined" within a body, but he did not use Einstein approach at all. Plank presented his findings in
Planck derived an expression

m-M= E/c^2

and interpreted that

"The inertia mass of body is altered by absorption or emission of heat energy. The increments of mass of body are equal to heat energy divided by square of speed of light"

Then in a footnote at page 566 Planck writes, "Einstein has already drawn essentially the same conclusions". Planck maintained Einstein derivation as approximation.

Recent Developments.
In 1907 Planck **[8]** even pointed out the conceptual and mathematical limitations of Einstein's derivation. In 1952, H E Ives **[12]** stressed that Einstein's derivation of the formula $E = \Delta mc^2$ is fatally flawed because Einstein set out to prove what he assumed.

Sharma **[13]** in 2003 extended $E = \Delta mc^2$ to $E = Ac^2\Delta m$, where A is conversion co-efficient and can be equal, less or more than one, depending upon inherent characteristics of conversions process in nature. The value of A is consistent with concept of proportionality factor existing since centuries. Energy emitted in celestial events Gamma Ray Bursts (most energetic events after Big Bang) is 10^{45} Joule/s. It can be explained with value of A equal to 2.57×10^{18}. Similar is the case of Quasars. Like wise kinetic energy of the fission Fragments of U^{235} or Pu^{239} is found 20-60 MeV less than Q-value (200MeV), Bakhoum **[14]** The similar deviations in experimental results are also quoted by Hambsch **[15],** Thiereus **[16]** etc. It can be explained with value of A less than one.To date, $E =\Delta mc^2$ is not confirmed in chemical reaction due to technical reasons, but is regarded as true.

Also a particle Ds (2317) discovered at SLAC **[17]** has been found to have mass lower than current estimates based upon E **=Δ** mc^2. Incidentally, there are proposals for both theoretical and experimental variations (increase or decrease) in value of c **[18-19];** as the fine structure constant ($\alpha = e^2/\hbar c$) is reported to be increasing over cosmological timescales, implying slowing down of speed of light, c. The proposals for variations of speed of light definitely affect the status of E **=Δ** mc^2, indirectly.

Einstein and Priority of E =Δ mc^2 Einstein did not mention Hasenöhrl's work (who gave first derived expression for mass-energy equation) in any of his paper on this subject from 1900 - 1909. However Hasenöhrl had published his paper in 1904, in the same very journal in which Einstein later published his derivation of $E =mc^2$ in 1905.
Einstein **[20]** applied his $E =\Delta mc^2$ derivation in 1906. In this paper he gave reference of Poincaré' s work **[3, 4]**. Einstein gave credit to Poincaré for mass energy equivalence at least for electromagnetic radiations.

But, even with Planck's complete derivation and this Poincaré acknowledgement, Einstein later refused to accept any other priority for this notion. Stark **[21]** stated that Planck gave the first derivation of $E =\Delta mc^2$, in fact Planck and Stark were convinced that Einstein's derivation of $E =\Delta mc^2$ is inconsistent. Then Einstein **[22]** wrote Stark on 17 Feb 1908, "I was rather disturbed that you do not acknowledge my priority with regard to the connection between inertial mass and energy." Max Born **[23],** co-originator of Quantum Mechanics stated, "The striking point is that it contains not a single reference to previous literature".

Einstein **[24]** in 1907 spelled out his views on plagiarism: "It appears to me that it is the nature of the business that what follows has already been partly solved by other authors. 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..."

The definition of "to plagiarise" from an unimpeachable source, *Webster's New International Dictionary of the English Language***[25]** "To steal or purloin and pass off as one's own (the ideas, words, artistic productions, etc. of one another); *to use without due credit the ideas, expressions or productions of another".* Undoubtedly Einstein's predecessors who contributed in concrete way in understanding or origin of $E = \Delta mc^2$ deserve credit of discovery as should be mentioned in literature.

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References
1. Newton, Sir Isaac (1704), *Opticks*, Dover Publications, Inc., New York, p. CVX
2. Preston, S. T. *Physics of the Ether*, E. & F. N. Spon, London, (1875).
3. Poincaré, J H, *Arch. neerland. sci.,* 2, 5,232 (1900)),
4. Poincaré's J H , *In Boscha* 1900:252
5. De Pretto, O. (1904), "Ipotesi dell'etere nella vita dell'universo", Reale Istituto Veneto di Scienze, Lettere ed Arti, Feb. 1904, tomo LXIII, parte II, pp. 439-500.
6. Hasenöhrl, F. Wien, *Sitzungen* IIA, 113, 1039 (1904)
7. Hasenöhrl,F. *Ann. der Physik,* 16, 589 (1905)
8. Planck, F. *Sitz. der preuss.* Akad.Wiss., Physik. Math. Klasse. 13 (June, 1907)
9. Cummingham, E. *The Principle of Relativity*, Cambridge University Press, 1914, p. 189
10. Einstein, W, A Ann. Physik 18, 639 (1905)
11. Kaufmann, W. *Nachr. K. Ges. Wiss.* Goettingen 2, 143 (1901)
12. Ives, H.E. *J. Opt. Soc. Amer.* 42:540-543 (1952).
13. Sharma, A*. Proceedings of International Conference on Computational Methods in Sciences and Engineering* 2003 World Scientific Co. Singapore, 585-586 (2003)
14. Bakhoum, E. G. *Physics Essays*, Vol.15, No 1 2002 (Preprint archive : physics/0206061)
15. Hambsch, F.J. *Nucl. Phys.A*, 491,p.56 (1989)
16. Thiereus, H. *Phys. Rev. C*, 23 P 2104 (1981)
17. Palano, A. *et al.,* Phys.Rev.Lett. 90 (2003) 242001
18. DAVIS T.M. *et al.,* Nature 418, (2002) 602. 19. WANG .L. J. et *al.,* Nature 406, (2000) 277
20. Einstein, A. *Ann.der Physik* 20(1906):627
21. Stark, J *Physikalische Zeitschrift* 8(1907):881
22. Einstein, A Vol. 2, J. *Stached Ed.,* Princeton University Press, 1989.
23. Born, M. (1956), *Physics in My Generation*, Pergamon Press, London, p. 193 (1956).
24. Einstein, A. (1907 ", *Annalen der Physik* 23(4):371-384, 1907 (quote on p. 373).
25. *Webster's New International Dictionary of the English Language*, Second Edition, Unabridged, 1947, p. 1,878