Some ($E = mc^2$) History before Einstein and related matters

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This article reviews some unappreciated history about "$E = 1mc^2$," even before Einstein. In particular, we note Laplace's belief that likely when our Sun radiates off a particle of mass, 'm', at the speed of light, that the Sun's mass decreases by that mass, 'm'. And in an 1899 publication, Hertz refers to a long-standing belief that the total energy of a conservative system is TWICE its kinetic energy, presumably "$(1)mc^2$," instead of "$(1/2)mc^2$." After further analysis, we conclude that Einstein's ($E = 1mc^2$) conclusion for radiation was very praise-worthy because it concisely stated and advocated two less-popular proposals of the time. But actually not new proposals! And we offer other thoughts, hopefully helpful.

1. Introduction

The aim of my article is to decipher more clearly some major issues in the evolution of physics from the 19th to the 20th Century.

The first issue was whether the so-called "Emission Theory of Light" was correct, vs. a pure "Ethereal Undulating Theory of Light". Basically, the Emission Theory involves the loss of mass by the emitter, the flight through space at velocity 'C' of that emitted mass (that flying corpuscle of light), the absorption of that mass (corpuscle) by the receiver some distance away. And, thus, the gain by that receiver of that mass earlier given off by the emitter.

But the competing pure Ethereal Undulation Theory does not require such loss of mass by the emitter and gain of mass by the receiver when the energy of the light leaves the emitter and arrives at the receiver. Rather – just that some vibration or movement by the emitter vibrates or stresses the aether and that that stress or strain is transmitted along the aether from the emitted area to a receiver area. And that that cause any receiver body, that may be present a distance away – to absorb some energy that such ethereal stress transmitted.

The second issue was, especially in the case of the Emission Theory, – how much energy was transmitted when a specific amount of mass was lost by the emitter and gained by the receiver?

Or, perhaps in the case of the Ethereal Undulation theory, – how much mass was there in a stressed 'slug' of ethereal mass as that activated slug of ethereal stressed mass progressed? I.e., How much mass in the activated ethereal slug as the aether behind it resumed non-activation again, and as the aether just immediately to the front of the slug began to activate? But the latter question was largely 'just academic', rather than crucial, in the case of the purely Ethereal Undulation Theory of light transmission.

We will examine the viewpoints, models, and the theorists involved during the 18th, 19th, and 20th Centuries, and general transitions in thinking. In my view, one important lesson to be learned is the importance of scientists, in any period, to write and present their theories as clearly as possible, using analogies, occasional summaries, sketches, and illustrations. And current writers should remember that a future 'crop' of scientists, who will eventually read the work they are now writing, may tend to view it differently. I.e., differently, regarding the words they use, the meanings, the language, and even their priorities - all that may have change somewhat.

2. What Einstein, Laplace, Hertz, and Newton Thought

Einstein, in his September 1905 paper, does make his main conclusions clear, and that is much to his credit [1]. His conclusion is that when a body, like the Sun, radiates away a given amount of total energy,*'E'*; the mass of that radiating body decreases by an amount,*'m'*, given by ($m = E/c^2$).

Almost all scientists consider that correct. For example, when the masses of an electron and positron annihilate, there will be no longer any gross mass left where they annihilated. But the energy of the resulting gamma rays, which fly away from the scene at the speed of light, 'c', can be measured directly or indirectly.

((Now, actually, we can 'knit-pick' Einstein's conclusion a pinch, in some ways. For example, suppose a supermassive body launches an amount of radiation, 'E', (or its equivalent mass), toward outer space? By the time that launched 'E' gets far away from the body's huge gravity – that initial 'E' will have become greatly reduced from its original, due to gravity. And the (inertial related) mass lost by the emitting body will thus be greater than all of its weakened radiation, as measured at a great distance from the body, divided by c^2.))

The above 'knit-picking' or 'minor paradox' does seem to be a very minor point, indeed. Yet, I do **not** think that the cause of the 'special relativity' paradox is that 'not quite straight line' motion is involved, if, in fact, that is involved. So I think that that paradox may have been (or should have been) one of several factors that prompted Einstein to try to draft a more general theory than his 'Special Relativity of Relativity' to address. I.e., likely his 'General Theory of Relativity' to address it. ((But, as I have said in previous papers; I think the best way to treat the paradox is as follows: To accept that the 'lost' kinetic energies occurring (when high-velocity particles overcome gravity and sale into outer space) – is energy that has been added to a vast 'aether'. That aether is a part of a sort of '**hidden** universal manifold' that Hertz referred to and comfortably embraced, but which I doubt if Einstein ever truly did.))

All that is hopefully interesting, but yet sort of a diversion, here. So we will generally avoid such further diversions here, because Einstein's main conclusions are quite accurate enough, and commendable. And, so here, we'll just accept Einstein's conclusions, and we'll use the terms, 'mass of the photon,' rather than 'equivalent mass of the photon'. And we will generally say 'the mass increase of the target due to absorption of the mass of the photon', rather than the mass increase "due to absorption of the 'mass equivalence' of the energy of the photon".

I believe that there are two major misunderstandings about Einstein's September 1905 ($m = E/c^2$) paper. I do not think that he made it very clear that all the mass of all bodies had an (mc^2) equivalent amount of energy associated with them, even if most of the body was very cold! Or so 'hidden or bound' that the energy could not be withdrawn.

But Einstein, in my view, made it clear that his conclusion (mc^2) did also apply to a body's energy that could potentially be radiated or even withdrawn from the body by other means.

((Of course, the amount of 'energy-related mass' that most bodies can radiate away - - is just a small fraction of those bodies' total mass, for example in the case of almost all stars. However, I think some readers, who read Einstein's Sept., 1905 paper, may infers that that '(mc^2)' applies **equally to all** of a body's mass, very cold or not, or whether the masses' energy is transferable or not. But it is not clear to me, myself, that Einstein view extends that far.))

I believe that it was the gradual evolution of physics that resulted in the general acceptance that there was an (mc^2) worth of energy associated with even a very cold body of mass, m, at rest (not traveling), and even if hardly any of its energy was 'radiatable' or transferable.

In my opinion, the other conundrum that is not discussed in Einstein's paper, and often ignored or obfuscated by slick word tricks – is this: There remains two fundamentally different options (strange delivery speeds vs. strange pushing energies required) for a mass, say equal to an electron, to be delivered from a massive emitter to a massive target:

I find that just saying "the photon can, in effect, deliver the mass to the target at speed, 'c', because the photon is not a mass" – is merely like a 'tautology'. A tautology that adds nothing to my understanding of what is really going on in one case vs. the other. That is – the comparatively high energy accelerations and de-accelerations required, to deliver a given mass to the target, at speed 'almost 'c' vs. exactly 'c'. I.e., the former when a so-called velocity-related mass increase occurs, vs. the latter when a so-called photon can be utilized as the 'carrier'.

A very good, so-called 'derivation' of those two different delivery methods, in my opinion, necessitates explaining for each case the main contrasting details that are really going on, including the different actions of the aether in each case. And not just some 'mathematical or relativistic schemes' that obfuscates that.

As to what Poincare thought, that is beyond the scope of my article, but perhaps not beyond others' articles [2].

But, consistent with Poincare's theory, Poincare might have imagined this: Suppose that two particles, an electron and positron, have a specific amount of empirically measurable mass, regardless of how much is due to their fields or is due to their simple gross mass. And suppose those particles 'annihilate' each other, and that light is the sole result, and that that light is an 'electromagnetic' field (that underlined considered highly likely in Poincare's time).

Then we would conclude from Poincare's theory that in order to maintain certain conservation principles – the energy that that complicated 'light field' had – must be equal the former empirical mass of the electron plus the positron multiplied by the square of the speed of light, i.e., the $1mc^2$, for each of two resulting 'gamma rays' being a correct conclusion!

But, as for other cases involving the emission of light, but where the mass of the emitters is not reduced to zero by the emission of the light – there I think Poincare's interpretation becomes too confusing to be useful. So, frankly, physics was in need of Einstein's simple, clearly stated, and generally applicable conclusion.

So we now return to the main theme of this paper by asking, "how much of Einstein's conclusion was really new?" That is a question that many scholars have tackled in many different ways. And below is 'my way':

The very prominent scientist, Laplace, wrote a major work that was translated in 1829 into English [3]. In it, Laplace said many important things, but I now present the most relevant part **in bold** characters, below:

(Vol. IV, Book 10, Chapter 7) "Section 21. These secular equations depend upon the impulse of the sun's light; but **if this light be an emanation from the sun, its mass will incessantly decrease**; and there will be found in the earth's mean motion, a secular equation, ... etc., etc."

(The translator, N. Bowditch, has assisted the reader, by printing in the left margin - a summary of that passage, as follows: **"Effect of the decrease of the sun's mass by the emission of light"**.)

Thus, in the early 1800s, one of the world's top scientists had made it very clear that light could well be an emission of mass by stars. And that when that mass flies away from the star at a speed, c; the mass of the emitting star decreases by that amount of radiated mass. I.e., very simple. Thus, importantly, Einstein's first proposition, *that when a body emits radiation, the mass of the body decreases due to that* *radiation* (often termed a photon) - **is nothing new!**

Thus, we next address the question of how much energy is lost by a star, or any body, when it radiates a specific 'm' worth of mass? Or, worded slightly differently; "how much energy does the emitted photon or lost mass, 'm', have when it 'flies' through space at speed, c? Is it only the expected 'kinetic energy', $(1/2)mc^2$? I.e., that is what one might expect from just a high school physics class. Or is the total energy lost given by $(1)mc^2$, or some other value higher than the simple $(1/2)mc^2$ – the latter term based on just the apparent kinetic energy?

To help answer this question, we will quote from a translation of Hertz's last work. (Hertz, himself, could not finish tidying up that work for publication, due to his ill health and early death [4]. But Lenard did tidy it up when he became its editor.)

And specifically, we will quote from its 'definition of terms', namely "kinetic energy": (I.e., Lenard added an 'index' to Hertz's work to helpfully refers readers to that term's definition, and to other terms, topics, and the page numbers where discussed.) In particular:

'Book 2', page 226, discussion number "605. Definition 3 That part of the energy of a conservative system which arises from the motion of its visible masses is called the kinetic energy of **the whole system**. In opposition thereto the energy of the *concealed masses* of the system is called the *potential energy* of **the whole system**."

"Kinetic energy is also called vis viva (lebendige Kraft). **According to another and older mode of expression, this term denotes TWICE the** kinetic energy."

I have shown most of the last sentence boldly, because it strongly implies the following: If light flies through space at speed 'c', and is part of a conservative system; then its total energy is $(1)mc^2$, not just the $(1/2)mc^2$ apparent 'kinetic energy'.

((The referred to older term, 'vis viva', was used by Leibniz when Leibniz explored some entity he felt was conserved besides momentum. The bold quote, a few paragraphs above, seems quite in the spirit of Maxwell who emphasized that **'all energy, hidden or not, is ultimately kinetic energy**, and vested in matter', (as we will give a reference for, a few paragraphs below).))

Also, even somewhat before Hertz's final work, light was known to have polarization features, and represented by a wavy line with, for example, up and down motion. I.e., not just only having the simple forward 'c' speed, the latter speed being obviously visible. So undoubtedly, some scientists still considered it a possibility that light travelled **as a system** through space!

During Hertz's time, scientists were aware of Maxwell's two viable conceptual methods ('candidates') for the transport of energy through space: "As the flight of material substance through space, or the propagation of a condition of motion or stress in a medium in space"[5].

Maxwell, and most of his contemporaries, considered it much more likely that light was an energy transported though space by a 'condition of stress in a medium in space'. And thus, presumably, a mass decrease by the emitter would not be deemed as required nor expected.

But, there is no doubt that there were still some scientists in Maxwell's time that still considered, as a possibility, the concept of light discussed by Laplace (I.e., as a mass emanation from the emitter). And for its flight through space 'to be part of a system'! And so that was also considered a possibility, especially in view of the Hertz definitions previously quoted, i.e., a total energy of $(1)mc^2$, not just $(1/2)mc^2$.

Thus, I strongly believe that (regardless of whether it had yet been submitted formally to a journal, or yet accepted by a journal, before Einstein) - that $(1mc^2)$ was strongly 'out there' as a possibility. And also in the minds of quite a few scientists. So I think that notion was already known to be a 'viable candidate', (although not the most popular), **and thus NOT a new thought by Einstein.**

BUT, I still think that takes very little away from the great merit of what Einstein did. I.e., formally submitting, for the mass lost by the emitter and its radiated energy, $(1mc^2)$ — submitting that to a major journal as the extremely likely conclusions! And regardless of any merit in his derivation of it (i.e., his 'derivation' was also published). And those Einstein conclusions were simply stated in one clear sentence, the first known clear, simple enunciation of that appearing in a publication.

That is my opinion, and many other experts' opinion, also. (And yes, those experts were also aware of Edmond Whittaker's and Poincare's passages which are seemingly related to the subject.)

Near the end of Newton's Opticks, one finds (Query) Qu. 28, where Newton argues, in effect,the following: That Huygens and others, who consider light **just** a wave, (i.e., pressure of one area against neighbors and those neighbors successively against neighbors) - are wrong, and their claim thus untenable [6]. That is, for the case of light and light rays.

Shortly after that, in (Question 30), Quest 30, Newton argues that regular gross bodies can give off light and thus be converted (transmuted) into light themselves. And that the reverse also occurs: Light absorbed by a small body of mass may thus incur an increase in mass as a result of absorbing light. And that that parallels a lot of behaviors in Nature or Natural Law.

That, along with other things found in Newton's Opticks, leads me to believe about Newton – what other experts even more strongly believe: That Newton believed that light is an ultra small material corpuscle emitted by a material body, and flying through space at speed 'c', and remaining intact unless disturbed. And as such, not spreading out like a wave – as might be otherwise expected if light was '**just** neighbors of ethereal regions pressing against other neighborly ethereal regions, successively'.

Even shortly before 1905, J. J. Thomson rather boldly advocated a return to an emission theory of light. Even when, by far, most scientists had shifted away from Newton's light projectile concept, and toward Maxwell's 'undulating aether' concept of light [7].

I think that what is missing from Einstein's treatment, and most people's view on the subject, is an appreciation of the concept of 'light transmitted' as a 'conservative **system**'! (Or even as any 'system'.) And that 'potential energy' is a hidden energy. And that sometimes there even exists a secondary, but somewhat hidden, kinetic energy.

And also too often ignored is this: That, for any material action in space involving momentary sideways movement, circular movement or 'centrifugal related forces'; the following holds true: A system involving aether's external pressure is the only way such material can remain 'together', without totally coming apart. (Unless you believe that mass has an 'innate' attraction ability, not just the ability to repel, i.e., to resist, when squeezed).

So we will next give some important examples of 'conservative systems', where the 'the total energy' equals **twice** the simple kinetic energy:

3. Some Key Systems where Total Energy is TWICE the Kinetic Energy

3.1. First Example - See Dwg., NEXT PAGE, for all Examples

The first system, (**Sys. A** in Fig. 1), is the very simple circular motion and incorporates an idealized nearly massless spring.

It is stretched from its null 'zero force' position to is full force, say F =1Newton, at a position, R=1 meter away. We'll assume the spring force increases proportionally to the radius pulled; so its average force when extending it was 0.5x1N.

So the spring's potential energy, PE, is equal to that average Force x 1meter = 0.5x1x1 = 0.5 Joule.

At that distance, R=1meter, we imagine a 1kg mass attached to the spring, and flying around in a simple circular orbit at speed=1meter/sec. The centripetal force thus produced is $F = mv^2/R$ or 1x1x1/1 = 1N, thus balancing exactly against the 1N force of the extended spring.

We know from basic physics, that the Kinetic Energy, K.E., of the orbiting mass is $0.5mv^2$, and thus 0.5x1x1x1= 0.5J.

And we notice that the 0.5J of K.E. for the flying mass is equal to the 0.5J of P.E. of the spring.

Thus, for that first system, the Total System Energy is **TWICE** its Kinetic Energy.

(In a sense, the spring's potential energy is 'hidden energy', and the orbiting mass is the easily 'visible energy', i.e., the 'kinetic energy'. And, of course, all my examples can alternately be presented or 'derived' in a more generalized, abstract form, i.e., without substituting specific values for radius, mass, etc.)

((Optionally, we can also imagine this: If the end of the spring broke loose from the circle's center (fixed) point, then the 1 kg mass, with the very light spring attached, would 'fly off' and wobble through space. So we can imagine the 1 kg mass with a very visible kinetic energy of almost exactly $(1/2)mv^2$, and the ultra-fast vibrating spring also with an equal amount of energy to add to the traveling system. But the light spring is vibrating too fast to see – in a sense like 'potential energy'.))

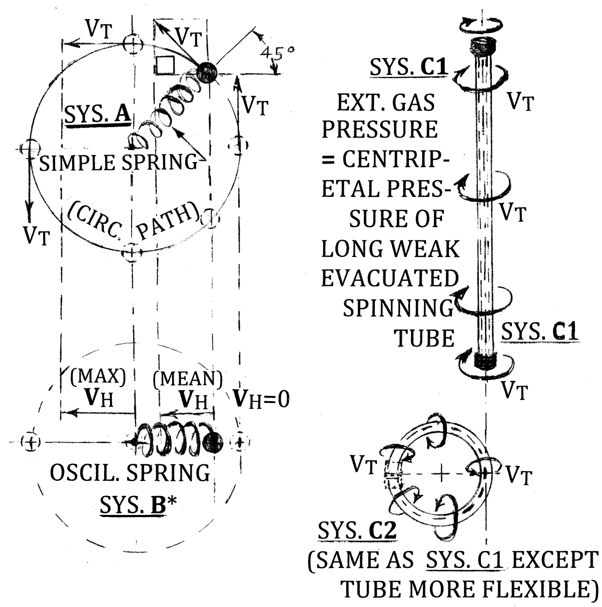

Figure 1. Systems with $tot.E = 1mv^2$

Figure 1 Examples above

3.2. Second Example

The second system, (**Sys. B*** in Fig. 1) is sometimes called simple harmonic spring oscillation. This is not an ideal example, but one aspect of it will serve our purpose.

For simplicity, we'll imagine it to use the same spring as in the first example. But this time the spring, and the same 1kg mass attached to it, oscillate horizontally, from the 1 meter position where F=1 N, to a null position where x = 0 meter and F = 0.0 N. And onward to x= -1 and F= -1N, and back.

When the spring is at the maximum position, (x= 1 meter, and v= 0 meter/sec.), the spring's potential energy is a maximum and the 1kg mass's kinetic energy is 0. And visa verse when the spring is at its null (x= 0 meter) position.

And, for this simple harmonic motion, the position of the 1 kg mass follows that of a linear projection, on a horizontal axis, x, of a constant speed, circularly orbiting mass that we'll imagine circles above it. And we'll imagine a reference 'moving point' on that upper circle to be at the circle's 45 Deg. position. And thus causing a projection that is moving in step with the 1kg horizontally oscillating mass below that upper circle's 45 Deg. 'mean' position.

At that 'average' or 'mean' position, (x=1/1.414 meter), v=1/1.414 meter/sec., ($v^2 = 0.5$). Thus, there, the 1 kg mass has a kinetic energy = 0.5x1x(1/1.414)x(1/1.414) = 0.25 Joule.

Since the spring, at that 'mean' position, is stretched only 1/1.414 meter, not 1.0 meter; the average force stretching it from x=0 to x=1/1.414 is 0.5x(1/1.414)x1.

And since it has only been stretched to just x=1/1.414 distance, the spring work-related potential energy there is thus only (0.5x1/1.414)x1x(1/1.414) = 0.25 Joule.

Thus, at that mean position, the 0.25 Joule K.E. of the moving 1kg mass = the 0.25 Joule P.E. of the spring. Thus, when the condition is considered at the system's 'mean position', (corresponding to that 45 Deg. projection); the Total System Energy is **TWICE** its Kinetic Energy.

3.3. Third Example

We will just describe this interesting example (**Sys. C1** and **Sys. C2** in Fig. 1), and the result, without deriving it here.

Let us imagine a hollow cylinder that is very long compared to the cylinder's small radius. And the cylinder wall is very thin compared to even the cylinder's radius, but it still has an appreciable mass.

Thus it is like a long oil drilling pipe, and we'll imagine it turning very fast, but not advancing forward. And we'll imagine, for now, that the long pipe's near and far end faces are capped, and there is a vacuum inside the pipe, and a high gas or ethereal pressure on the outside.

And we'll next imagine that the pipe or tube is even flexible enough to bend into a very large circle, so that the near end meets and attaches to the far end. So that we will even shortly dispense with the need for the previously mentioned caps.

We imagine that that curved and somewhat flexible cylinder (in **Sys. C2**) is turning at such a high speed that its centripetal pressure just equals the exterior pressure of gas or aether against the cylinder's outer surface. So the cylinder wall can have almost no strength and still maintain stability. So, indeed, let us imagine that it has only trivial strength.

Under those balancing conditions, we find the following: That the kinetic energy of the fast turning pipe wall equals the potential energy (pressure x volume) of the pressure outside the pipe times the internal volume of the long, curved pipe cylinder. I.e., that hollow long cylinder that curved slowly around, so its two ends are coupled, and no caps were necessary.

Thus, again we have, "the Total System Energy is **TWICE** its Kinetic Energy"!

Optionally, the next four paragraphs are offered, to perhaps better grasp the dynamics, if needed:

Try visualizing this: One end of that bent-around cylinder does not quite meet the other end that is capped. And also imagine a flexible piston is sticking into the now imagined open end of the bent-around cylinder. (But the interior of that bent-around cylinder still holds a vacuum.)

And now let us imagine that that piston is driven by the outside pressurized medium all the way to the other capped end of the hollow cylinder. And thus, the piston, by so moving under pressure, can do a (pressure x volume) amount of work. I.e., so that represents 'potential energy' that could do work, as just described.

Let us now imagine that as that piston advances, it passes by a portion of that long and very weak cylinder wall, which is turning at high speed. (As the portion of that cylinder's wall is passed by the moving cylinder, the highly pressurized outside medium rushes into that region that is now exposed, i.e., the region just passed by the piston. And thus that portion of the fast spinning wall is no longer 'sucked' in.)

Thus, that weak cylinder spinning wall disintegrates and flies 'out and away', manifesting a $(1/2)mv^2$ amount of standard kinetic energy, as it flies away 'tangentially'.

The following is very **interesting**: Just as we had to 'cap' the ends of our 'idealized' spinning hollow cylinder in **'Sys. C1'**, but could uncap them in curved **'Sys. C2'**, when the ends met – note this: In large pools of water, there may be caused to occur, 'toroidal vortices', and they are more stable if their end faces curve around and meet. Or curve around in only a half-circle, such that the faces 'terminate' at the water's surface, i.e., that 'water-to-air' transition. And less stable if an end just 'dangles' in the water. That follows an important theorem noted by, or derived by, Helmholtz![8]

Incidentally, some scientists model some particles as like spinning vortices, somewhat like our **'Sys. C2'**, shown in our Fig. 1. If the kinetic and potential energies are equal for that system, and the spinning velocity 'v'='c', the following holds: If 'E' is that system's total energy, $E = (1)mc^2$, not $(1/2)mc^2$.

4. Conclusions

Einstein's $(1mc^2)$ paper, published and dated September, 1905, was very needed, helpful, and praise-worthy, since it concisely and clearly enunciated two previously existing, but less popular, propositions:

The first was that when a body emits radiated energy, the body's mass decreases.

And the second was that the radiating body's mass, m, decreases by an amount, $m = 1E/c^2$, not $(1/2)m = E/c^2$, when an 'E' amount of energy is radiated by the body. I.e., in other words, in the case of radiated energy: $E = 1mc^2$, not just the $(1/2)mc^2$ which most people associate with simple, visible kinetic energy alone. (And Einstein emphasized that that mass-decrease holds even if that amount of energy escapes from the body by means - - 'other than radiation'!)

But. as mentioned in my 'Abstract', in view of Laplace's and Hertz's earlier work, and apparently others'; those proposals of Einstein, (as applied to radiated energy), were previously 'out there' already. I.e., even before Einstein. Even though those earlier proposals were not as popular as other proposals during the 50 year period before Einstein. And likely had not yet appeared in a physics journal. ((I.e., the earlier idea being an '(mc^2)' amount of total energy associated with a system.))

I believe that an 'awards procedure' that gives modest and sometimes even great recognition, awards, and time-limited patents to pioneer innovators – can be constructive for all concerned.

But, regarding how much recognition and reward, I think it is important to ask, "Were other people obviously about to discover the same thing independently, anyway"? (And, in fact, did so, in many cases. And 'spread the word', whether by publishing in a journal or by other means.)

And "how much good and/or financial benefit did society obtain by not having to wait how many days, weeks, months or years for a similar discovery, proposal, innovation or invention by others?" I.e., asking that, as well as just "how great was the discovery alone or as considered abstractly"?

So, roughly speaking, I think the 'Nobel prize committee' was right to cite a different accomplishment by Einstein - an independent accomplishment or such independent accomplishment as well as Einstein's '(mc^2)' paper. I.e., the Nobel prize – carrying even more prestige than so many other great and deserving recognitions and awards.

But suppose if Einstein would have also **very clearly** written in that September, 1905 paper, that the atoms and molecules of even very cold, virtually non-radiating materials also have great hidden energies. I.e., such as ultra-fast spinning and/or vibrational energies? And maybe other such high counter-balancing potential energies? And so much so – that the total energies associated with those bodies, even when very cold, was still of the order of $1mc^2$?

Then I would have adjudged Einstein's September, 1905 paper as having even greater merit, scope, and originality than otherwise, and also, being so importantly very 'futuristic'. And as such, to merit a Nobel prize, by that **paper alone**, or to merit other top prize and recognition.

((In fairness to Einstein, I do think that even his abstract wording did encourage further research into how much energy is associated with even very cold mass. And, as to whether his wording, (especially in the last 4 sentences of his paper), merit even more praise; the readers may be well advised to read that themselves.))

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