the general science journal

Einstein did not derive $E=mc^2$ from Special Relativity

Roger J Anderton

R.J.Anderton@btinternet.com

The equation $E=mc^2$ is derived from Newtonian physics not from special relativity. This is contrary to what most relativists believe, due to relativity being messed up by Einstein, so that much of the maths is wrong or is the wrong way round to how it should be. Einstein believers would have us believe Newtonian physics is an approximation of special relativity, but really Newtonian physics' maths is same as general relativity, just interpreted differently; hence the true relationship between special relativity and Newtonian physics they have the wrong way.

Philip Ball talks about Hasenohrl having derived the equation $E=mc^2$ but introducing a factor ¾ instead of it being unity, he says:

"What Hasenöhrl really missed in his calculation was the idea that if the radiators in his cavity are emitting radiation, they must be losing mass, so his calculation wasn't consistent", says Rothman. "Nevertheless, he got half of it right. If he had merely said that *E* is proportional to *m*, history would probably have been kinder to him." "

What is really interesting is that he explains $E=mc^2$ can be derived without Einstein's SR (special relativity), and even Einstein's attempt to derive $E=mc^2$ does not come from SR:

"But if that's the case, where does relativity come into it? Actually, perhaps it doesn't. While Einstein's celebrated 1905 paper, "On the electrodynamics of moving bodies", clearly laid down the foundations of relativity by abandoning the ether and making the speed of light invariant, his derivation of $E = mc^2$ did not depend on those assumptions. You can get the right answer with classical physics, says Rothman, all in an ether theory without *c* being either constant or the limiting speed. "Although Einstein begins relativistically, he approximates away all the relativistic bits, and you are left with what is basically a classical calculation.""

So the MS (mainstream) now seems to be shifting its position about $E=mc^2$, it is now deemed as not being derived from SR. .

As the article explains Einstein "approximates away all the relativistic bits" of SR and so does not derive $E=mc^2$ from SR.

Yet we still call this - Einstein's theory.

People thinking that deriving $E=mc^2$ but not from SR constitutes a different theory to MS, now find that the MS does not agree.

MS makes a position that $E=mc^2$ does not come from SR anyway.

As proviso - we have to grant that MS has people of many different opinions, so many in the MS can have the opinion that $E=mc^2$ not derived from SR is controversial.

I.e the MS is supposed to be following Einstein's relativity, but don't really understand it and teach it incorrectly.

My position on this subject roughly follows what Pentcho Valev has to say, he says:

"Philip Ball wrote: "While Einstein's celebrated 1905 paper, "On the electrodynamics of moving bodies", clearly laid down the foundations of relativity by abandoning the ether and making the speed of light invariant, his derivation of $E=mc^2$ did not depend on those assumptions. You can get the right answer with classical physics, says Rothman, all in an ether theory without c being either constant or the limiting speed." This sounds like an implicit attack against Einstein's 1905 constant-speed-of-light postulate. If so, the ether theory is irrelevant. The only reasonable alternative to the false postulate (compatible with the Michelson-Morley experiment) is given by Newton's emission theory of light."

I don't go along with saying "ether theory is irrelevant", I think ether has been modified by Einstein's revolution, and that Newtonian emission theory of light can be made good, and both emission theory and ether theory are alternative ways of looking at same thing. There is still wave-particle duality in context of Newtonian physics; wave of ether waves and particles of emission theory.

Ball works from Boughn and Rothman's paper. [2] The analysis of Hasenohrl calculation is quite complicated in that paper but the relevant part of Einstein's calculation for $E=mc^2$ is:

“Certainly, if not in 1904 then at some point, Einstein must have learned of Hasenohrl's work. Jakob Lamb asks Einstein directly in a 1908 letter whether Einstein has read Hasenohrl's recent paper “On the thermodynamics of moving bodies." Einstein's replies provide no answer but the famous photograph of the first Solvay conference in 1911 shows Hasenohrl and Einstein, separated by other illustrious physicists, standing around the same conference table. One can only imagine the conversations.”

Einstein as usual presents us with problems because he does not cite from what he is working from. The paper continues:

“Apart from historical questions, it is reasonable to ask what constitutes an acceptable proof of a statement that we now regard as a law of nature, and in what respects was Einstein's demonstration more general than Hasenohrl's. Unquestionably, Einstein's thought experiment in his famous 1905 paper “Does the inertia of a body depend on its energy content?" was the simpler and in choosing a problem that is readily solved he displayed the sagacity of a great scientist. Einstein's major simplication, aside from the introduction of relativity itself, was that he effectively considered a point mass, one that emits two bursts of electromagnetic radiation in opposite directions. In a frame, say the lab, where the mass is initially at rest, it clearly remains at rest. Einstein assumes that the radiation carries away an energy E_γ such that $E_i = E_f + ½ E_\gamma + ½ E_\gamma$ where E_i is the initial energy of the particle and E_f is the final energy. “

The paper says of Einstein's derivation of $E=mc^2$ from this: “ Consequently, one must concede that his derivation is, at best, a low-velocity approximation.”

i.e. Einstein was not working from SR to obtain $E=mc^2$ instead he is working from Newtonian physics and assumes Newtonian physics is good for low velocity hence being an approximation of SR.

Also it should be noted that Einstein is using point-particle and that is a fundamental object from Boscovich's theory (extension of Newtonian physics), so he was working from Boscovich's theory and once again not giving credit for that.

As the paper mentions it: “Einstein was not in the habit of citing others in his early papers”. This issue of citing others would not have been important if Einstein had not made so many mistakes. But since he made so many mistakes and did not cite where he was making the mistakes from, it has made things a very difficult mess to untangle.

On the issue of point-particle the paper says: “Einstein's assumption of a point particle is also open to criticism.” But that sort of criticism is from people who don't appreciate that the maths modelling process has to start from idealisations, and so are people who don't have a proper understanding of how physics should be.

The paper also makes reference to Ohanian who accuses Einstein of making mistakes in all his attempts at deriving $E=mc^2$. It maybe on this issue that Ohanian does not appreciate that Newtonian physics is being treated as an approximation of SR, so that derivation of $E=mc^2$ in Newtonian physics can be treated as valid for SR.

However on this issue – as dealt with in other papers- the maths of general relativity (GR) is the same as the maths of Newtonian physics, so for MS view that SR is approximation of SR would mean SR is really an approximation of Newtonian physics not the other way around!

In fact – Newtonian physics in its usual setting deals with Euclidean geometry, and if a different geometry were used such as non Euclidean geometry I would still think it was still Newtonian physics. And to large extent GR is merely Newtonian physics using non Euclidean geometry instead of Euclidean geometry. And since mathematically either geometry is valid. Then using non Euclidean geometry in Newtonian physics is merely using a different mathematical tool. All these type of issues have been messed up as regards the true relation between Newtonian physics and Einstein's relativity. Thus when we look at SR from a Newtonian physics perspective, we can look at it several different ways. One of the easiest ways is to look at it that SR deals with the case of two observers separated by a constant velocity v both measuring same speed of light c. Newtonian physics would then claim v=0, and those people who decide instead to treat v as other than zero are making a mistake. Of course Einstein seeks to change things about time etc., so then that leads to other complications, but basically it is building upon adding one mistake on top of another. (So then it becomes issues of clock synchronizations etc.) But looking at it as a straightforward claim of A and B looking at the same light and separated by velocity v, and observing same value of lightspeed then by Newtonian physics says v = 0, and to treat v as non-zero is a mistake.

It is possible to do a simple derivation from Newtonian physics to get the equation $E=mc^2$

Starting from the Kinetic energy equation (see appendix for its derivation):

$KE = ½\ mv^2$

(note: v is now being used differently to earlier.)

Then substituting Newtonian equation of motion (for constant acceleration):

$v^2 = u^2 + 2\ as$

gives:

$KE = ½\ m\ (u^2 + 2as) = ½\ m\ u^2 + mas$

v = final velocity, u = initial velocity, a = acceleration, s = displacement

What we now have is initial Kinetic energy = $½\ m\ u^2$ and
potential energy = mas

So, now the equation instead of KE we can call total energy:

Total energy = initial KE + potential energy = $½\ m\ u^2 + mas$

We now want to consider the case when $½\ m\ u^2 = mas$ so we have:

Total energy = $2\ (½\ m\ u^2) = m\ u^2$

And when u =c (such as for light in vacuum free of influences) this is
$E = m\ c^2$

Others have derived this equation from Newtonian physics by their own means. [3]

Also by perspective of Newtonian Physics (NP) then SR is a mistake and would treat the scenario of A and B separated by velocity v (nb dealing with v in the earlier context) as v =0 for A and B i.e. in same inertial frame.

I.e from perspective of NP then NP is not an approx of SR

Also from by other papers NP = GR maths; if treat GR as NP but dealing with Non Euclidean geometry instead of usual Euclidean and correcting the mistakes made by Einstein et al, then GR=NP with SR as sub-theory usually with the mistake of treating v as non-zero etc.

References

[1] Did Einstein discover *E* = *mc2* ? Philip Ball Aug 23, 2011

http://physicsworld.com/cws/article/news/46941

[2] Hasenohrl and the Equivalence of Mass and Energy, Stephen Boughn and Tony Rothman

http://arxiv.org/PS_cache/arxiv/pdf/1108/1108.2250v4.pdf

[3] There are various sources dealing with $E=mc^2$ derived from Newtonian physics, for instance see: Hartwig Thim and Ronald Pearson. The problem with Pearson though is that he has muddled a few things, and I opposed to things like absolute rest concept being advocated to replace relative motion.
An Exact Classical Mechanics leads toward Quantum Gravitation
Ronald D. Pearson (October 1997; revised May 2003)
http://www.cfpf.org.uk/articles/rdp/cm/cm_full/old/cfpf-cm.pdf
The Long History of the Mass-Energy Relation by Hartwig Thim,
http://www.worldsci.org/pdf/abstracts/abstracts_4677.pdf

Appendix:

The work done accelerating a particle during the infinitesimal time interval *dt* is given by the dot product of *force* and *displacement*:

where we have assumed the relation $\mathbf{p} = m\mathbf{v}$.

Applying the product rule we see that:

$$d(\mathbf{v}\cdot\mathbf{v}) = (d\mathbf{v})\cdot\mathbf{v} + \mathbf{v}\cdot(d\mathbf{v}) = 2(\mathbf{v}\cdot d\mathbf{v}).$$

Therefore (assuming constant mass), the following can be seen:

$$\mathbf{v} \cdot d(m\mathbf{v}) = \frac{m}{2} d(\mathbf{v} \cdot \mathbf{v}) = \frac{m}{2} dv^2 = d\left(\frac{mv^2}{2}\right).$$

Since this is a total differential (that is, it only depends on the final state, not how the particle got there), we can integrate it and call the result kinetic energy:

$$E_k = \int \mathbf{F} \cdot d\mathbf{x} = \int \mathbf{v} \cdot d(m\mathbf{v}) = \int d\left(\frac{mv^2}{2}\right) = \frac{mv^2}{2}.$$

Reference: http://en.wikipedia.org/wiki/Kinetic_energy#Derivation at 03 – 9-2011