Experimental evidence of E ≠ mc^2

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Abstract – Presented measured energies of cosmic rays prove themselves that the expression E= mc^2, as well as the expression for the relativistic kinetic energy, is untenable.

Introduction

The definition of cosmic rays as found on Wikipedia sounds: “Cosmic rays are high-energy protons and atomic nuclei which move through space at nearly the speed of light.”
In this article a closer investigation is shown concentrated on just protons.

The concept “nearly the speed of light”

The importance of this concept is found in the expression E = mc^2, in which the mass m is considered to be dependant on its velocity v in accordance to the alleged function

$$m = m_{rest} / \sqrt{(1-v^2/c^2)}, \text{ shortly expressed as } m = \gamma\, m_{rest}$$

Because only velocities of nearly the speed of light will be considered, v will be presented as

$$v = c - \varepsilon_v, \text{ with } \varepsilon_v << c.$$

Given: $1-v^2/c^2 = c^{-2}(c^2-v^2) = c^{-2}(c-v)*(c+v) \approx c^{-2}\ \varepsilon_v\ 2c = 2\varepsilon_v/c$, the expression for m can be approximated sufficient accurately, regarding the purpose of this article, by

$$m \approx \sqrt{c/2\varepsilon_v}\ m_{rest}.$$

The alleged energy of such a mass is $E= \sqrt{(c/2\varepsilon_v)}\ m_{rest}\ c^2$ Joule = $6.25\times10^{18}\sqrt{(c/2\varepsilon_v)}\ m_{rest}\ c^2$ eV.

Table I shows a few examples for $m_{rest} = 1.7\times10^{-27}$ kg, the mass of a proton. These examples are based on the text written in reference [1]:
“*Cosmic rays attract great interest practically, ... and scientifically, because the energies of the most energetic ultra-high-energy cosmic rays have been observed to approach 3×10^{20} eV, about 40 million times the energy of particles accelerated by the Large Hadron Collider ($7.5*10^{12}$ eV).*
One can show that such enormous energies might be achieved by means of the centrifugal mechanism of acceleration in active galactic nuclei. At 50 J, the highest-energy ultra-high-energy cosmic rays (such as the Oh-My-God particle recorded in 1991)....... “

v (m/s)	γ	Joule	eV	specification
0	1	$1.5*10^{-10}$	$9.6*10^{8}$	
$c/3$	1.06	$1.6*10^{-10}$	$1.0*10^{9}$	
$2c/3$	1.34	$2.1*10^{-10}$	$1.3*10^{9}$	
$c - 135$	1000	$1.6*10^{-7}$	$1.0*10^{12}$	CERN
$c - 2.4$	7872	$1.2*10^{-6}$	$7.5*10^{12}$	LHC
$c - 1.4*10^{-15}$	$3.3*10^{11}$	50	$3.1*10^{20}$	Oh-My-God

Table I Examples of theoretical energies of cosmic rays

In the next chapter the distance d_b of the protons to earth, where the gravitational forces of galaxy and earth are in equilibrium, plays a significant role. This distance is $\sqrt{M_e/M_g}\times$‘total distance’.
With $M_g = 8*10^{31}$ kg, $M_e = 6*10^{24}$ kg and ‘total distance’ = $2.4*10^{20}$, d_b is about $2*10^{14}$ m.

Three fundamental problems of E = mc^2

1 Relativistic kinetic energy and potential energy

The backgrounds of these concepts are in detail considered in the appendix, with the following results:

- The potential energy of a mass m at distance d from earth equals $GM_em(1/r_e - 1/d)$, with r_e earth's radius, M_e its mass and G the gravitational constant. For d = d_b the result is GM_em/r_e.

- According to the Newtonian laws, "releasing" m at distance d_b causes instantaneously kinetic energy. Having arrived at earth, this energy (½mv_{re}^2) must equal GM_em/r_e. So $v_{re}=\sqrt{2GM_e/r_e}$, being the so-called escape velocity: Quote: "......escape velocity is the minimum speed needed for a free, non-propelled object to .... achieve an infinite distance from it."
  Newtonian laws prescribe the addition of v_{re} to the speed v_i of m at d_b, resulting in $v_{eN}= v_i + v_{re}$.

- Following the rules of the theory of relativity the increase of kinetic energy on the same trajectory is $\Delta K = (\gamma_{re\Delta K} - \gamma_i)m_{rest}\boldsymbol{c}^2$, with γ_{re} the multiplication factor for m_{rest} at r_e and γ_i at d.
  The end velocity v_{eR} has been deduced in order to compare it with the just shown Newtonian.
  $v_{eR} = \sqrt{\{ \boldsymbol{c}^2 - (\boldsymbol{c}^2 - v_i^2)/(GM_e/r_e\boldsymbol{c}^2 + 1)^2\}}$. See the appendix for the derivation.

- The few examples below show that the more v_i approaches $\boldsymbol{c}$, the more the influence of the potential energy on the protons is reduced. Seen from a physical point of view unacceptable.
  $\boldsymbol{c}$ has been chosen exactly 3*10^8 m/s.

v_i	v_{eR}	$v_{eR} - v_i$
0	11200	11200
100000	100625	625
10000000	10000006	6
299999900	299999900	0

2 The violation of the axiom* of conservation of mass

The theory of relativity does not and can not explain how the extreme increase of the mass of the cosmic particle, as function of its velocity, is realised in order to fulfil the axiom of conservation of mass.

3 The violation of the axiom of conservation of energy

The theory of relativity does not and can not explain how the extreme increase of the energy of the cosmic particle, as function of its velocity, is realised in order to fulfil the axiom of conservation of energy.

Conclusions

1 The measured extremely high energy of the "Oh-my-God particles" in cosmic rays explicitly implies that, according to the expression E=mc^2 as well as to the expression of the relativistic kinetic energy, the existence of potential energy of such particles with respect to earth is completely ignored.

2 The second fundamental problem is that the interpretation of the measurements implies the violation of the axiom of conservation of mass.

3 The third fundamental problem is that the interpretation of the measurements implies the violation of the axiom of conservation of energy.

4 The moral question thus is: why would a sincere physicist defend E = m$\boldsymbol{c}^2$ as a realistic physical concept?

References

[1] https://en.wikipedia.org/wiki/Cosmic_ray

[2] http://www.phys.ufl.edu/~acosta/phy2061/lectures/Relativity4.pdf

[3] https://vixra.org/abs/1709.0440 Conventional Calculation of Potential Energy Fundamentally Incorrect

* An axiom is a presumption of which its validity is strongly self-evident.

Appendix Newtonian and relativistic kinetic energy

Newtonian potential and kinetic energy.

The Newtonian *potential* energy of an object with mass m at distance d from *the centre of* earth with mass M_e can be calculated by applying the law: W(ork) = ∫F(s).ds, with $F(s) = GM_e m/s^2$. The lower boundary of the integral is the radius r_e of earth and the upper one is d. The outcome is: $E_p = GM_e m(1/r_e - 1/d)$. See [3].

E_p is and must be positive, because it needs energy to transport m from r_e to d. In the reverse direction starting at d, with m at rest relative to earth, this energy will be released and instantaneously transformed into kinetic energy. At distance r_e, from the centre of earth, the kinetic energy of m must be equal to E_p, so

$$½mv_{re}^2 = GM_e m(1/r_e - 1/d)$$

An extreme situation is $d \rightarrow \infty$, leading to $½mv_{re}^2 = GM_e m/r_e$. The resulting velocity $v_{re} = \sqrt{2GM_e/r_e}$ equals to so called escape velocity, in this case of earth. v_{re} = 11200 m/s, as rounded value.

So the **Newtonian** kinetic energy of an object with mass m, starting its "fall" at very large distance, w.r.t. the radius of earth, arriving at earth is $½mv_{re}^2 = GM_e m/r_e$.
If this process is started with a constant velocity v_i at position d, then the additional velocity, as a result of the potential energy, is simply added to v_i. At the end of the trajectory the velocity is $v_{eN} = v_i + v_{re}$.

Relativistic potential and kinetic energy.

The relativistic potential energy is equal to the Newtonian one, because there is no velocity involved. The transformation of potential energy to relativistic kinetic energy (K) can be carried out as follows.
The force in the expression of "Work" is now written as F=ma, with a=dv/dt, and ds written as vdt, resulting in $m_{rest}\, dv/dt\, \gamma\, vdt = m_{rest}\, v\, d(v\gamma)$.
Integrating by parts gives: $K = \gamma m_{rest} v^2|_0^v - m_{rest}\int_0^v \gamma v\, dv$.
The integral $\int_0^v \gamma v\, dv$ turns out to be $\boldsymbol{c}^2/\gamma|_0^v = \boldsymbol{c}^2\sqrt{(1-v^2/\boldsymbol{c}^2)} - \boldsymbol{c}^2$, so $K = \gamma m_{rest} v^2 - m_{rest}\boldsymbol{c}^2 = (\gamma - 1)\, m_{rest}\boldsymbol{c}^2$.

This solution eliminates the ambiguity between classic kinetic energy for v = 0, because K = 0 for v = 0. But $E = m\boldsymbol{c}^2$ is still $m_{rest}\boldsymbol{c}^2$ for v = 0.
This problem has been "solved' *semantically* by stating that $E = \gamma m_{rest}\boldsymbol{c}^2 = K + m_{rest}\boldsymbol{c}^2$, defining $m_{rest}\boldsymbol{c}^2$ as *potential* energy and E as *total* energy!
Static energy would have been a more appropriate definition for $m_{rest}\boldsymbol{c}^2$.

In order to compare the Newtonian transformation, of potential energy into kinetic energy with the relativistic transformation, the relativistic velocity $v_{eR} = v_i + v_{re}$, will be calculated in such a situation.

If the initial velocity is v_i the increase of the relativistic kinetic energy is $(\gamma_e - \gamma_i)\, m_{rest}\boldsymbol{c}^2$, with $\gamma_e=1/\sqrt{(1-v_{eR}^2/\boldsymbol{c}^2)}$ and $\gamma_i=1/\sqrt{(1-v_i^2/\boldsymbol{c}^2)}$, and a potential energy at position $d>>r_e$ equal to $GM_e\, \gamma_i m_{rest}/r_e$.

Fulfilling the law that potential energy is transformed into kinetic energy

it follows from $(\gamma_e - \gamma_i)\, m_{rest}\boldsymbol{c}^2 = GM_e\, \gamma_i m_{rest}/r_e$,

that $(\gamma_e - \gamma_i)\, \boldsymbol{c}^2 = \gamma_i\, GM_e/r_e$,

to be written as: $\gamma_e = \gamma_i\, (GM_e/r_e\boldsymbol{c}^2 + 1) = \gamma_i\, (G_c + 1)$.

Applying $\gamma_e = 1/\sqrt{(1-v_{eR}^2/\boldsymbol{c}^2)}$ it follows that $v_{eR} = \boldsymbol{c}\sqrt{(1 - 1/\gamma_e^2)}$

Applying $\gamma_e = \gamma_i\, (G_c + 1)$ it follows that $v_{eR} = \boldsymbol{c}\sqrt{\{1 - 1/\gamma_i^2(G_c + 1)^2\}}$

Applying $\gamma_i = 1/\sqrt{(1-v_i^2/\boldsymbol{c}^2)}$ it follows that $v_{eR} = \sqrt{\{\boldsymbol{c}^2 - (\boldsymbol{c}^2-v_i^2)/(G_c + 1)^2\}}$ $G_c = GM_e/r_e\boldsymbol{c}^2$

This expression shows that for v_i = 0, the end velocity v_{eR} equals, just like in the Newtonian situation, the escape velocity of earth. For $v_i = \boldsymbol{c}$ the velocity v_{eR} also equals $\boldsymbol{c}$, completely ignoring the influence of the potential energy of the proton relative to earth. Values of v_i in between these two extreme situations eliminate the potential energy fluently more, the more v_i increases, as shown in the main article.