

EINSTEIN'S MASS ENERGY EQUATION – THE ATOMIC BOMB AND THE MODERN DAY TERRORISM

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Abstract - This paper discusses the relationship between mass (m) and energy (E) in the special theory of relativity of Albert Einstein, embodied by the formula, $E = mc^2$ where C is the speed of light. However scientific evidences have shown that the analysis of this equation has led to the discovery of Atomic bomb which is now mostly used in the modern day terror. The advantages and disadvantages of this equation have been summarily analyzed in this writing. Going by the analysis, this paper tries to show that the earlier creation of the atomic bomb led to the increasing terrorism nowadays. Without the atomic bomb, the ease at which lives are massively lost might have been small.

Keywords - Atomic Bomb, Terrorism, Nuclear Bomb, Relativity, Mass, Energy, Speed of Light,

Figures: fig. 2.1 Albert Einstein, fig. 3.1 the nuclear bomb explosion.

I. INTRODUCTION

THE MASS

Mass is one of the most difficult variables to understand, but it is also one of the most important. As we have seen thus far, length, area, and volume have straightforward definitions. The volume of an object, for example, was defined as a measure of the space it occupies. Does mass have a similar straightforward definition? In a sense it does and in a sense it does not.

Basically, mass is a measure of the quantity of matter in an object. That is the simple definition. Unfortunately, that begs the following question. One can ask, "What is matter?" and we are back to where we started. So we have to look more closely at the question of what exactly mass is. And that is where things get difficult. Mass is defined through what it does, and this sets it apart from length, area, and volume. Moreover, mass does two things, which means in a sense, it has two definitions. One of the things that mass does is absolutely crucial for the existence of our universe. Mass is the cause of the force of gravity. Without mass, there would be no gravity, and without gravity, matter would not have clumped into galaxies and stars and us. Since mass causes gravity, we can define mass through the pull of gravity—the greater the pull, the greater the mass an object has.

The other thing that mass does has to do with the motion of an object. All other variables being equal, the mass of an object determines how much the velocity of an object will change when subject to a given force. In layman's terms, the larger the mass of an object, the harder you have to push to change its speed. Since we are not yet ready to study motion, we will not discuss the details of this aspect of mass. Nevertheless, we might note that it was

Einstein's contemplation of both properties of mass (gravity and motion), that led him to his general theory of relativity.

However, the American Institute of Physics (© 1989), described mass as one of the most fundamental concepts of physics. Understanding and calculating the masses of the elementary particles is the central problem of modern physics, and is intimately connected with other fundamental problems such as the origin of CP violation, the mystery of the energy scales that determine the properties of the weak and gravitational interactions, the compositeness of particles, super symmetry theory and the properties of the not-yet-discovered Higgs bosons.

In the modern language of relativity theory there is only one mass, the Newtonian mass m , which does not vary with velocity; hence the famous formula $E = mc^2$ has to be taken with a large grain of salt.

1.2 Qualitative View about Energy

Most dictionaries define energy as "the capacity to do work." This implies that energy is a more abstract concept than work. The definition is correct, of course, but it is incomplete.

Work is certainly an important 'manifestation' of energy; indeed, the Industrial Revolution went into full swing in late eighteenth century when breakthroughs were achieved in converting other forms of energy into work. But work is not the only 'palpable' form of energy.

Heat is another important energy form; a lot of effort and expense is made by society to remove heat from our homes and offices in the summer and to bring it to them in the winter. And radiation too, for better or for worse, is energy that we can sense. Hence, a more complete definition is the following:

Energy is a property of matter that can be converted into work, heat or radiation. Strictly speaking, both work and heat are processes by which energy can be

changed but we don't need to worry about this subtlety here. A good analogy is that energy is like money in the bank, while heat, work and radiation are like cash, checks and money orders. Most dictionaries cite the year 1599 as the date of the earliest recorded use of the term 'energy' in English. This may be so, but it took another two and a half centuries for its meaning to be understood completely. Indeed, its precise definition, together with that of entropy is one of the greatest intellectual achievements of mankind. An instructive analogy can be drawn between the rather abstract concept of energy and another more or less abstract but familiar property of (living) matter: our health. Health is a God-given property that we have, to which we often pay little attention, until we lose it. Similarly, energy is a property that humans and others – both living and nonliving matter – possess to a greater or lesser extent; we are pretty much unaware of its existence, however, until it is converted into work, heat or radiation.

The above definition of energy highlights the fact that energy conversion is essential for energy utilization. We shall discuss this in detail. We shall see that the quantity of energy available in the universe is constant. It cannot be created or destroyed; it is only transformed from one form to another. In other words, it is conserved in all these transformations.

II. THE MASS – ENERGY EQUIVALENCE

This is the most famous equation in the history of equations. It has been printed on countless T-shirts and posters, starred in films and, even if you've never appreciated the beauty or utility of equations, you'll know this one. And you probably also know who came up with it – physicist and Nobel laureate Albert Einstein.

The ideas that led to the equation were set down by Einstein in 1905, in a paper submitted to the *Annalen der Physik* called "Does the Inertia of a Body Depend Upon Its Energy Content?". The relationship between energy and mass came out of another of Einstein's ideas, special relativity, which was a radical new way to relate the motions of objects in the universe.

At one level, the equation is devastatingly simple. It says that the energy (E) in a system (an atom, a person, the solar system) is equal to its total mass (m) multiplied by the square of the speed of light (c, equal to 186,000 miles per second). Like all good equations, though, its simplicity is a rabbit-hole into something profound about nature: energy and mass are not just mathematically related, they are different ways to measure the same thing. Before Einstein, scientists defined energy as the stuff that allows objects and fields to interact or move in some way – kinetic energy is associated with movement, thermal energy involves heating and electromagnetic fields contain energy that is transmitted as waves. All these types of energy can be transformed from one to another, but nothing can ever be created or destroyed. In relativity theory, Einstein introduced mass as a

new type of energy to the mix. Beforehand, the mass of something in kilograms was just a measure of how much stuff was present and how resistant it was to being moved around. In Einstein's new world, mass became a way to measure the total energy present in an object, even when it was not being heated, moved or irradiated or whatever else. Mass is just a super-concentrated form of energy and, moreover, these things can turn from one form to the other and back again. Nuclear power stations exploit this idea inside their reactors where subatomic particles, called neutrons, are fired at the nuclei of uranium atoms, which causes the uranium to split into smaller atoms. The process of fission releases energy and further neutrons that can go on to split more uranium atoms. If you made very precise measurements of all the particles before and after the process, you would find that the total mass of the latter was very slightly smaller than the former, a difference known as the "mass defect". That missing matter has been converted to energy and you can calculate how much using Einstein's equation.

However, Einstein's equation became useful for Particle accelerators studying fundamental physics. Special relativity says that the faster something moves, the more massive it becomes. In a particle accelerator, protons are accelerated to almost the speed of light and smashed into each other. The high energy of these collisions allows the formation of new, more massive particles than protons – such as the Higgs boson – that physicists might want to study. Which particles might be formed and how much mass they have can all be calculated using Einstein's equation.

It would be nice to think that Einstein's equation became famous simply because of its fundamental importance in making us understand how different the world really is to how we perceived it a century ago. But its fame is mostly because of its association with one of the most devastating weapons produced by humans – the atomic bomb. The equation appeared in the report, prepared for the US government by physicist Henry DeWolf Smyth in 1945, on the Allied efforts to make an atomic bomb during the Manhattan project. The result of that project led to the death of hundreds of thousands of Japanese citizens in Hiroshima and Nagasaki.

Einstein himself had encouraged the US government to fund research into atomic energy during the Second World War but his own involvement in the Manhattan project was limited because of his lack of security clearances. It is unlikely that Einstein's equation was much use in designing the bomb, beyond making scientists and military leaders realize that such a thing would be theoretically possible, but the association has stuck.

2.1 THE PHYSICS BEHIND $E = MC^2$

Einstein correctly described the equivalence of mass and energy as "the most important upshot of the

special theory of relativity” (Einstein, 1919), for this result lies at the core of modern physics. According to Einstein's famous equation $E = mc^2$, the energy E of a physical system is numerically equal to the product of its mass m and the speed of light c squared. It is customary to refer to this result as “the equivalence of mass and energy,” or simply “mass-energy equivalence,” because one can choose units in which $c = 1$, and hence $E = m$. The two main philosophical questions surrounding Einstein's equation concern how we ought to understand the assertion that mass and energy are in some sense *equivalent* and how we ought to understand assertions concerning the convertibility of mass into energy (or vice versa).

The force is defined as the rate of change of momentum i. e.,

$$F = \frac{d}{dt}(mv) \quad (1)$$

According to the theory of relativity, both mass and velocity are variable. Therefore,

$$F = \frac{d}{dt}(mv) = m \frac{dv}{dt} + v \frac{dm}{dt} \quad (2)$$

Let the force F displace the body through a distance dx ,

Then the increase in the kinetic energy (dE_k) of the body is equal to the work done (fdx).

$$\text{Hence } dE_k = fdx = m \frac{dv}{dt} dx + v \frac{dm}{dt} dx$$

$$\text{i.e., } dE_k = mv dv + v^2 dm \quad (3)$$

But from the law of variation of mass with velocity

$$m = \frac{m_0}{\sqrt{(1-v^2/c^2)}} \quad (4)$$

$$\text{Squaring both sides, } m^2 c^2 = m_0^2 c^2 + m^2 v^2$$

$$\text{Differentiating, } c^2 2m dm = m^2 2v dv + v^2 2m dm$$

$$c^2 dm = mv dv + v^2 dm$$

$$\text{Comparing (3) and (5) we have, } dE_k = c^2 dm \quad (6)$$

Thus the change in K. E. dE_k is directly proportional to a change in mass dm

When a body is at rest, its velocity is zero. (K. E. = 0) and $m = m_0$. When its velocity is v , its mass becomes m . Therefore integrating equation (6)

$$E_k = \int_0^{E_k} dE_k = c^2 \int_{m_0}^m dm = c^2 (m - m_0)$$

Therefore,

$$E_k = mc^2 - m_0 c^2 \quad (7)$$

This is the relativistic formula for K.E. When the body is at rest, the internal energy stored in the body is $m_0 c^2$. $m_0 c^2$, is called, the rest mass energy. The total energy (E) of the body is the sum of K.E. (E_k) and rest mass energy ($m_0 c^2$), therefore,

$$E = E_k + m_0 c^2 = (mc^2 - m_0 c^2) + m_0 c^2 = mc^2$$

Therefore, $E = mc^2$

This is the Einstein's mass – energy relation

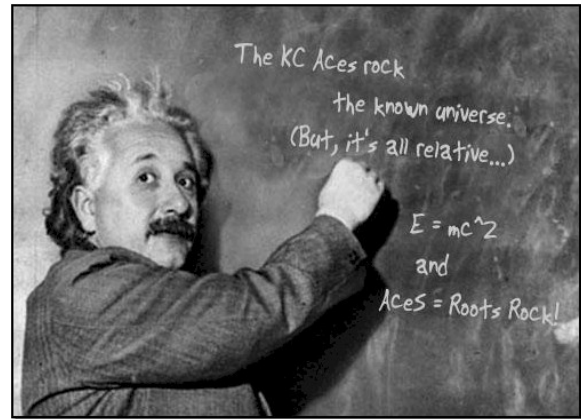


Fig. 2.1 Albert Einstein

III. THE ATOMIC BOMB AND TODAY'S TERRORISM

On August 2, 1939, just before the beginning of World War II, Albert Einstein wrote to then President Franklin D. Roosevelt. Einstein and several other scientists told Roosevelt of efforts in Nazi Germany to purify uranium-235, which could be used to build an atomic bomb. It was shortly thereafter that the United States Government began the serious undertaking known then only as "The Manhattan Project." Simply put, the Manhattan Project was committed to expediting research that would produce a viable atomic bomb.

The most complicated issue to be addressed in making of an atomic bomb was the production of ample amounts of "enriched" uranium to sustain a chain reaction.

At the time, uranium-235 was very hard to extract. In fact, the ratio of conversion from uranium ore to uranium metal is 500:1. Compounding this, the one part of uranium that is finally refined from the ore is over 99% uranium-238, which is practically useless for an atomic bomb. To make the task even more difficult, the useful U-235 and nearly useless U-238 are isotopes, nearly identical in their chemical makeup. No ordinary chemical extraction method could separate them; only mechanical methods could work.

A massive enrichment laboratory/plant was constructed at Oak Ridge, Tennessee. Harold Urey and his colleagues at Columbia University devised an extraction system that worked on the principle of gaseous diffusion, and Ernest Lawrence (inventor of the Cyclotron) at the University of California in Berkeley implemented a process involving magnetic separation of the two isotopes.

Next, a gas centrifuge was used to further separate the lighter U-235 from the heavier, non-fissionable U-238.

Once all of these procedures had been completed, all that needed to be done was to put to the test the entire

concept behind atomic fission ("splitting the atom," in layman's terms).



Fig. 3.1 Nuclear bomb explosion

However, global terrorism is one of the most worrying problems the world is facing today. Terrorists from different corners of the world use what we called suicide bombings to attached any intended targets, mostly the human beings, leading to massive loss of human life which in turn leads to the reduction of the world population

Supposing the idea of nuclear bomb was not brought up, then today's loss of life through suicide bombings might have not happen and the rate of terrorism must not be as it is today

CONCLUSIONS

The idea of mass – energy equivalence have led to the discovery of atomic bomb and those who those who contributed to its discovery could have regretted discovering it if they were on Earth today.

The atomic bomb is responsible for today's massive depopulation and global unrest through abominable terror act.

The global community should enforce ban against the increasing demand and supply of nuclear weapons other massive killings will turn to a modern day judgment.

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