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The Generalized Mass-Energy Equation $\Delta E = Ac^2\Delta M$ in Cosmology

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Abstract: Newly suggested equation $\Delta E = Ac^2\Delta M$ implies that energy emitted on annihilation of mass (or vice- versa) can be equal, less and more than predicted by $\Delta E = \Delta mc^2$. It successfully explains the energy emitted (10^{45}J) in Gamma Ray Bursts (duration 0.1s-100s) with value of A i.e. 2.57×10^{18}. Also energy emitted by quasars and supernovas etc. can be explained with higher value of A. Recent work at SLAC confirmed discovery of a new particle, whose mass is far less than current estimates, the same can be explained with help of equation $\Delta E = Ac^2\Delta M$ with value of A more than one. $\Delta E = Ac^2\Delta M$, is the first equation which mathematically explains that mass of universe 10^{55}kg was created from dwindling amount of energy (10^{-4444}J or less) with value of A equal to 2.568×10^{-4471} J or less. Whereas $E = \Delta mc^2$ predicts the mass of universe 10^{55}kg was originated from energy neither less nor more than 9×10^{71} J.
Keywords: Mass-energy equation, cosmology.

1.0 Conservation of mass and energy and $\Delta E = Ac^2 \Delta M$.

The law of conservation of mass or energy has existed in literature since 18th century (or may be even before informally) the French chemist Antoine Lavoisier was the first to formulate such a law for chemical reactions. The very first idea of mass-energy interconversion was given by Fritz Hasenohrl [1]. Einstein [2] derived first Interconversion equation between light energy (L) and mass $L = c^2 \Delta M$, and speculated from it the general equation (for every type of energy) $\Delta E = \Delta mc^2$. To explain the astounding amount of energy emitted by some heavenly bodies and possibly visualise the origin of universe before Big Bang, the equation is $\Delta E = Ac^2\Delta M$ is anticipated or visualised by author [3-4].

Here the derivation involves calculation of infinitesimally small amount of energy dE when small amount of mass dm is converted (in any process) into energy. The energy may be in any form i.e. light energy, sound energy, energy in form of invisible radiations etc or energy may co-exist in various forms as in case of atom bomb then

$$dE \propto dm$$

In the existing literature conversion factor c^2 between mass and energy has been experimentally confirmed. Thus in above proportionality, it can be taken in account as,

$$dE \propto c^2\, dm \quad \text{or} \quad dE = Ac^2\, dm \tag{1}$$

where A is used to remove the sign of proportionality it has nature like Hubble's constant {50 to 80 kilometres per second-Mega parsec (Mpc)} or like coefficient of viscosity (1.05×10^{-3} poise to 19.2×10^{-6} poise) or coefficient of thermal conductivity ($0.02 Wm^{-1}K^{-1}$ to $400\ Wm^{-1}K^{-1}$ etc), also force constant or spring constant is another similar example. It may be termed as conversion–coefficient, as it highlights extent of conversion of mass to energy or vice –versa and depends upon the characteristics and intrinsic conditions of a particular process. Let in some conversion process mass decreases from M_i to M_f and energy increases from E_i to E_f .Initially when no mass is converted into energy, $E_i = 0$. Thus integrating Eq. (1) we get,

$$E_f - E_i = Ac^2 (M_f – M_i) \tag{2}$$

$$\Delta E = Ac^2\, \Delta M \quad \text{or} \quad \text{Energy evolved} = Ac^2 \text{(decrease in mass)} \tag{3}$$

If value of A =1, then Eq.(3) is simply $\Delta E = \Delta mc^2$, if A >1 then energy emitted more than $\Delta E = \Delta mc^2$ and if A<1 then energy emitted is less than $\Delta E = \Delta mc^2$. Thus $\Delta E = Ac^2\Delta M$ is general equation and $\Delta E = \Delta mc^2$ is its special case. Thus mass-energy equivalence may be stated as

The mass can be converted into energy or vice-versa under some characteristic conditions of the process, but conversion factor may or may not always be c^2 ($9 \times 10^{16}\ m^2/s^2$) or c^{-2}.

Eq.(3) can be obtained by method of dimensions. Let the energy emitted (ΔE) on annihilation of mass, depends upon annihilated mass (ΔM) as dimensions; a, depends upon speed of light c, as dimensions b and depends upon time t as dimensions c. Thus

$$\Delta E \propto (\Delta M)^a c^b t^c \quad \text{or} \quad \Delta E = A\, (\Delta M)^a c^b t^c \tag{4}$$

where A is constant of proportionality and is called Conversion Co-efficient. Hence

$$ML^2T^{-2} = A\, M^a (LT^{-1})^b T^c = A\, M^a L^b T^{-b+c}$$

$$\text{or} \quad a=1,\ b=2 \quad \text{and} \quad -2 = -2 + c \quad \text{or } c = 0$$

$$\text{thus,} \quad \Delta E = A\, \Delta Mc^2\, t^{o} = Ac^2\, \Delta Mc^2 \tag{3}$$

Hence the same result is obtained by the method of dimensions also. The equation may be derived by conceptual derivation or by method of dimensions the constant or co-efficient of proportionality is experimentally measured, even the value of G has been found slightly more than the accepted value in recent measurements, Gundlach et al [5]. Also there are both theoretical and experimental variations in value of c [6-7], as fine structure constant ($\alpha = e^2/\hbar c$) is reported to be increasing over cosmological timescales, implying slowing down of speed of light, c.

2.0 $\Delta E = Ac^2 \Delta M$ in Cosmology

For determination of A, the value of ΔM i.e. mass annihilated in case of heavenly body is required; which can not be directly measured like many other parameters. Thus for simplicity or calibration (standard or reference can be chosen) the magnitude of value of ΔM is regarded as 4.322×10^9kg i.e. mass annihilated in case of sun (luminosity of the sun is 3.89×10^{26} Js^{-1}), thus

$$\Delta M = \Delta E/c^2 = 3.89\times10^{26}\ Js^{-1}/\ 9\times10^{16} = 4.322\times10^9 kg \qquad (5)$$

If for some cases the value of ΔM is experimentally measured then its actual value (ΔM) can be used instead of Eq.(5), which may be regarded as standard value of ΔM. Many more such phenomena like Gamma Ray Bursts (GRBs), quasars etc. may be revealed as innovative precision in investigative measurements is increasing continuously.

2.1 Gamma Ray Bursts

Gamma-ray bursts are short-lived bursts of gamma-ray photons, the most energetic form of light, the origins of the bursts are placed in other galaxies. GRBs are the most energetic events after the Big Bang in the universe and energy emitted is approximately 10^{45} J with the most extreme bursts releasing up to 10^{47} J. In these intense and short (approximately 0.1-100 seconds long) bursts of gamma-ray radiations are emitted and they occur at very distant galaxies (several billion light years away). It implies that for annihilation small mass in short time unimaginably high amount of energy is emitted, which can be explained with help of $\Delta E = Ac^2\Delta M$ with exceptionally high value of A. If for simplicity the value of ΔM can be taken standard as in Eq.(5) as actual estimate of ΔM is not available, then

$$A_{grb} = \Delta E / c^2\, \Delta M = 10^{45}/\ 9\times10^{16}\times (4.32\times10^9) = 2.57\times10^{18} \qquad (6)$$

$$\text{or} \quad \Delta E = 2.57\times10^{18}\ c^2\ \Delta M \qquad (7)$$

Louis de Broglie in 1923 his original and compact research note in French [8] derived dual nature of particle in the following way.

$$hf = m_r c^2 \qquad \text{or} \qquad f = m_r c^2/h \qquad (8)$$

where m_r is relativistic mass of body, f is frequency emitted, h and c are well known constants. From here relation between wavelength (wave property) and momentum (particle property) i.e. $\lambda = h/m_r v$ was deduced. The generalized expression for frequency according to $\Delta E = Ac^2\Delta M$, can be written as ($\Delta E = E_f - E_i = E$),

$$hf = Ac^2\Delta M \qquad \text{or} \qquad f = Ac^2\Delta M/h \tag{9}$$

Thus for annihilation of 1gm (10^{-3} kg) of mass energy produced will have frequency, $A_{grb}1.36\times10^{47}$ Hz or 3.495×10^{65} Hz as value of $A_{grb} = 2.57\times10^{18}$, given by Eq.(6). In the GRBs intense and short (approximately 0.1-100 seconds long) bursts of gamma-ray radiation are emitted; which implies for small mass, in small region, in small time huge amount of energy is liberated. It is direct confirmation for $\Delta E = Ac^2\Delta M$ with very high value of A i.e. for annihilation of small mass, in short time enormous amount of energy is emitted (in this case 2.31×10^{32} J for annihilation of 1gm) compared to Einstein's $\Delta E = \Delta mc^2$ (maximum energy is 9×10^{13}J for annihilation of 1gm of mass).

2.2 Quasars

The observations taken with the 2.5-meter Isaac Newton Telescope at La Palma in the Canary Islands reveals that the quasar is 4 million-billion ($15.56\text{x}10^{41}$ Js^{-1}) to 5 million-billion times brighter than the Sun or this energy is thousand times more than emitted by the brightest galaxy. The most peculiar characteristics of quasar is reported by Arav et al. [9] that this prodigious amount of energy is generated in a small region approximately one light year across. By comparison the diameter of the Milky Way is about 100, 000 light years. It implies corresponding to a small region (a measure of mass and its hence annihilation) mammoth amount of energy is emitted in case of quasars. $\Delta E = Ac^2\Delta M$ is useful in explaining such aspects.

According to Wilkes and Vestergaard [10-11] that the mass of the quasars with the most massive black holes would be around a few*10^{12} times the mass of the sun (order of 10^{42} kg),but exact estimates are not available The energy emitted by quasar in life time of 1 billion year is $4.93\text{x}10^{58}$J, which implies mass annihilated according to $E = \Delta mc^2$ is equal to $5.48\text{x}10^{43}$kg, which is equal to mass of nearly 55 galaxies (mass of Milky Way galaxy is 10^{42}kg). Thus value of A in case of quasar (A_{qu})

$$A_{qu} = \Delta E / c^2\ \Delta M = 15.56\times10^{41}Js^{-1}/9\times10^{16}\times (4.32\times10^{9}) = 4\times10^{16}$$

With this value of the generalized form of mass-energy equivalence becomes,

$$\Delta E = 4\times10^{16}\ c^2\ \Delta M \tag{10}$$

Thus for small mass, according to Eq.(10) energy emitted is 4×10^{16} times more than $\Delta E = \Delta mc^2$, with high value of A. Thus corresponding to small mass (size) energy emitted is more thus comparatively smaller quasars are feasible. So in small region even when small amount of mass is annihilated, huge amount of energy is emitted. The lower limit of quasars mass is not yet determined, Vestergaard [12] . It is further justified from the fact that the quasars possibly or inexorably ending as super massive black holes, presently the maximum mass of the order of 2×10^{40} kg, Vestergaard [11]. Thus in spite of emitting huge amount of energy in own life time, significant amount of matter is remnant in quasar and which are expected to behave like super massive black hole. Normally a black hole having mass equal to 10 solar masses possesses radius 30km, thus having density of the order of 10^{18}kg/m^3, and even light cannot escape from them.

It can be concluded that to attain such state quasars must under go series of large number of exceptionally intense compressions utilizing energy produced in itself. But energy used for this purpose is not taken in account in current measurements of luminous energy, implying that total energy (including measurable and immeasurable) is far higher than current estimates i.e. A_{qu} may be more than 4×10^{16} (it is only for luminous energy) This large amount of energy emitted by quasar and other heavenly bodies is consistent with $\Delta E = Ac^2\Delta M$ with higher values of A. Similarly energy emitted by supernova and other bodies can be explained. Thus according to this equation more energetic and abundant such explosions in universe are feasible and universe is more long lived.

Table I: The values of Conversion–Coefficients (A) for various heavenly bodies and phenomena.

Sr. No	Event emitting energy	Energy (Joules)	ΔM (kg)	$A=\Delta E / c^2 \Delta M$
1	Sun	3.89×10^{26}	4.32×10^{9}	1
2	Gamma Ray Burst	10^{45}	4.32×10^{9}	2.57×10^{18}
3	Quasar	15.56×10^{41}	4.32×10^{9}	4×10^{16}
4	Supernova	$5x\times10^{35}$	4.32×10^{9}	1.286×10^{9}
5	Bright Star	2.73×10^{31}	4.32×10^{9}	7.02×10^{4}
6	Before Universe	10^{-4444}	4.32×10^{9}	2.568×10^{-4471}

3.0 Creation of Mass of the Universe (10^{55} kg) before Big Bang

The Big Bang Theory assumes that initially (t=0) whole mass 10^{55}kg of universe was infinitely compact and in singular state enclosing a space even smaller than an atomic particle instantaneously exploded in gigantic detonation (various heavenly bodies figured) and ever since the universe is expanding, Hawking [13]. How the whole mass of universe was formed and condensed to infinitely compact point? How explosion was triggered causing expansion, reduction in temperature and density drastically? Which source provided energy for these events? Why universe of mass 10^{55}kg, instead of getting into a point mass of density of undreamt magnitude did not start moving away in the beginning itself? Like this that energy would have been saved which was consumed in making universe a point mass and causing explosion.

Currently, transformation of mass to energy or vice-versa is explained with $\Delta E = \Delta mc^2$ i.e. a gamma ray photon of energy at least 1.02 MeV (1.623×10^{-13} J) gives rise to electron and positron pair (18.2×10^{-27} kg) consistent with it. The mass of universe is estimated to be nearly 10^{55} kg, thus as above it must have been materialized from energy ($\Delta E=\Delta mc^2$) i.e. 9×10^{71}J. Further additional energy (which may infinitely large i.e. unimaginably high to be appraised) is required to change mass 10^{55}kg *into a point of exceedingly high density*, and *raise the temperature*, trigger an explosion and to impart *kinetic energy* to it (even now accelerating outward continuously). Now it has to be assumed that energy 9×10^{71}J and spectacular amount of additional energy (may be infinitely large amount of energy for above events) as mentioned above is created from nothing or naught or cipher automatically and spontaneously. The law of conservation of energy does not permit creation of mass out of nothing at all, hence the law was not obeyed at that stage. How the energy of the order of 9×10^{71}J was produced? How the energy materialized to mass (a gamma ray changes into electron–positron pair when passes near the field of nucleus)? All these intrigues are neither answered by detractors nor adherents of Big Bang Theory, and are open for plausible elucidation.

The generalised equation predicts that in this primordial bang (exceptionally-2 super special event) , diminishingly small pulse of energy, say 10^{-4444} J (or less) equivalent to 2.4×10^{-4443} calorie (or less), can manifest itself in mass 10^{55}kg if the value of A is regarded 2.568×10^{-4471} .The energy 10^{-4444} J or less is regarded as to exist inherently in the universe, even when there was no material particle or when process of formation of space started. The assumption of existence of such diminishing small energy is consistent with various theories, such as Steady State Theory believes that mass is being continuously created out of nothing, but in existing space.

The primordial value of conversion coefficient A_{uni} : Now the value of various parameters can be written as

$$A_{uni} = 10^{-4444}/9\times10^{16}\times4.32\times10^{9} = 2.568\times10^{-4471} \text{ or } \Delta E = Ac^2\,\Delta M = 2.568\times10^{-4471}\,c^2\,\Delta M \quad (11)$$

Thus $\Delta E = Ac^2\Delta M$, is the first equation which at least theoretically predicts that universe (10^{55}kg) has been created from minuscule or immeasurably small amount of energy (10^{-4444}J or less, which may be easily available compared to 9×10^{71} J).Whereas $\Delta E=\Delta mc^2$ predicts that mass of universe (10^{55}kg) has originated from mammoth energy i.e. 9×10^{71} J (plus additional energy as cited above) . Thus the generalised equation explains the origin of mass of universe with ease and simplicity; and in addition universe is more long lived than present estimates.

4.0 Discovery of Particle having Mass Less than Predicted Mass

Recent work at SLAC confirmed discovery of a new particle dubbed as Ds (2317) having mass 2,317 mega-electron volts. But this mass is far less than current estimates, is a mathematical puzzle [14]. This discrepancy can be explained with help of equation $\Delta E = Ac^2\ \Delta M$ with value of A more then one.

The annihilation of matter and antimatter or vice-versa is explained by $\Delta E = \Delta mc^2$ and experiments are being continuously conducted in this regard [15]. In case at some stage more anomalies (i.e. magnitude of mass converted into energy in annihilation of matter and antimatter or vice-versa is observed less or more than predicted by $\Delta E = \Delta mc^2$ are observed then it would further serve as an evidence in favour of $\Delta E = Ac^2\ \Delta M$.

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References

1. Hasenohrl, F. *Annalen der Physik*, 15 344 (1905).

2. Einstein, A. *Annalen der Physik* 18 639-641 (1905).

3 Sharma, A. *Proceedings of International Conference on Computational Methods in Sciences and Engineering* 2003, World Scientific Co. Singapore, 585-586 (2003).

4. Sharma, A Accepted for presentation in various international conference.

5. J.H. Gundlach, E.G. Adel Berger, B.R. Heckel, and H.E. Swanson, *Phys. Rev. D* 54, 1256R (1996).

6. T.M. Davis & C. Lineweaver, *Nature* 418, 602 (2002).

7. L. J. Wang, A. Kuzmich, and A. Dogariu, *Nature* 406, 277-9 (2000).

8. Louis de Broglie, *Comptes rendus*, Vol. 177, 1923, pp. 507-510].

9. Arav, N., Korista, K.T., Barlow, T.A. and M.C. Begelman, *Nature*, Vol. 376, pp.576-578 (1995).

10. Wilkes, B. (Harvard/Smithsonian,Center for Astrophysics) scientific communication dated 15 Nov 2003.

11. Vestergaard, M to be published ApJ in Jan 2004 issue 2004.

12. Vestergaard, M (Ohio State University, Department of Astronomy) in scientific communication.

13. Hawking, S. *A Brief History of Time* (Bantum Books, New York) p 121-130, 1988.

14. The BaBar collaboration Observation of a Narrow Meson Decaying to Ds+pi0 at a Mass of 2.32 GeV/c^2.
Preprint, http://arxiv.org/abs/hep-ex/0304021 (2003).
15 Amoretti, M *Nature* 419, 456 - 459 (2002).

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