Gene H. Barbee
July 2014

On Cosmology, Time and the Second Law of Thermodynamics

Abstract

The first law of thermodynamics is fairly straightforward. It states that energy can be converted from one form into another but not created or destroyed. The author's work on the subject indicates that net energy is zero [6][7][13] but separated into two different types of energy that balance one another. The second law is not as straightforward. A quantity called entropy describes the probability of energy states for systems with many particles. The second law states that more probable energy states become filled over time and energy differences that can be used to carry out work become less available. How everything achieved a high state that can continually "run down" has been somewhat of an enigma.

There is a strange situation in fundamental physics regarding time. Well respected physicists [Julian Barbour for example] point out that all quantum mechanical equations are cyclical with time. Common sense tells us that time advances and tension exists between fundamentals and what we observe. This situation extends to fundamentals of space as well as fundamentals of time. Special relativity and curvature of space time is known to be the source of gravity at the large scale but efforts to understand quantum gravity encounter significant theoretical difficulties.

The author uses a cellular model that describes gravity, space, time, expansion, kinetic and potential energy at the quantum level [6][7]. Using cosmology as a platform, the present paper explores time and the second law. It concludes that time advances because expansion converts kinetic energy to potential energy. Further, the gravitational coupling constant appears to convert quantum behavior to large scale behavior. Although pressure expands the universe, gravitational accumulation begins to dominate locally. The improbable expanded state and the many states available related to gravitational accumulation explain how everything can "run down" as time progresses.

Gravitation

Using a small cell of radius r to simulate a large radius R (literature would call this the radius of the universe) is critical to understanding cosmology. In this model, the universe is filled with the *surface* of many small cells that are equivalent to the *surface* of one large sphere. This is important conceptually because we can be inside the universe (something we all observe), each surface can be identical and the concept that there is no preferred location can be preserved. The model proposed is based on exp(180) cells, each associated with a proton like mass.

The derivation of a coupling constant for gravitation from reference 7 is reviewed below. Let small r represent the radius of a many small spheres and large R represent the same surface area of one large sphere containing exp(180) spheres. There is one proton like mass (m) on the surface of each cell. The mass of the universe M equals m*exp(180). The laws describing each particle are no different than any other particle. Geometrically, many small cells with the same combined surface area offer this feature. General relativity uses the metric tensor (ds^2)[4]. The surface area of a 2-sphere is broken into many small spheres with an equal surface area, i.e. r=R/exp(90). The total energy will be that of a proton mass/cell plus a small amount of expansion kinetic energy. Based on geometry, two substitutions are placed in the gravitational constant G below, i.e. M=m*exp(180) and R=r*exp(90).

	Area=4 pi R^2			
	Area=4 pi r^2*exp(180)			
	A/A=1=R^2/(r^2*exp(180)			
	R^2=r^2*exp(180)			
	R=r*exp(90)			
	M=m*exp(180)			
Large space G		cellular size G		
RV^2/M	G=G	rv^2/m	r is the cell radius	
R'V^2/M	G=G	r'v^2/m	r' is the proton size geodesic	
R'=r*('v/V)^2*(M/m)*1/exp(90)				
	RV^2/M=	r*exp(90) *v^2/(m*exp(180))		
		G=(r *v^2/m)*1/exp(90)		

For G to be equivalent between many small cells and one large sphere the geodesics of cells must be multiplied by the small factor 1/exp(90). This value is the gravitational coupling constant for a cell that has cosmological properties, i.e. the force is shared with exp(180) particles on a surface that is 1/exp(90) of the total surface.

Fundamentals of space and time

Reference 6 identifies the source of the gravitational constant at the quantum level. The gravitational field energy 2.683 MeV from the Proton Mass model (Appendix) underlies the quantum mechanics for a fundamental radius r and a fundamental time t. In the equation below, the value 1.93e-13 meters-MeV is HC/(2*pi) where H is Heisenberg's constant 4.136e-21 MeV-sec and C is light speed, 3e8 meters/sec. The radius r is the radius of a quantum circle for gravity with 2.68 MeV field energy.

Identify the radius and time for the gravitational orbit described above

Fundamental radius=1.93e-13/(2.68*2.68)^.5=7.354e-14 meters

Fundamental time=7.354e-14*2*PI()/(3e8)=h/E=4.13e-21/2.68

Fundamental time 1.541E-21 seconds

If radius r for the conventional physics force calculation is 7.35e-14 meters, as proposed above, the force in Newtons (NT) is:

F=(5.9068e-39)*hC/R^2				
	hbar		6.5821E-22	mev-sec
	hbar in NT-m-sec		1.05E-34	NT m sec
	hbarC in NT-m^2=K		3.16E-26	NT m^2
F=(5.9068e-39)*K/R^2				
F=(5.9068e-39)*3.16e-26/(7.35e-14)^2=3.39e-38 NT				
3.453E-38	NT			

This result agrees with the simple Newtonian force for particles separated by 7.35e-14 meters.

F=Gm^2/R^2 (NT)=6.67428e-11*1.6726e-27^2/7.35e-14^2=3.452e-38 NT where m is proton mass and R is meters.

Using values for the proton mass model that the author believes unify nature's forces (6), the gravitational constant is calculated below and agrees with the published constant, G=6.674e-11 NT meters^2/kg^2. The gravitational coupling constant 1/exp(90) derived above appears in the fundamental calculation for the inertial force in a cell that has cosmological properties.

GRAVITY			
			proton
Proton Mass (mev)			938.272
Proton Mass M (kg)			1.673E-27
Field Energy E (mev)			2.683
Kinetic Energy ke (mev)			9.720
Gamma (g)=M/(M+ke)			0.9897
Velocity Ratio v/C=(1-g^2)^0.5			0.1428
R (meters) =(HC/(2pi)/(E*E)^0.5			**7.354E-14**
F (NT)=M/g*(v/C*C)^2/R/exp(90)			3.452E-38
HC/(2pi)=1.97e-13 mev-m			
Calculation of gravitational constant G			
Inertial Force=(M/g*C^2/R)*1/EXP(90)			3.452E-38
Radius R (Meters)			7.354E-14
Mass M (kg)			1.673E-27
G=F*R^2/M^2=NT m^2/kg^2			**6.674E-11**
Published by Partical Data Group (PDG			6.674E-11
PE fall MeV			19.34
Ke fall MeV			9.720
F =PE/R *1.6022e-13 NT			3.4524E-38
PE/R=(19.34*1.603e-13/7.3543e-14/exp(90))			

The use of 1/exp(90) and Heisenberg's uncertainty principle has the affect of dramatically reducing the force between protons and makes gravity very long range compared to the other forces.

The author believes that the space we walk around in is defined by gravity at the quantum level (r=7.35e-14 meters) with each cell expanded to a present radius of about 0.55 meters/cell. In three dimensions exp(180) cells give large R=0.55*exp(60)=6.1e25 meters. Further, the author believes that the time we experience is the cycle time 1.54e-21 seconds repeated many times since the beginning. In other words, a quantum mechanical time is defined that cycles and counts forward (cycle time*exp(N)). Defining gravity, time and distance together allows nature to use the special theory of relativity at the quantum level. The coupling constant 1/exp(90) scales the quantum level to the large scale we observe around us.

Expansion

Consider for a moment why the universe expands. Kinetic energy (ke) must be turned into gravitational potential energy (pe=Fr) over *time*. Time enters physics through cosmology! The derivation below indicates that the increasing radius of the universe and increasing time are related through expansion.

ke	pe
ke	F r
1/2M(v)^2	GMM/r
1/2M(r/t)^2	GMM/r
1/2Mr^3/t^2	GMM
1/(2GM)*r^3	t^2

(r/r0)^3 increases as (t/t0)^2

(r/r0)^3 increases as (t/alpha)^2 (kinetic energy requirement)

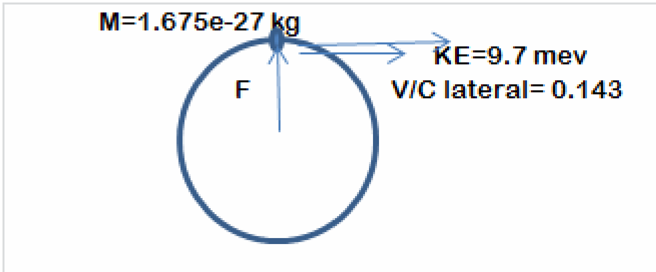
Expansion of each cell involves the kinetic energy of a proton like mass on the surface of each cell. The model's geometrical and numerically similarity allows many small cell surfaces to represent large scale cosmology.

Cell diagram

Initial cell radius is 7.35e-14 meters. Initial forces in the cell are balanced and are 3.45e-38 Newtons. With an initial kinetic energy of 9.8 MeV, the initial expansion velocity can be calculated.

Gamma (g)=938.27/(938.27+9.8)=0.9897

V/C=(1-0.9897^2)^.0.5=0.143.



PE expansion=integral F dR
KE=mv^2/2

Cell diagram showing tangential kinetic energy

Kinetic energy decreases (and gravitational potential energy increases) as expansion occurs. The derivation below is based on gravitation constant G remaining constant.

G remains constant G=rv^2/(M)

RV^2/(M/g)=rv^2/(M/g0)	**RV^2/M=rv^**	**9.75 ke**
RV^2*g=rv^2*g0	**RV^2=rv^2**	
(v/V)^2=(r/R)*g0/g	**(v/V)^2=(r/R)**	
(v/V)=(r/R)^.5*(g0/g)^.5		
ke=ke0*(r/R)	**Ke decreases with r**	

Kinetic Energy decreases with Expansion

Important values originate in the proton model. The model shows protons with about 20 MeV that fall into "orbits" with 9.8 MeV of kinetic energy and 9.8 MeV of potential energy. Initially the mass on the cell surface has high velocity (0.14C) that gives an inertial force equivalent to gravity. Tangential kinetic energy (diagram above) decreases directly with expansion ratio and defines an orbit that maintains the gravitational constant at G. This "orbit" is again a model since it will be shown below that temperature and pressure associated with kinetic energy drive expansion. After expansion, potential energy allows protons to fall (accelerate) toward each other and establish orbits as mass accumulation occurs. It is this energy that we see when orbits are established around galaxies and planetary systems. It is also this energy that provides pressures and temperatures high enough to initiate fusion.

The goal below is to model expansion of a small cell that provides values scalable to the universe.

Nomenclature

(all calculations are MKS)
t-time
g=dimensionless time=time/alpha time
Lower case r is a cell radius
Upper case R=r*exp(60)
R1 radius is first expansion component
R3 radius is second expansion component
H3 is Hubble's constant for R3

First expansion component; R1

(r/r0)^3 increases as (t/alpha)^2 (kinetic energy requirement)

r=r0*g^(2/3)

R=r0*exp(60)*g^(2/3)

r0=1.93e-13/(2.683*2.683)^.5=7.35e-14 m

R1=(7.35e-14*exp(60))*g^(2/3)

Second expansion component: R3

dr/(r*dt)=H3

dr=H3*r*dt

dr=H3*alpha*r *dg (dt=alpha dg)

dr=H3*alpha*r0*g^(2/3) *dg

r=H3*alpha*r0*g^(5/3)/1.6666

R3=H3*alpha*(7.35e-14*exp(60))*g^(5/3)/1.666

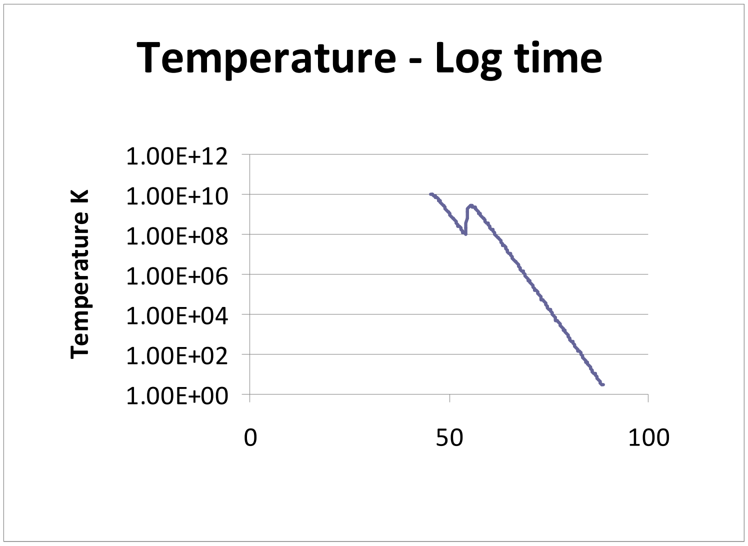
r1+r3=(7.35e-14)*g^(2/3)+(7.35e-14)*g^(5/3)*H1*alpha/1.666

R1+R3=r1*exp(60)+r3*exp(60)

Integral dr adds a late stage term that expands with time, after integration, raised to the power (5/3). The equations are consistent with the cold dark matter cosmology model described by Pebbles [4] with constants determined by the COBE, WMAP [5] and PLANCK missions.

Thermodynamics and expansion

The Boltzmann relationship T(K)=ke/(1.5 B) with B=8.62e-11 MeV/K assigns a temperature to kinetic energy. Cosmologists use the expansion ratio z to scale temperatures and the x axis is the natural logarithm 45 progressing to about 90. Large scale time is approximately exp(88.5)*1.54e-21seconds= approximately 14 billion years presently. The discontinuity in temperature is explained in reference 12.



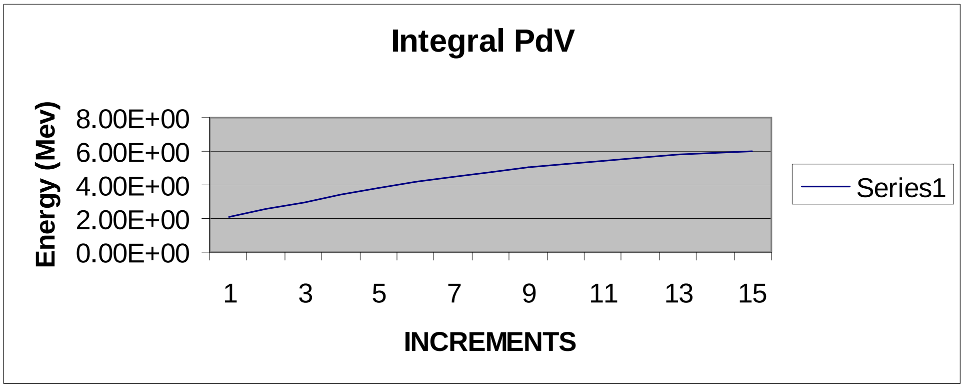
There is a critical concept at stake that needs our understanding. If the kinetic energy is temperature, it is no longer limited to a surface. Particles with kinetic energy bounce off of one another and create pressure. Is it this pressure that expands the universe? Can the particles fill all of space or are they quantum like and limited in their travel. If we calculate what a gas would do perhaps we can answer the above two questions.

The gas constant R, is 8.317 Joule/K/Mole. (Joule=NT-m and 1000 Mole/Kg for H). If we assume an ideal gas for hydrogen the gas constant R=8317 NT-m/K/Kg and the pressure would be:

P=8317*density*temperature (NT-m/K/kg*kg/m^3*K=NT/m^2) where density is kg/m^3 and temperature is degrees Kelvin (K).

With density based on one proton for half the cells (the other half is probably cold dark matter [7]) and an initial radius of 7.35e-14 meters, the above initial pressure is 2.97e26 NT/m^2 where initial temperature=7.58e10 K.

Volume/cell (m^3)		1.67E-39	2.72E-39	4.43E-39	7.24E-39	1.18E-38
Density (kg/m^3)		5.02E+11	3.08E+11	1.89E+11	1.16E+11	7.09E+10
Temperature (K)		7.56E+10	1.01E+10	1.08E+10	1.05E+10	9.84E+09
Pressure (NT/m^2)		2.97E+26	2.44E+25	1.60E+25	9.54E+24	5.46E+24
Pressure (lb/in^2)			3.54E+21	2.32E+21	1.38E+21	7.92E+20
Pdv (MeV)			2.11E+00	4.33E-01	4.47E-01	4.28E-01
Integral Pdv (MeV)	6.6		2.11E+00	2.55E+00	2.99E+00	3.42E+00



The integral of Pdv quickly saturates at a level consistent with the initial kinetic energy of 9.8 MeV (the gas is not ideal and the constant is somewhat uncertain). Overall, pressure can be considered the driver for expansion. The net affect is the proton receives gravitational potential energy against a resisting gravitational force.

Transition from quantum behavior

In quantum mechanics, particles move in circles and are statistically "everywhere" at once on a surface and movement into the interior of the sphere that defines them is very limited. For example, the electron does not normally move inside the sphere 5.29e-11 meters and if it is forced to, it is called relativistic or de-generate. Pressure is the collective action of particles with kinetic energy (temperature) that bounce off of each other in all directions. The fact that protons are colliding and able to move throughout the space created by expanding the fundamental radius 7.35e-14 meters indicate that a critical transition has occurred. Protons enter the radius that defines gravity and pressure expands space itself. Particles now exhibit non-quantum behavior (perhaps because the force is now very low and it is easy to force particles into the interior of the volume). Apparently the transition is associated with 1/exp(90) that weakens and extends the gravitation force.

Entropy changes during expansion

In the author's view inflation from the compact original state was the duplication of improbable particles P=1/exp(180) by exp(180) that preserved the original probability 1 state.

P=1=1/exp(90)*1/exp(90)*exp(180)

Thermodynamics is the physics of groups of particles. Entropy, S is defined as follows [1] and helps characterize the second law of thermodynamics.

The cyclic integral of change in heat energy/divided by temperature is equal or less than S where S is defined as entropy, i.e. cyclic integral of dQ/T< or = dS.

The change in the entropy of a system as it undergoes a change of state may be found by integrating: S2-S1= integral (dQ/T) from state to 1 to state 2 [1]. The overall change in dQ/T will always be less than entropy dS. In other words entropy, defined this way, always increases. There is a limiting (ideal or reversible) condition where entropy might be equal.

In thermodynamics we expect the equation Tds=du+Pdv to be satisfied [1]. For expansion, the internal energy term (du) is 9.8 MeV [9] and decreases as Pdv increases to about 9.8 MeV. This leaves Tds zero if there is ideal conversion of kinetic energy to potential energy. If it is slightly non-ideal, TdS will have a low positive value. For Tds to remain low during expansion the term dS would increase dramatically to account for the decrease in temperature from 8e10 K to 2.73 K.

Relationship between entropy and probability

In some thermodynamic texts S=-ln P where P is probability. Information theory uses this convention [2][3]. A negative natural logarithm can be confusing. Remember that improbable states contain more information (S). When P is low, S is high and decreases to zero when probability is 1. In thermodynamics, this convention allows energy TdS to be positive but dS is always decreasing. (Actually temperature is energy and dS is information about the energy state).

P	S=-ln P
1	0
0.1	2.302585093
0.01	4.605170186

Expansion and entropy

After expansion, a very improbable (high information) state has been established. Expanded particles separated from one another are ready to fall to low energy (more probable) states. The thermodynamics of a gravitational potential has not been developed to the author's knowledge. Think about it this way. The protons can now fall and gain kinetic energy (temperature). If they fall into large bodies the temperature and pressure can become so high that they fuse, subsequently explode spewing out elements [10] that can combine into molecules and life [13]. Conventional thermodynamics describes the behavior of gases that gathers around planets and stars. There are a lot of potential states awaiting particles that fall due to gravitation potential. Thermodynamics and entropy count states and probability is the ratio of the state divided by all the states available. A particle that has not fallen into the states available is very improbable. In fact it must lose energy to fall from its geodesic.

Freedom to accumulate due to gravity

Expanded particles do not simply reverse expansion as they fall due to gravitation. Normally gravity is not an important force in pressure and temperature changes considered by thermodynamics (it can be important in the thermodynamics of weather). Again, pressure is the collective action of particles with kinetic energy (temperature) that bounce off of each other. At about 200K years after the beginning a condition known as equality [4][5] of photon density and matter density occurred and particles started to be affected by gravity. Initially, gravitational accumulation was aided by acoustic waves but as particles collided, their gravitational attractive forces started to dominate and particles no longer behaved like gases that we are familiar with. The pressure at equality was about 5e-8 psi (pounds per square inch) and the temperature was 9100 K. The gas was low pressure plasma. A later critical juncture in thermodynamics occurred as the plasma cleared (this condition is called decoupling and electrons assume orbits around protons). The temperature at this point was about 3300 degrees K and the pressure was 6e-14 psi. At the present time it is 3.7e-27 psi and 2.7 K.

The universe also contains cold dark matter. In the author's work [13], cold dark matter is proton like except it does not interact like normal matter. However, it is gravitationally active and this aids accumulation. Apparently it never acts like a gas and is free to accumulate earlier than normal matter.

Conclusions

Time enters physics through cosmology. Particles have kinetic energy in the beginning that must be converted to gravitational potential energy. Time cycles at the quantum level but at the large scale is forced to count forward. The cycle time for one count is the fundamental time defined by quantum gravity.

The space we walk around in is defined by gravity at the small scale but through expansion and the gravitational coupling constant gravity also defines large scale space time.

Expansion and critical transitions create conditions for the second law of thermodynamics. Firstly, although quantum mechanics and the proton model define kinetic energy in the gravitational orbit, it is pressure and temperature that expand the universe. Rather than being limited to a quantum mechanical orbit, particles are free to move throughout space because the coupling constant 1/exp(90) reduces and extends the force between particles. After two early transitions (equality of photon and mass density and decoupling of electrons [11]), gravitation is locally able to dominate gas pressure. This gas does not act like the one that thermodynamics normally describes. The particles are gravitationally "sticky" and small accumulations of matter grow and eventually form clusters, galaxies, stars and planets [8][13].

After expansion there are many potential states for particles to fall into. Particles that have not fallen have maximum potential but are very improbable. As they falls into the many probable states below, the second law of thermodynamics describes their behavior.

References

1. Gordon J. Van Wylen, *Thermodynamics*, New York: John Wiley & Sons, Inc., 1959.
2. Brillouin, L., *Science and Information Theory*, New York: Academic Press, Inc., 1956.
3. Shannon, Claude. A mathematical Theory of Communication, 1948.
4. P.J.E. Peebles, *Principles of Physical Cosmology*, Princeton University Press, 1993.
5. Bennett, C.L. et al. *First Year Wilkinson Microwave Anisotropy Probe (WMAP) Observations: Preliminary Maps and Basic Data*, Astrophysical Journal, 2001 L. Verde, H. V. Perris, D. N. Spergel, M. R. Nolta, C. L. Bennett, M. Halpern, G. Hinshaw, N. Jarosik, A. Kogut, M. Limon, S. S. Meyer, L. Page, G. S. Tucker, E. Wollack, E. L. Wright
6. Barbee, Gene H., *A Top-Down Approach to Fundamental Interactions*, FQXi essay, June 2012 and vixra:1307.0082 revised Mar 2014. Reference Microsoft ® spreadsheet Unifying concepts of nature.xls.
7. Barbee, Gene H., *On the Source of the Gravitational Constant at the Low Energy Scale*, vixra:1307.0085, revised Feb 2014. Prespacetime Journal Vol. 5 No. 3 March 2014.
8. Barbee, Gene H., *Application Proton Mass Model to Cosmology*, vixra:1307.0090, revised Mar 2014. Reference spreadsheet simple1c.xls.
9. Barbee, Gene H., *On Expansion Energy*, *Dark Energy and Missing Mass*, Prespacetime Journal Vol. 5 No. 5, May 2014. Previously vixra:1307.0089, revised Mar 2014.
10. Barbee, Gene H., *Semi-Fundamental Abundance of the Elements*, vixra:1308.0009, revised Nov 2013.
11. Bergstom, L. and Goobar, A., *Cosmology and Particle Astrophysics*, 2nd Edition, Springer-Praxis Books in Astrophysics and Astronomy, 2004.
12. Barbee, Gene H., *The Effect of He4 Fusion on Primordial Deuterium*, vixra:1404.0465, May 2014.
13. Barbee, Gene H., *The Language of Nature*, Amazon books, May 2014.

Appendix

The Proton Mass Model

Mass and Kinetic Energy					Field Energies	
Mass	Difference ke	Strong residual ke	Neutrinos	Expansion ke	Strong & E/M	Gravitationa
mev	mev	mev	mev	mev	field energy	Energy
101.947	641.880				-753.29	
						-0.69
13.797	78.685				-101.95	
						-0.69
13.797	78.685				-101.95	
						-0.69
		10.151		20.303	expansion pe	
				0.000	expansion ke	
0.000	0.000	-0.671	0.671	v neutrino		
129.541	799.251	**938.272013**	**PROTON MASS**			
0.511	0.111	e neutrino			5.44E-05	-0.622
ELECTRON		2.47E-05				
130.052	0.111		0.671	20.303	-957.185	-2.683
		1.673E-27		Total m+ke	Total fields	
				Total positive	Total negative	
				959.868	-959.868	0.00E+00

Values extracted from the model above unify nature's forces:

	Mass (m) (mev)	Ke (mev)	gamma (g)	R meters	Field (E (mev)
Gravity	938.272	9.800	0.9897	**7.3543E-14**	-2.683
Electromagnetic	0.511	1.36E-05	0.99997	**5.2911E-11**	-2.72E-05
Strong	129.541	799.251	0.1395	**2.0928E-16**	-957.18
Strong residual	928.121	10.151	0.9892	**1.4297E-15**	-20.303