Title: Negative Mass, the e-dimensional Universe and the Hubble Tension

Author and Discoverer: Rajib Kumar Bandopadhyay

Abstract: In the earlier paper, *The Absence of the Implications of Negative Mass and the Resultant Problems in Physics*, various insights on different kinds of matter and the existing ideas such as the Dark Matter and the Dark Energy were presented. The article, *Non-Stellar Black Holes, including microscopic Black Holes*, brings into attention a very pertinent aspect overlooked by all earlier researchers. The present article probes further into such various overlooked aspects of our universe. Various other important inferences are drawn from the said model that seem to agree to the experimental results better than the existing models, such as the possible reason for Hubble Tension.

Introduction:

In the earlier paper, *The Absence of the Implications of Negative Mass and the Resultant Problems in Physics*[(1)], various insights on different kinds of matter and the ideas such as Dark Matter, the Dark Energy, anti-gravity, pratiparticles (conjugate particles with opposite or zero charges but with opposite masses, +ive and -ive), etc., were presented and analysed in details.

The hypothesis of the Residual Potential Energy and an Infinite Upper and Lower Continuum of Particles and Fields[(1)(2)] indicates a Universe that is beyond the four forces and the Standard Model. This Universe is represented by an Infinite Upper and Lower Continuum of Force, Energy, Mass, Charge, etc., and other Measurable quantities, distributed in a Scale along an infinite Order of length, volume, Field Strength, Mass Density, etc., a *fractal*[(4)] existence at a glance.

The article, *Non-Stellar Black Holes*[(5)], derives a relationship between c, the speed of light, m, the mass of a physical body, G, the Universal Gravitational Constant and r, the radius of the sphere around that massive body for which light can’t escape the gravitational influence of the said body, similar to the Schwarschild Radius for a massive star that has become a Black Hole. The uniqueness of the said paper is in its indication that rather than a particular limiting mass or the radius of its total containment, the determining value for a non-stellar Black Hole is the density for the said mass distribution confined within a particular volume for that mass distribution to be a Black Hole.

The article, *Non-Stellar Black Holes*[(5)], brings into attention a very pertinent aspect overlooked by all researchers. It shifts the focus from the emphasis on the limiting Stellar Mass to end up as a Black Hole at the end of the stellar fuel exhaustion to sustain the nuclear fusion to any arbitrary mass, and *from* a limiting *Mass* to a limitng

Mass density, and a specific limit for that mass density to exist as a Black Hole, even when microscopic. In other words, the emphasis shifts from Mass to Mass Density. This one aspect leads to an unification possible between Gravity and the other forces.

It appeared very strange indeed that neither Schwarzschild, nor Einstein, nor any other original researchers derived the simple and straightforward equation directly from the *Principle of Equivalence* that preceeds the development of the *General Theory of Relativity*.

The article, *The Absence of the Implications of Negative Mass and the Resultant Problems in Physics*(1), and its parent copyrighted article, *Inadequacies of the existing interpretation of the quantum phenomena, and the hypothesis of RePInULCoPaFil*(2), indicate a flaw in the interpretation of the Dirac's solution for a charged particle, and indicates that other than conjugate antiparticles, i.e., particles with same positive mass but opposite charge, there is also an identical possibility of conjugate Pratiparticles, i.e., particles with an opposite or zero charge and opposite mass. The said article draws its contents from the copyrighted book, Inadequacies of the existing interpretations of the quantum phenomena, and the hypothesis of RePInULCoPaFil, copyrighted in 2003.

The present article probes further into such various overlooked aspects of our universe, and various other important inferences are drawn from the said model.

Orders of smallness:

Let A be the magnitude of a quantity. A small fraction 'n' of A, say a millionth A/(10^6) part of A, is negligibly small in comparision to A. A millionth of a millionth of A, i.e., A/(10^12), would again be negligible in comparision to A/(10^6), and the logic could be extended indefinitely. We thus obtain a series in which each is negligible small in comparision to one prededing it, but very large compared to the one following it. The series is A, A/(10^6), A/(10^12), A/(10^18)…. Such an arrangement of a magnitude and its fractions with the above-stated property between the neighbours gives us what we call a scale of smallness. But we should remember that smallness or largeness are comparative terms and retain their meaning as long as there are two or more quantities in question, and they are compared. A quantity by itself is neither large nor small.

The fraction 'n' need not have a fixed value. All that we require is that 'n' should be negligibly small compared to 1. Again, what value of n may be considered negligibly small depends on the circumstances and accuracy we expect to achieve. But the series A, nA, n^2A, n^3A, n^4A, … constitute a scale of smallness. nA, n^2A, n^3A, n^4A, … are called small quantities of the first, second, third, fourth, … orders respectively. n, n^2 (=n multipled with n), n^3 (= n^2 multiplied with n), n^4 (= n^3 multiplied with n), etc., … are small fractions of first, second, third, fourth, … orders. The quantity A and 1 are the zeroth order terms.

This concept would we subsequently use in quantitatively visualising the new premises.

Our observation is that particles give rise to field, and fields give rise to particles, and for the sake of continuity and symmetry in the laws of Physics the chain should continue. Why is this so? The most generalised (and simple) reason behind this is that particulate interactions are far from being exact, and the field-particle conglomerate never achieve an absolute, zero potential energy configuration. They only achieve a minimum potential energy by arriving at a particular configuration, leaving behind enough energy for the field-particle conglomerate to interact further. Only, that the interaction may seem exact and complete in our experimental devices. Thus we can conclude that there indeed is a requirement for a hypothesis of residual potential and existence of Infinite upper and lower continuum of particles and fields (let us use the acronym: RePInULCoPaFil), one building on the other.
Thus a particle wave function may be thought to be represented by an equation as follows:
$\Psi = \Psi(G, E, B, S, W, \ldots$ infinite no. of terms.$)$ – (1)
Therefore, the particle represented by Ψ would have infinite scopes (or degrees) of freedom. We would have to truncate the number of terms, i.e., impose a completeness condition, according to our requirement.
And corresponding Hamiltonian may have the form:
$H = G+E+B+S+W+\ldots$infinite no. of terms – (2)

So we see that the question of a *Grand Unified theory* is rendered both irrelevant and trivial. At one scale it may seem that Electric, Magnetic and Van Der Waals energy are all different, but at some other scale they are just different manifestation of the same force. Similarly, we who expect a GUT of everything would find upon adequate contemplation that it was part of something more unified energy, as we go down this ladder of hierarchy, or go higher up. Also, if we look much further beyond the present scales of observation we are likely to comment that Big Bang might not be as unique as it seems now. It is only that our tools for direct and indirect observation has not been refined enough to reach beyond the site of origin for the Big Bang.

The proposal of Subhas Kak[3] could be utilised to identify the coefficients of the lower and the higher order terms of the wavefunction and the terms of the Hamiltonian individually, in order to determine each term and energy values quantitatively so that the dimensionality of the wavefunction could be renormalised to correlate with the value e, the Euler's number, numerically **2.71828... .** Further future experimentations could be designed to determine if the lower order terms introduce matter and charge of a determined quantity to a system to be quantified.

In such a physical world represented by the hypothesis of RePInULCoPaFil, the eigenvalues obtained from a measure of the radius from the wave function for a particular particle in our defined scale of smallness applicable to this physical world using the given Hamiltonian must be of the form: …, $Ah^{+3}r$, $Bh^{+2}r$, $Ch^{+1}r$, $Dh^{+0}r$,

$Eh^{-1}r$, $Fh^{-2}r$, $Gh^{-3}r$, … where, the quantities A,B,C,D,E,F, etc., are small, finite quantities, and h is numerically equal to Plank’s constant, but has no dimensionality.

For infering about the nature of the dimensionality, let us, for simplicity, assume that the length of an observable particle **r** would be represented, with its infinite degrees of freedoms or dimensions, as:
$L = (... + Ah^{+3} + Bh^{+2} + Ch^{+1} + Dh^{+0} + Eh^{-1} + Fh^{-2} + Gh^{-3} + ...).r$

Also, the Euler’s number is represented by:
$$e=1+1+\frac{1}{2!}+\frac{1}{3!}+\frac{1}{4!}+\ \ldots\infty$$

Hence, it now remains a matter of term-wise comparison between the various observables and the coefficients of the terms of the Euler’s number, considered with the properties of Symmetry and Isotropy of space-time applied to the above equation, and the mathematical trick of Scale Shifting, to help us determine the values of the coefficients of each terms, to any level of accuracy desired.

Other Big Bangs and Mass Injections into the realm of the anthropic Universe:

The anthropic universe is the observable universe wherein the classical physics domain ranges from micrometers to the galactic proportions, and the Electromagnetic Force, Strong Force, Weak Force and the Gravitational Force influence the observable universe.

The two articles, (1) *The Absence of the Implications of Negative Mass and the Resultant Problems in Physics*[(1)], and (2) *Inadequacies of the existing interpretation of the quantum phenomena, and the hypothesis of RePInULCoPaFil*[(2)], immediately clarify that the Big Bang that appeared to have occurred 13.8 billion years in the past, may not have been unique, and there could very well be remnants from the other Big Bangs that had occurred earlier than the latest one. In fact, later higher resolution telescopes could definitely find Red Dwarf stars, brown dwarves and Galaxies well before the latest Big bang.

Also, a more important aspect is to infer that mass injection to our present anthropic universe isn’t limited by the Big Bang alone. It has been deduced that a vacuum fluctuation could produce two massive particle-pratiparticle pair at a zero energy, in contrast to two massive particle-antiparticle pair at a non-zero large energy in the viccinity of a heavy particle owing to mass conservation constraints.

By the very nature of their properties the particle-pratiparticle pair would repel each other and move away from each other, and not merge and annihilate. Hence, the mass that is constantly injected to our domain of observable universe indicates the nature of the domain in the scale below our observable anthropic universe.

Different values for Hubble's Constant and the possible cause for Hubble's Tension:

Hubble's constant H_0[6] is a ratio of the speed of separation between any two galaxies and the proper distances between them, with units of "velocity per distance," such as kilometers per second per megaparsec (km/s/Mpc). This choice reflects the observation that for every megaparsec of separation between galaxies, their velocity of separation increases by a certain number of kilometers per second. The unit of H_0 is therefore T inverse.

While the units do reduce to an inverse time, textbook explanations often emphasise the velocity-distance relationship rather than explicitly describing it in terms of T inverse or *v*, frequency, i.e.

Relationship in Terms of Distance:

The local Hubble constant H_0[6] applies at low redshifts (nearby galaxies), while another related term H(z)[7] increases with redshift, reflecting conditions when the universe was denser. For galaxies further away, we are observing a higher value of H(z) because we see them as they were in a younger, faster-expanding universe. These measurements combined reveal how expansion slows over time due to gravitational interactions yet accelerates at certain distances due to dark energy's influence in recent cosmic history.

H(z)[7] is the Hubble parameter as a function of redshift z, describing the universe's expansion rate at different times in its history. Unlike H_0, which represents the expansion rate at the current time, H(z)[7] varies with redshift, reflecting the evolution of expansion due to changes in cosmic density and the influence of dark energy.

There are some of the prominent measurements of the Hubble constant H_0 each obtained through different methods:

1. Local Measurements (Standard Candles):
   SH_0ES (Supernovae and H_0 for the Equation of State): $H_0 \approx 73.04 \pm 1.04 H_0 \approx 73.04 \pm 1.04$ km/s/Mpc.[8]
   This value comes from measuring Cepheid variables and Type Ia supernovae in nearby galaxies.

2. Cosmic Microwave Background (CMB) Measurements:
   Planck Satellite (CMB): $H_0 \approx 67.4 \pm 0.5 H_0 \approx 67.4 \pm 0.5$ km/s/Mpc[9].
   This is derived from fitting data from the early universe to the ΛCDM model, assuming standard cosmological parameters.

3. Tip of the Red Giant Branch (TRGB):
TRGB Method: H_0≈69.8±1.9H_0≈69.8±1.9 km/s/Mpc.[10]
TRGB stars are used as a different standard candle approach to obtain an independent value closer to the CMB result.

4. Gravitational Lensing (Time Delay):
H_0LiCOW (H_0 Lenses in COSMOGRAIL's Wellspring): H_0 ≈ 73.3±1.8H_0 ≈73.3±1.8 km/s/Mpc.[11]
This method uses time delays in light paths of gravitationally lensed quasars, giving a value close to the local measurements.

5. Megamasers in Galaxy Clusters:
Megamaser Cosmology Project: H_0≈73.9±3.0H_0 ≈ 73.9±3.0 km/s/Mpc.[12]
This method observes water megamasers in galaxies, providing an independent and direct measurement.

These values highlight the Hubble tension, as we see a clear split between local measurements (around 73 km/s/Mpc) and CMB-based measurements (around 67 km/s/Mpc). This tension remains unresolved, with values consistently clustering around these two ranges despite improvements in measurement precision.

Together, these measurements across different scales and times make up a considerable number of data points (on the order of hundreds in total), leading to the roughly 5% discrepancy that constitutes the Hubble tension. This tension is now robust enough to suggest it may not just be a measurement error, hence why it's a topic of active research.

So the possible evidences for *RePInULCoPaFil* could be the different values of Hubble's Constant for the earlier and the later ages, i.e., at various stages of evolution of the universe. Averaging out the different values for different eras of the expanding universe would actually be an error of judgement in that case.

The Hypothesis *RePInULCoPaFil*, elaborated in the paper, *The Absence of the Implications of Negative Mass and the Resultant Problems in Physics*[1], indicates that numerous particle-pratiparticle pairs are/were introduced, because of vacuum fluctuations and other reasons elaborated earlier, even at zero energy throughout the evolution of the anthropic universe.

While the particles pumped into our universe may coalasce to form conglomerations of matter, ranging to patches of hydrogen gas clouds, some of which might eventually form non-observable matter clusters, rogue planets (masses upto several Jupiter masses), sub-brown dwarfs (surface temperature < 300K), Y-Dwarfs (surface temperature < 600K), T Dwarfs (surface temperature ~600 to 1,300 K), L Dwarfs (surface temperature ~1,300 to 2,400 K) all these being Brown Dwarf stars (surface temperature ~1,300 to 2,400 K), Red Dwarf stars (surface temperature ~600 to 3,700

K) and other normal stars, etc.; the pratiparticle, while attracting another pratiparticle, repel a normal particle of our anthropic universe, because of the simple reason that uncharged pratiparticle-conglomarate attract each other just like particle-conglomerate does. However, a conjugate pratiparticle pair with opposite charges would annihilate each other just like two conjugate particle-antiparticle pair do. There is no restriction on pratiparticle-conglomerate to even form massive bodies of stellar proportions, *the Stellar bodies composed entirely of pratiparticles,* only that they couldn't be stars in the normal sense. It would be interesting to note that if a Black Hole is imagined as an endless pit from which even light can't escape, the analogous pratiparticle conglomerate is to be an absolutely rigid body, near-spherical because of symmetry and isotropy, behaving as a Perfect reflector: light or matter shot at it will never reach it, but be reflected back fully following the laws of conservation of energy-momentum without absorption.

But the moot point to note is that the amount of pratiparticles introduced through zero energy vacuum fluctuations continued to change, from the earliest epoch of the universe to the present times, its number increasing over time as the observable universe evolved. Hence, in different epochs, a different H_0 emerges. Also, the remnants from the earlier Big Bangs, such as Black Dwarfs, when discovered, with better telescopes built in future, or with a telescope built as two mirrors positioned in the Langrange Points around the earth and used as a gigantic interferometer will also indicate an influence on the measurements of mass distribution, Red Shift and H(z).

The future of experimental physics is therefore quite exciting.

References:

(1) *Rajib Bandopadhyay, The Absence of the Implications of Negative Mass and the Resultant Problems in Physics, viXra:2309.0130, the final submission replaced on 2023-10-24 02:31:23.*

(2) Rajib Bandopadhyay, *Inadequacies of the existing interpretation of the quantum phenomena, and the hypothesis of RePInULCoPaFil* , copyrighted from the Indian Copyrights Office, 2003.

(3) Kak, S., I*nformation theory and dimensionality of space. Sci Rep 10, 20733 (2020). https://doi.org/10.1038/s41598-020-77855-9*

(4) Mandelbrot, B. B. *The Fractal Geometry of Nature* (W. H. Freeman, New York, 1983).

(5) Rajib Bandopadhyay, *Non-Stellar Black Holes,* viXra:2301.0140 submitted on 2023-01-27 01:13:43

(6) Riess, A. G., et al. "A 2.4% Determination of the Local Value of the Hubble Constant." The Astrophysical Journal, vol. 826, no. 1, 2016, p. 56. doi:10.3847/0004-637X/826/1/56.

(7) Simon, J., Verde, L., & Jimenez, R. "Constraints on the redshift dependence of the Hubble parameter and other cosmological parameters." Physical Review D, vol. 71, no. 12, 2005, p. 123001. doi:10.1103/PhysRevD.71.123001.

(8) Riess, A. G., et al. "Milky Way Cepheid Standards for Measuring Cosmic Distances and Application to Gaia DR2: Implications for the Hubble Constant." The Astrophysical Journal, vol. 876, no. 1, 2019, p. 85. doi:10.3847/1538-4357/ab1422.

(9) Aghanim, N., et al. "Planck 2018 results. I. Overview and the cosmological legacy of Planck." Astronomy & Astrophysics, vol. 641, 2020, A1. doi:10.1051/0004-6361/201833880.

(10) Freedman, W. L., et al. "The Carnegie-Chicago Hubble Program. IX. A Comprehensive Distance Ladder to the Nearby Universe." The Astrophysical Journal, vol. 882, no. 1, 2019, p. 34. doi:10.3847/1538-4357/ab2f73.

(11) Suyu, S. H., et al. "H_0LiCOW – I. H_0 Lenses in COSMOGRAIL's Wellspring: Measuring H_0 with time delays in gravitational lens systems." Monthly Notices of the Royal Astronomical Society, vol. 468, no. 1, 2017, pp. 1-13. doi:10.1093/mnras/stx1103.

(12) Reid, M. J., et al. "Megamaser Cosmology: A 73 km/s/Mpc Measurement of the Hubble Constant." The Astrophysical Journal, vol. 783, no. 2, 2014, p. 130. doi:10.1088/0004-637X/783/2/130.