New Advances in Physics, Vol. 14, No. 1, January 2020, pp. 27-33

A model for the universe

B. G. Sidharth* and Abhishek Das†

Abstract: *In this short note we consider a model for the universe as a fluid in motion and apply the Navier Stokes equation to incorporate all the forces of nature.*

1. Introduction

It is known that the Navier Stokes equation describes the motion of an incompressible fluid. In this article we consider the universe to be a fluid that has body forces acting on it. These body forces are four fundamental forces of nature. Interestingly, we also derive a continuity equation where a quantity named as mass flow rate is conserved. This continuity equation reduces the Navier Stokes equation to a much simpler form where only the gradient of the pressure and stress tensor remain.

After the Navier Stokes equation is simplified we consider the results of a previous paper [1] and then related the body forces with the fundamental forces in the classical and quantum level.

2 Theory

Let us consider the universe to be governed by the Navier-stokes equation for incompressible flow that is given as

$$\rho \frac{\mathrm{D}\vec{u}}{\mathrm{D}t} = -\vec{\nabla} p + \vec{\nabla}.\vec{\tau} + \rho g$$

where, $\frac{\mathrm{D}}{\mathrm{D}t}$ is the material derivative defined as:

$$\frac{\partial}{\partial t} + \vec{u}.\vec{\nabla}$$

where, ρ is the fluid density, $\vec{u}$ is the fluid velocity, p is the pressure, τ is the

B.M. Birla Science Centre, Adarsh Nagar, Hyderabad - 500 063, India
*Email: birlasc@gmail.com
†Email: parbihtih3@gmail.com

deviatoric stress tensor of order 2, and g represents body forces like gravity, electrostatic interactions and such. Now, we rewrite the above equation as

$$\rho\frac{\partial u}{\partial t} + \rho\vec{u}.\nabla u = -\vec{\nabla}p + \vec{\nabla}.\vec{\tau} + \rho g$$

This can also be written as

$$\frac{\partial(u\rho)}{\partial t} - u\frac{\partial\rho}{\partial t} + \rho\vec{u}.\nabla u = -\vec{\nabla}p + \vec{\nabla}.\vec{\tau} + \rho g$$

Again, we know the following continuity equation as

$$\frac{\partial\rho}{\partial t} + \vec{\nabla}.(\rho\vec{u}) = 0$$

Thus using this we have

$$\frac{\partial(u\rho)}{\partial t} + u\vec{\nabla}.(\rho\vec{u}) + \rho\vec{u}.\nabla u = -\vec{\nabla}p + \vec{\nabla}.\vec{\tau} + \rho g$$

Now, we define a parameter 'A' such that

$$M = \rho u A$$

and

$$\sigma = \frac{M}{A} = \rho u$$

M is essentially the mass flow rate used in aerodynamics, thus σ can be defined as the mass flow rate per unit area. So, we have

$$\sigma = \rho u$$

This is essentially a vector quantity and can be written in vector form as

$$\vec{\sigma} = \rho\vec{u}$$

Therefore, we have

$$\frac{\partial\sigma}{\partial t} + u\vec{\nabla}.\sigma + \sigma.\nabla u = -\vec{\nabla}p + \vec{\nabla}.\vec{\tau} + \rho g$$

which can be rewritten as

$$\frac{\partial\sigma}{\partial t} + \vec{\nabla}.(\vec{\sigma}u) = -\vec{\nabla}p + \vec{\nabla}.\vec{\tau} + \rho g$$

Now,

$$\vec{\sigma} u = \rho \vec{u} u = \sigma \vec{u}$$

Thus we have

$$\frac{\partial \sigma}{\partial t} + \vec{\nabla}.(\sigma \vec{u}) = -\vec{\nabla} p + \vec{\nabla}.\vec{\tau} + \rho g \tag{1}$$

Now, if the mass flow rate per unit area (σ) is conserved then we will have the following continuity equation for fluid flow

$$\frac{\partial \sigma}{\partial t} + \vec{\nabla}.(\sigma \vec{u}) = 0$$

which gives us

$$\vec{\nabla} p - \vec{\nabla}.\vec{\tau} = \rho g$$

Or more precisely we have

$$\vec{\nabla}[p - \tau] = \Gamma \tag{2}$$

where, $\Gamma = \rho g$. This is the equation for the fluid flow. So, if we consider a universe as an incompressible fluid then the divergence of the difference between pressure and deviatoric stress produces all the forces of the universe. The gravitational force, the electromagnetic force, the weak and strong nuclear forces – all of them culminate from the divergence given in the above equation, subject to the conservation of mass flow rate given by the continuity equation

$$\frac{\partial \sigma}{\partial t} + \vec{\nabla}.(\sigma \vec{u}) = 0$$

So, essentially, we have derived an expression that brings out all the forces existent in nature. These forces engender from the gradient term given in the last equation. When the stress tensor is generalized to the stress-energy tensor we find that it can be correlated with general relativity as well.

In the context of the Planck scale and Compton scale we can say that the right side gives all the forces in the Compton scale. This concept was also elaborated in a previous paper [1], with a different approach.

By virtue of the universality of critical phenomena we know that gauge theories can demonstrate By virtue of the universality of critical phenomena we know that gauge theories can demonstrate different phases. Quantum electrodynamics, weak force, strong force all exhibit different phases. Now, it was shown by the author Sidharth [2, 3] that at the Planck scale we have only gravitation and at the Compton scale all other forces emerge. This does not entail that at the Compton scale gravitation vanishes. Actually, at such a scale gravitation becomes very weak. It is also conspicuous because of the fact that the Planck length 10^{-33} cms and the Compton length 10^{-11} cms. This also explains why the electromagnetic force is many times stronger than the gravitational force. In this context we would like to mention that, in a previous paper [4], we had been able to substantiate that the 2D universe undergoes a phase transition from the *Planck phase to the Compton phase*. This result should also be hold in the case of a 3D universe. Now, if we take into consideration the author Sidharth's previous works [2, 3] then we have the *coherence parameter*

$$\xi = \frac{h}{mc} = \frac{2\pi\hbar}{mc}$$

where, $l_c = \frac{\hbar}{mc}$ is the Compton length of a particle of mass 'm'. This Compton length is the fundamental aspect of the *Compton phase* or according to other authors [5] the Electroweak phase which is the current phase of the universe.

Interestingly, as we found in our derivation, the pressure and stress tensor play pivotal roles in our theory. As we have previously shown that we could resort to the notion of the renormalization group [6, 7, 8] and the universal nature of critical phenomena. It is justified if we say that while the transition from the Planck scale to the Compton scale there is a critical point where the various physical parameters reach their critical value. Therefore, one must use the renormalization group methodology so that the effects of the length scale below the correlation length or the coherence parameter ξ[1] gets averaged out and we get the proper physical results in the Compton scale.

Executing this task one can achieve a fixed point or equilibrium point where all the forces of nature come into play. In the same vein of logic, the divergence of the difference between the pressure and stress tensor gives this equilibrium point from whence all forces emerge.

$$\psi(x) = \psi_m(x) + \sum_n r_n \phi_n(x) \tag{3}$$

where, each wavefunction $\phi_n(x)$ fills a unit volume in the phase space. Here, the integration is performed upon the coefficients r_n. where, each wavefunction $\phi_n(x)$ fills a unit volume in the phase space. Here, the integration is performed upon the coefficients r_n. Now, since we are considering fluctuations and their effectswe may consider Ito's lemma [9, 10] regarding stochastic dynamics, as

$$d\psi(x_t) = \psi'(x_t)dx_t + \frac{1}{2}\psi''(x_t)\sigma_t^2 dt$$

where, the *primes* denote derivative with respect to x^t, σ_t is the standard deviation and the subscript refers to the instant of time. From this we can obtain a covariant derivative of the form

$$\Gamma_1 = d\psi_m(x_t) = \{\psi'_m(x_t) + \sum_n r_n\phi'_n(x_t)\}dx_t + \frac{1}{2}\{\psi''_m(x_t) + \sum_n r_n\phi''_n(x_t)\}\sigma_t^2 dt - \sum_n d\{r_n\phi_n(x_t)\} \quad (4)$$

This covariant derivative might be able to describe the interaction arising after the phase transition, namely electromagnetism.

$$\phi''(x_t) = \delta'(l)\frac{dl}{dx_t} + \delta(l)\frac{d^2l}{dx_t^2} \quad (5)$$

where, $\delta(l)$ represents a point charge and $\delta'(l)$ represents a magnetic dipole. One can say that from the general theory of relativity we get electromagnetism and all other forces. So, gravitation and electromagnetism are the ones who maintain the evolution of the universe in the classical level (given by Γ_1) and the strong and weak nuclear forces in the atomic level interactions (given by Γ_2).

The other terms in equation (8) are residues of the interactions due to the phase transition that occurs from the Planck scale to the Compton scale. It will be the prospect of future research as to relate the strong and weak nuclear forces and incorporating in the Γ_2 part.

Now, several years ago, Sidharth [3, 11] had pointed out that starting with a linearized metric of general relativity

$$g_{\mu\nu} = \eta_{\mu\nu} + h_{\mu\nu}$$

interior region as a quantum mechanical Kerr-Newman black hole represented by an effectively rotating shell distribution of radius, $R = \frac{\hbar}{2mc}$, where

$$h_{\mu\nu} = \int \frac{4T_{\mu\nu}(t - |\mathbf{x} - \mathbf{x}'|, \mathbf{x}')}{|\mathbf{x} - \mathbf{x}'|} d^3x' \quad (6)$$

Also, it was shown that considering the interior region, where

$$\mathbf{x} \sim \mathbf{x}'$$

one can have from the relation (6)

$$h_{\mu\nu} = 4\int \frac{T_{\mu\nu}(t, \mathbf{x}')}{|\mathbf{x} - \mathbf{x}'|} d^3x' + 2\int \frac{d^2}{dt^2} T_{\mu\nu}(t, \mathbf{x}')|\mathbf{x} - \mathbf{x}'| d^3x' + f(|\mathbf{x} - \mathbf{x}'|^2) \quad (7)$$

Now, below the Compton scale, or more precisely in the interior region one has

$$|\frac{\mathrm{d}u_\nu}{\mathrm{d}t}| = |u_\nu|\omega$$

where, $u_\nu = c$ and ω is the angular velocity given by

$$\omega = \frac{|u_\nu|}{R} = \frac{2mc^2}{\hbar}$$

Using these relations, one can obtain

$$\frac{\mathrm{d}}{\mathrm{d}t}T_{\mu\nu} = \rho u_\nu \frac{\mathrm{d}u_\mu}{\mathrm{d}t} + \rho u_\mu \frac{\mathrm{d}u_\nu}{\mathrm{d}t} = 2\rho u_\mu u_\nu \omega$$

and

$$\frac{\mathrm{d}^2}{\mathrm{d}t^2}T_{\mu\nu} = 4\rho u_\mu u_\nu \omega^2 = 4\omega^2 T_{\mu\nu}$$

Substituting the last result in (7) gives

$$h_{\mu\nu} \approx -\frac{\beta M}{r} + 8\beta \frac{M^3 c^4}{\hbar^2} r \tag{8}$$

where, β is a constant. It is obvious that the relation (8) represents a QCD potential. So, in (2) if we extend the stress tensor to the stress-energy tensor of general relativity we have a contribution of the strong nuclear force which is manifested in the right hand side incorporated in the Γ_2 term which also consists the contribution of the weak nuclear force that is mediated during the interaction of subatomic particles.

REFERENCES

[1] B. G. Sidharth & A. Das, A note on gravitation and electromagnetism, MPLA, Vol. 33, No. 13, 1850071 (2018).

[2] B. G. Sidharth, Gravitation and Electromagnetism, Nuovo. Cim. B116, 735 (2001).

[3] B.G. Sidharth, The Universe of Fluctuations, pp. 13-19, DOI: 10.1007/1-4020-3786-4, Springer Netherlands, 2005.

[4] B. G. Sidharth & A. Das, 2-state asymmetries: Matter-antimatter and other effects, IJMPA, Vol. 31, No. 32, 1650167, 2016.

[5] C.R. Das, L.V. Laperashvili and A. Tureanu, Int. J. Mod. Phys. A 28, 1350085 (2013), arXiv:1304.3069.

[6] K. G. Wilson, The Renormalization Group and Critical Phenomena, Reviews of Modern Physics, Vol. 55, No. 3, 1983.

[7] K. G.Wilson, Renormalization group methods, Advances in Mathematics, Volume 16, Issue 2, May 1975, Pages 170-186.

[8] K. G.Wilson and J. Kogut, The renormalization group and the expansion, Physics Reports, Volume 12, Issue 2, 1974, Pages 75-199.6

[9] K. Ito, Stochastic Integral, Proc. Imperial Acad. Tokyo 20, 519-524, 1944.

[10] K. Ito, On stochastic differential equations, Memoirs, American Mathematical Society 4, 1-51, 1951.

[11] B.G. Sidharth, Chaotic Universe: From the Planck to the Hubble Scale, pp. 39-45, Nova Science Publishers, New York, 2001.