LIQUID SPACETIME (AETHER) VISCOSITY, A WAY TO UNIFY PHYSICS

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ABSTRACT

Recent experimental measurements performed by American satellite Gravity Probe B showed that Einstein space time warped and pulled by earth movement. This important result could signify that Einstein space time exhibits a viscous behavior. Moreover, in a recent publication, T. Padmanabhan demonstrated that general relativity and Navier-Stokes equations can be identical. In this paper we tried to apply fluid mechanics approach to both general relativity and quantum mechanics. Considering that space time is a liquid (the old aether), we found that a single dynamic viscosity value can be calculated from both Einstein general relativity and Planck equations. Surprisingly, space time appeared to be a highly viscous liquid. Calculations of stresses produced by bodies at both atomic and astronomic levels appeared to be coherent if universe density is greater than critical density meaning that universe could have a spherical shape. Finally, a generalized form of Maupertuis/Fermat principle is proposed giving a unified theory of physics.

1. INTRODUCTION

Since the famous Michelson and Morley experiment, the aether theory was forgotten and all physics developed during the 20th century considered that no support was necessary to wave or particles to propagate. The main consequence was the existence of void and the main proportion of our world was considered as void.

But recent measurements performed by American satellite Gravity Probe B (GP-B) [1] disagreed with Michelson and Morley results. Einstein space time is warped by earth and space time produces a drag force or friction force acting on earth surface. These experimental results of great importance demonstrate that space time acts on physical bodies through a well known physical property of fluids: the dynamic viscosity. This possibility was recently suggested by C. Eling [2]. This author used a thermo dynamical approach to introduce the entropy to viscosity ratio and he concluded that void should have a viscosity value. Both GP-B results and C. Eling [2] approach showed that void does not exist meaning that Einstein space time could be a physical reality. C. Eling [2] tried to calculate space time viscosity and he found that this value should be very low.

More recently, T. Padmanabhan published a paper entitled "The hydrodynamics of atoms of spacetime: gravitational field equation is Navier-Stokes equation" [3]. Navier-Stokes equation describes the flow of real fluids having a dynamic viscosity. And if "gravity is hydrodynamics" like expressed in the conclusion of T. Padmanabhan paper, we should be able to calculate it by use of classical fluid mechanics equations.

The aim of this paper is first to examine if space time viscosity can be calculated from basic equations of general relativity and quantum mechanics. In a second time, we compared results obtained at very small and very large scales in order to find if a unique value could be calculated. Considering the classical relationship between stress and displacement rate tensors used to describe the flow of a Newtonian liquid we calculated stresses produced by bodies at both atomic and astronomic scales. We proposed then a stresses scale able to describe bodies' behavior whatever is the scale.

Finally, in order to try a unified approach of physics laws, we proposed a generalized form of Maupertuis/Fermat principle available whatever the scale.

2. THEORY

2.1 General relativity and viscosity

The well known Einstein equation describing space time mechanical behavior takes the following form:

$$R_{ij} - \frac{1}{2}\, g_{ij}\, R = \frac{8\,\pi\, G}{c^4}\, T_{ij} \qquad (1)$$

The left side of this equation often called the Einstein tensor represents space time curvature, its unit is "m^{-2}". "R_{ij}" is the Ricci tensor, "g_{ij}" the Riemann metric tensor and "R" the scalar curvature. The right side is made of a constant multiplied by the energy impulsion tensor "T_{ij}". "G" is the gravitation constant and "c" the light speed.

In rheology, dynamic viscosity "η" of a fluid is defined as the ratio between stress "τ_{ij}" and displacement rate "γ_{ij}" tensors giving the following relationship:

$$\tau_{ij} = \eta\, \gamma_{ij} \qquad (2)$$

If we assume that space time is a liquid, then equations (1) and (2) should be comparable. It is well known that energy impulsion tensor "T_{ij}" is similar to a stress tensor, its unit is "Pa" like "τ_{ij}". Let us consider that "T_{ij}" and "τ_{ij}" are similar. The only difference being the number of dimensions. This number is "4" in general relativity and "3" in rheology giving respectively tensors with "16" and "9" components.

We need then to modify equation (1) in order to obtain both a displacement rate tensor and the dynamic viscosity. If we multiply both sides of equation (1) by impulsion diffusivity "D_m" we obtain in left side the product of curvature by impulsion diffusivity which is a velocity gradient and then a displacement rate tensor:

$$D_m\, R_{ij} = \gamma_{ij} \qquad (3)$$

In the right side of equation (1), we obtain a new constant "K" multiplied by the energy impulsion tensor "T_{ij}":

$$K = D_m\, \frac{8\,\pi\, G}{c^4} \qquad (4)$$

In fluid mechanics, impulsion diffusivity is a well known quantity often called kinematic viscosity "υ" and defined as the ratio between dynamic viscosity "η" and density "ρ":

$$\upsilon = \frac{\eta}{\rho} \qquad (5)$$

Then, equation (4) can be rewritten as followed:

$$K = \frac{\eta}{\rho} \frac{8\,\pi\,G}{c^4} \qquad (6)$$

If we identify equations (1) and (2) as proposed above, it gives:

$$K = \frac{\eta}{\rho} \frac{8\,\pi\,G}{c^4} = \frac{1}{\eta} \qquad (7)$$

We can then express space time dynamic viscosity as followed:

$$\eta = \sqrt{\frac{\rho\,c^4}{8\,\pi\,G}} \qquad (8)$$

2.2. Quantum mechanics and viscosity

If we maintain our assumption of a liquid space time, we should be able to introduce it at the atomic level. Quantum mechanics describes behaviors of atoms kernels and their surrounding electrons. Planck quanta theory allowed understanding of electrons energy levels and the way they change from orbitals close to the kernel to those far away. The main equation used to calculate energy levels "E" is the following one:

$$E = h\,\frac{c}{\lambda} \qquad (9)$$

"h" is the Planck constant, "**λ**" the wave length and "c" the light speed.

In order to find a link between equation (9) and the previous ones, we need to use another fluid mechanics analogy. Equation (2) is the general tensorial form describing the motion of a viscous Newtonian liquid. Considering the classical problem of the established laminar flow of a Newtonian liquid in a pipe, it is possible to simplify in order to obtain a scalar relationship between pressure drop "ΔP" and wall velocity gradient "γ_w". "L" and "D" being respectively the pipe length and pipe diameter:

$$\tau_w = \frac{\Delta P\,D}{4\,L} = \eta\,\gamma_w \qquad (10)$$

Considering that wall shear rate "γ_w" can be calculated from parabolic velocity (laminar flow) profile in the pipe, we have:

$$\gamma_w = \frac{8\,\bar{u}}{D} \qquad (11)$$

"$\bar{u}$" being the average velocity and "D" the pipe diameter. Replacing "γ_w" in equation (10) leads to the well known Hagen-Poiseuille relationship between pressure drop and flow rate in a pipe of circular cross section shape.

We tried then to find a link between equation (9) and (10) through a dimensional analysis. If we want to obtain a pressure in Pascal unit in the left side of equation (9), we need to divide energy by a volume. Let us call this volume a control volume "V_c". We obtained then the following relationship:

$$\frac{E}{V_c} = \frac{h}{V_c}\,\frac{c}{\lambda} \qquad (12)$$

We can then identify equations (10) and (12), the quantities "$\frac{h}{V_c}$" and "$\frac{c}{\lambda}$" being respectively the dynamic viscosity and the velocity gradient. It is then interesting to consider Planck constant as a physical property of liquid space time. The problem remaining at this stage is the definition and calculation of the control volume "V_c". At atomic scale, what should be the representative volume we have to use in order to calculate the right viscosity and then the right stress? In this representation, atoms are considered as small viscosimeters or mixing tanks and we need geometrical characteristics in order to calculate dynamic viscosity of liquid space time.

It is possible to perform the same calculations from Einstein relativistic equation:

$$E = m\,c^2 \qquad (13)$$

Dividing each side of equation (13) by a control volume "Vc" leads to the following relationship:

$$\frac{E}{Vc} = \frac{m\,c^2}{Vc} \qquad (14)$$

Equation (14) allows calculation of stress produced by each relativistic particle of mass "m" in liquid spacetime. But how to make the link with the modified Planck law (equation 12) we proposed above. Using dimensional analysis, it is possible to rewrite equation (14) in the following form:

$$\frac{E}{Vc} = \frac{m\,c}{S}\,\frac{c}{\lambda} \qquad (15)$$

Identifying equation (12) and (15) leads to the following equation:

$$\eta = \frac{h}{V_c} = \frac{m\,c}{S} \qquad (16)$$

Atomic particles have different masses; consequently, we will have several surfaces "S" to introduce in order to respect equation (16). From this analysis, Planck law and Einstein formula appear very different. Planck law does not take into account the differences between atomic particles then the control volume is certainly a mean volume representative of all particles (electron, proton and neutron). Einstein law is then more accurate and takes into account each particle mechanical behavior in liquid space time. Roughly speaking, we can say that Einstein viscosimeter is more accurate than Planck viscosimeter. But whatever is the viscosimeter geometry, dynamic viscosity have to be the same.

2.3 Shear rate calculations whatever the scale.

Shear rate is a very important value in both fluid mechanics and engineering of continuous media. At our scale, a very good example of its importance is the case of a mixing tank used to prepare a product or the case of the laminar flow of a viscous liquid in a pipe. From our previous calculations, it is then interesting to give all equations allowing shear rates values to be calculated. Sometimes experiments and theories allow mean values to be calculated, we will call them "$\bar{\gamma}$" and sometimes local values "γ".

- For a mixing tank: it is well known from experiments that the mean value of the shear rate is proportional to the rotational speed of the turbine "N". The proportionality constant often called "Ks" depending only on the geometry of the system.

$$\bar{\gamma} = Ks\,.N \qquad (17)$$

- For a Couette system (viscosimeter), equation (17) applies and because the geometry is simple, the average value is the same than the local value and we can write:

$$\bar{\gamma} = \gamma = Ks\,.\frac{\bar{u}}{D} \qquad (18)$$

In that case, "Ks" can be calculated analytically due to the simple geometry of the Couette system compared to the complex shape of an industrial mixing tank where "Ks" can only be determined experimentally by measurements of rotational speed "N" and torque exerted on the shaft of the turbine.

- For the laminar flow in a pipe of circular cross section shape, the velocity profile in permanent flow regime can be calculated analytically giving a parabolic form. It is then easy to calculate the mean value of shear rate giving the following equation:

$$\bar{\gamma} = 8\,.\frac{\bar{u}}{D} \qquad (19)$$

From these results, it is clear that shear rate equations take the same form in both batch (tank) and continuous flow systems (pipes).

- At cosmological scale, we showed above that general relativity equation can be modified in order to obtain a relationship between stress and displacement rate tensors. We know that angular velocity "N" is the product of curvature by linear velocity. Extending this equation to complex Riemann curved space used by Einstein, it gives that angular velocity "N" is the product of Riemann curvature by diffusivity. This leads to the following expression for universe mean shear rate:

$$\bar{\gamma} = Ku\,.N \qquad (20)$$

This equation is analogous to equation (17) well established and experimentally verified for a mixing tank. "Ku" is then a geometrical parameter characterizing universe flow shape.

- At atomic scale, we showed that velocity gradient or shear rate can be expressed as followed:

$$\bar{\gamma} = \frac{c}{\lambda} \qquad (21)$$

This equation is analogous to equation (19) and then to all others proposed above. The mean shear rate produced by atomic particles in spacetime will increase when their wave length will decrease explaining why short wave length waves like gamma rays will be extremely penetrating.

Equations (17) to (21) show that a single and simple mathematical form can be found whatever the scale to calculate the shear rate or velocity gradient produced by the flow of particles

3. RESULTS

3.1 General relativity viscosity calculation

In equation (8), the only value necessary to calculate dynamic viscosity is the universe density "ρ". Even if this physical property is always an intensive research subject, we can use the often called critical density coming from Hubble expanding universe theory: $\rho = 9.24\ 10^{-27}$ kg.m^{-3}. Using this value in equation (8) leads to the dynamic viscosity: $\eta = 0.21\ 10^{9}$ Pa.s.

Surprisingly, space time dynamic viscosity appears to be very high, in the order of magnitude of values found for bitumen. This result contradicts C Eling [2] analysis giving a low value. But it seems to be in agreement with recent GP-B measurements [1] giving a high viscosity value often compared to honey viscosity.

3.2 Quantum mechanics viscosity calculation

In a first approach, It is quite easy to use volumes of atomic particles: electron, neutron and proton. Considering them as perfect spheres, we found respectively: 7.1 10^{9}, 114.6 10^{9} and 247 10^{9} Pa.s. These values have the same order of magnitude than those found previously in general relativity. Such result indicates that space time liquid viscosity could be very high as expected before.

Another approach consists in assuming that space time dynamic viscosity is the value found for general relativity and trying to calculate the control volume we obtain and the radius of the corresponding space volume (considered as spherical). By this approach, we found a radius of 9.1 10^{-15} m corresponding to 3.2 times the electron radius.

Calculating from equation (16) the radius of surfaces necessary to obtain the general relativity viscosity (0.21 10^{9} Pa.s) for electron, neutron and proton, we found: 0.32 10^{-15} m for electron and 13.8 10^{-15} m for proton and neutron (they have nearly the same mass). As expected, the radius corresponding to "V_c" i.e. 9.1 10^{-15} m is between these two values and not very far from the arithmetic mean value.

4. DISCUSSION

4.1 Stress calculations at all scales.

At this time, assuming that spacetime is a liquid of high viscosity, we are able to calculate stress or pressure exerted by bodies embedded in the liquid at both atomic and astronomic scales. For astronomic bodies: planets, stars, dwarf stars and neutron stars, we used the simple relationship between pressure and force:

$$P = \frac{F}{S} \qquad (22)$$

Gravity acceleration values were calculated using the classical relationship:

$$g = \frac{G\, m}{R^2} \qquad (23)$$

For atomic particles (electron, proton and neutron), we used equation (14) with the control volume obtained from equation (12) and space time viscosity determined with general relativity equation.

The following pressure values were obtained for earth, sun, sun degenerated into dwarf star and sun degenerated into neutron star:

- Earth: 1.15 10^{11} Pa

- Sun: 0.9 10^{14} Pa

- Sun degenerated into dwarf star: 0.34 10^{23} Pa

- Sun degenerated into neutron star: 0.34 10^{35} Pa

As expected, pressures are growing up when mass and gravity increase. We can notice the extremely high values found for degenerated stars. Moreover, pressure obtained for neutron star is well in agreement with the value obtained for a single neutron which is 0.26 10^{35} Pa.

Performing the calculations for electron, neutron and proton gave the following values:

- Electron: 2.61 10^{28} Pa

- Neutron: 4.8 10^{31} Pa

- Proton: 4.8 10^{31} Pa

Even if these values are in the right range (around 10^{30} Pa) it is not acceptable that stresses produced by neutron and protons are not in agreement with neutron star pressure. The only way to explain this difference is to consider that our spacetime viscosity calculated from equation (8) is false. Then the density used in this equation has to be changed in order to obtain the same stress caused by a single neutron and a neutron star in liquid spacetime. Using a spacetime density value of 4.91 10^{-21} kg.m-3 gives a dynamic viscosity of 1.54 10^{11} Pa.s. The corresponding radius used in equation (14) is 10^{-15} m or 1 fm corresponding exactly to the mean value of proton and neutron radius. Using these new values, stresses produced in liquid spacetime by electron, neutron and proton are the following:

- Electron: 1.85 10^{31} Pa

- Neutron: 0.34 10^{35} Pa

- Proton: 0.34 10^{35} Pa.

We have then the following coherent scale of stresses produced by bodies in liquid spacetime from atomic to astronomic scale:

- Earth: 1.15 10^{11} Pa

- Sun: 0.9 10^{14} Pa

- Sun degenerated into dwarf star: 0.34 10^{23} Pa

- Electron: 1.85 10^{31} Pa

- Sun degenerated into neutron star, neutron and proton: $0.34\ 10^{35}$ Pa

One of the most surprising things is the value obtained for universe density "ρ". In the first chapter of this paper, we started our general relativity calculations using the commonly admitted critical density value ($9.24\ 10^{-27}$ $kg.m^{-3}$). Universe density determines its geometry or shape. Critical density gives a flat shape. But we demonstrate that we need to use a universe density greater than critical density to obtain a single dynamic viscosity value from atomic to astronomic scale. The value we found is $5.31\ 10^{5}$ times greater than critical density. From a geometrical point of view, it means that space is curved like the surface of a huge sphere. This result combined with recent demonstration of an accelerating, expanding universe indicates that we are living in an accelerating, expanding spherical world.

Based on this view, we tried to modify Einstein general relativity equation to obtain both acceleration and curvature terms. We found that the following factor "ξ" applied on both sides of equation (1) could be of great interest:

$$\xi = \frac{c^2}{\sqrt{R}} \qquad (24)$$

The dimension of this quantity is "$m^3.s^{-2}$ " meaning a volumetric acceleration. Applying this factor to both sides of Einstein equation gives acceleration dimension in agreement with recent observation of an accelerating rate of universe expansion.

4.2 A generalized form of Maupertuis/Fermat principle.

De Broglie, following the approach of Maupertuis and Fermat defined the action as the summation of the difference between kinetic and potential energy along a trajectory. The action "A" can then be expressed by the following equation:

$$A = \int_{t0}^{t1} \left(\frac{1}{2} . m\, u^2 - Ep \right) dt \qquad (25)$$

Both quantum mechanics and general relativity equations can be derived from this formula showing how powerful this principle is.

Let us divide each side of equation (25) by a volume representative of the system like in equations (12) and (14). We obtain then what we called a generalized form of the action:

$$Ag = \int_{t0}^{t1} \left(\frac{1}{2} . \rho\, u^2 - Ep/V \right) dt \qquad (26)$$

In equation (26), the quantity "Ep/V" represents the stress value exerted by liquid spacetime or aether on the particles whatever the scale. According with this principle, the "nature" will always use a path making "Ag" an extremum, meaning "$\delta Ag = 0$". In that way, it is interesting to notice that nature will always follow a trajectory of minimum stress.

Finally, because of the basic hypothesis of Maupertuis/Fermat principle, the existence of a continuous media is absolutely necessary to apply equation (26). This clearly proves the existence of the aether as support of all actions whatever the scale.

5. CONCLUSION

In this paper, we tried to apply fluid mechanics concepts in theoretical physics. Even if this approach is not new, our originality was to consider space time as a liquid. Using this assumption and a comparison between Einstein general relativity equation and viscous liquid flow equation, we found that space time can be considered as a highly viscous liquid.

In a second time, at atomic scale, we modified Planck and Einstein equations to obtain relationships between stress and velocity gradient. We found then dynamic viscosity values comparable to those obtained for general relativity scale. But calculations of stresses caused by bodies at atomic and astronomic scales were not in agreement. Stress calculated in the case of a neutron star was very different than stress calculated for a single neutron.

The only explanation we found was the value of universe density we used to calculate viscosity through general relativity equation. Using a value greater than critical density commonly admitted, we found a space time viscosity of $1.54\ 10^{11}$ Pa.s available whatever the scale.

Considering that this high value of universe density means a spherical geometry of our universe under accelerating expansion, we proposed a factor, having the dimension of a volumetric acceleration, to introduce in general relativity equation.

Finally, coming back to the minimum action principle introduced by Maupertuis and Fermat and used by De Broglie in quanta theory, we proposed a modified form in agreement with fluid mechanics and continuous media physics. From this equation based on stress produced by particles moving in the aether or liquid spacetime we conclude that the existence of a continuous media cannot be ignore today. This conclusion signifies a coming back to the old aether theory by us of modern knowledge in fluid mechanics.

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