Quantum-Foam In-Flow Theory of Gravity and the Global Positioning System (GPS)

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Abstract

It is shown that a new quantum-foam in-flow theory of gravity is mathematically equivalent to the General Relativity theory of gravity for the operation of the Global Positioning System (GPS). The differences between the two theories become experimentally evident in other situations such as in the so-called 'dark matter' effect, in the observation of absolute motion and *ipso facto* in the observation of the in-flow motion into the sun, and in the observation of a new class of gravitational waves, effects which are present in existing experimental observations, but are *not* within General Relativity. This new theory of gravity arises within the information-theoretic *Process Physics*.

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*** Process Physics:**

http://www.mountainman.com.au/process_physics/

http://www.scieng.flinders.edu.au/cpes/people/cahill_r/processphysics.html

Contents

1 Introduction

It has been extensively argued that the very successful operation of the Global Positioning System (GPS) [1] is proof of the validity of the General Relativity formalism for gravity. However as is well known, and was most clearly stated by Popper, in science agreement with observation does not amount to the proof of the theory used to successfully describe the experimental data; in fact experiment can only strictly be used to disprove a theory. We illustrate this herein by discussing a very different theory of gravity in which gravitational forces are caused by inhomogeneities in the effective in-flow of the quantum-foam substratum, that is space, into matter. We shall show that this new theory of gravity and General Relativity are mathematically equivalent when it comes to explaining the operation of the GPS, because of special circumstances prevailing in this case[1]. The predictive differences between the two theories become experimentally evident in other situations such as in the so-called 'dark matter' effect, in the observation of absolute motion and *ipso facto* in the observation of the in-flow into the sun, and in the observation of a new class of gravitational waves, and various other known 'gravitational anomalies', effects which are present in existing experimental observations, but are *not* in General Relativity.

The new theory of gravity arises within the information-theoretic *Process Physics* [2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13]. Here we proceed by showing that both the Newtonian theory of gravity and General Relativity, in the case of the external Schwarzschild metric relevant to the GPS, may be written as in-flow dynamical systems. A generalisation of these in-flow formalisms is proposed giving the new theory of gravity. This theory possesses distinct and observable effects already evident in existing experimental data. However in the case of high spherical symmetry, which is relevant to the GPS, the new theory of gravity becomes mathematically equivalent to General Relativity with an external Schwarzschild metric, but has a vastly different interpretation and ontology. The key insight is that the dynamical effects of the detectable motion through the quantum-foam substratum causes relativistic effects and these, together with the quantum-foam in-flow effects, explain the operation of the GPS.

As discussed in [9] numerous interferometer and non-interferometer experiments have detected absolute motion of the Solar system in the direction (Right Ascension $= 5.2^{hr}$, Declination$= -67^0$) with a speed of 417 ± 40 km/s. This is the velocity after removing the contribution of the earth's orbital speed and the sun in-flow effect. It is significant that this velocity is different to that associated with the Cosmic Microwave Background (CMB) relative to which the Solar system has a speed of 369 km/s in the direction ($\alpha = 11.20^h, \delta = -7.22^0$), see [14]. As well the experimental data also reveals an in-flow of

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[1]The key parts of this paper are considerably changed from the earlier version of September 2003. Since that time the new theory of gravity has developed considerably, and the analysis regarding the approximate velocity 'flow' superposition principle, and the mapping of the new theory of gravity, in the case of the circumstances for the GPS, back to the corresponding General Relativity mathematical formalism treatment, is considerably enhanced.

space past the earth towards the sun. It needs to be emphasised that the detection of absolute motion is fully consistent with the well known special relativity effects, and indeed these effects, namely time dilations and length contractions, are needed to understand the operation in particular of the Michelson interferometer, which formed the basis of several key experiments. The major insight is that absolute motion through the quantum foam substratum is the cause of the special relativistic effects. The detection of this absolute motion is evidence that space has structure though the scale of that structure is not revealed by the experiments analysed in [9].

2   Gravity as Inhomogeneous Quantum Foam In-Flow

Here we show that the Newtonian theory of gravity may be exactly re-written as a 'fluid flow' system, as can General Relativity for a class of metrics. This 'fluid' system is interpreted [2, 3] as a classical description of a quantum foam substructure to space, and the 'flow' describes the relative motion of this quantum foam with, as we now show, gravity arising from inhomogeneities in that flow. These inhomogeneities can be caused by an in-flow into matter, or even as inhomogeneities produced purely by the self-interaction of space itself, as happens for instance for the black holes.

The Newtonian theory was originally formulated in terms of a force field, the gravitational acceleration $\mathbf{g}(\mathbf{r}, t)$, which is determined by the matter density $\rho(\mathbf{r}, t)$ according to

$$\nabla.\mathbf{g} = -4\pi G\rho. \tag{1}$$

For $\nabla \times \mathbf{g} = 0$ this gravitational acceleration $\mathbf{g}$ may be written as the gradient of the gravitational potential Φ

$$\mathbf{g} = -\nabla\Phi, \tag{2}$$

where the gravitational potential is now determined by

$$\nabla^2\Phi = 4\pi G\rho. \tag{3}$$

Here, as usual, G is the Newtonian gravitational constant. Now as $\rho \geq 0$ we can choose to have $\Phi \leq 0$ everywhere if $\Phi \to 0$ at infinity. So we can introduce $\mathbf{v}^2 = -2\Phi \geq 0$ where $\mathbf{v}$ is some velocity vector field. Here the value of $\mathbf{v}^2$ is specified, but not the direction of $\mathbf{v}$. Then

$$\mathbf{g} = \frac{1}{2}\nabla(\mathbf{v}^2) = (\mathbf{v}.\nabla)\mathbf{v} + \mathbf{v} \times (\nabla \times \mathbf{v}). \tag{4}$$

For zero-vorticity (irrotational) flow $\omega = \nabla \times \mathbf{v} = \mathbf{0}$. Then $\mathbf{g}$ is the usual Euler expression for the acceleration of a fluid element in a time-independent or stationary fluid flow. If the flow is time dependent that expression is expected to become

$$\mathbf{g} = \frac{\partial \mathbf{v}}{\partial t} + (\mathbf{v}.\nabla)\mathbf{v} = \frac{d\mathbf{v}}{dt}, \tag{5}$$

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which has given rise to the total derivative of $\mathbf{v}$ familiar from fluid mechanics. This equation is then to be accompanied by the 'Newtonian equation' for the flow field

$$\frac{1}{2}\nabla^2(\mathbf{v}^2) = -4\pi G\rho,\tag{6}$$

but to be consistent with (5) in the case of a time-dependent matter density this equation should be generalised to

$$\frac{\partial}{\partial t}(\nabla.\mathbf{v}) + \nabla.((\mathbf{v}.\nabla)\mathbf{v}) = -4\pi G\rho.\tag{7}$$

This exhibits the fluid flow form of Newtonian gravity in the case of zero vorticity $\nabla \times \mathbf{v} = 0$. For zero vorticity (7) determines both the magnitude and direction of the velocity field, for in this case we can write $\mathbf{v} = \nabla u$, where $u(\mathbf{r}, t)$ is a scalar velocity potential, and in terms of $u(\mathbf{r}, t)$ (7) specifies uniquely the time evolution of $u(\mathbf{r}, t)$. Note that (5) and (7) are exactly equivalent to (1) for the acceleration field $\mathbf{g}$, and so within the fluid flow formalism (5) and (7) are together equivalent to the Universal Inverse Square Law for $\mathbf{g}$, and so both are equally valid as regards the numerous experimental and observational checks of the acceleration field $\mathbf{g}$ formalism, particularly the Keplerian rotation velocity law. So we appear to have two equivalent formalisms for the same phenomenon. Indeed for a stationary spherically symmetric distribution of matter of total mass M the velocity field outside of the matter

$$\mathbf{v}(\mathbf{r}) = -\sqrt{\frac{2GM}{r}}\hat{\mathbf{r}},\tag{8}$$

satisfies (7) and reproduces the inverse square law form for $\mathbf{g}$ using (5):

$$\mathbf{g} = -\frac{GM}{r^2}\hat{\mathbf{r}}.\tag{9}$$

So the immediate questions that arise are (i) can the two formalisms be distinguished experimentally, and (ii) can the velocity field formalism be generalised, leading to new gravitational phenomena? To answer these questions we note that

1. The velocity flow field of some 417 ± 40 km/s in the direction (Right Ascension $= 5.2^{hr}$, Declination$= -67^0$) has been detected in several experiments, as described in considerable detail in [2, 9, 10]. The major component of that flow is related to a galactic flow, presumably within the Milky Way and the local galactic cluster, but a smaller component of some 50km/s being the flow past the earth towards the sun has also recently been revealed in the data.

2. In terms of the velocity field formalism (7) a unique term may be added that does not affect observations within the solar system, such as encoded in Kepler's laws, but outside of that special case the new term causes effects which vary from small to extremely large. This term will be shown herein to cause those effects that have been mistakenly called the 'dark matter' effect.

3. Eqn.(7) and its generalisations have time-dependent solutions even when the matter density is not time-dependent. These are a form of flow turbulence, a gravitational wave effect, and they have also been detected, as discussed in [2, 9, 10].

4. The need for a further generalisation of the flow equations will be argued for, and this in particular includes flow vorticity that leads to a non-spacetime explanation of the 'frame-dragging' effect, and of the 'dark matter' network observed using the weak gravitational lensing technique.

First let us consider the arguments that lead to a generalisation of (7). The simplest generalisation is

$$\frac{\partial}{\partial t}(\nabla.\mathbf{v}) + \nabla.((\mathbf{v}.\nabla)\mathbf{v}) + C(\mathbf{v}) = -4\pi G\rho, \tag{10}$$

where

$$C(\mathbf{v}) = \frac{\alpha}{8}((trD)^2 - tr(D^2)), \tag{11}$$

and

$$D_{ij} = \frac{1}{2}(\frac{\partial v_i}{\partial x_j} + \frac{\partial v_j}{\partial x_i}) \tag{12}$$

is the symmetric part of the rate of strain tensor $\partial v_i/\partial x_j$, and α is a dimensionless constant - a new gravitational constant in addition to G. It is possible to check that for the in-flow in (8) $C(\mathbf{v}) = 0$. This is a feature that uniquely determines the form of $C(\mathbf{v})$. This means that effects caused by this new term are not manifest in the planetary motions that formed the basis of Kepler's phenomenological laws and that then lead to Newton's theory of gravity. As discussed in [11, 12] the value of α determined from the Greenland bore hole g anomaly experimental data is found to be the fine structure constant, to within experimental error. As well, as discussed in [11, 12] (10) predicts precisely the so-called 'dark matter' effect, with the effective 'dark matter' density defined by

$$\rho_{DM}(\mathbf{r}) = \frac{\alpha}{32\pi G}((trD)^2 - tr(D^2)). \tag{13}$$

So the explanation of the 'dark matter' effect becomes apparent once we use the velocity field formulation of gravity. However (10) must be further generalised to include (i) the velocity of absolute motion of the matter components with respect to the local quantum foam system, and (ii) vorticity effects.

For these further generalisations[2] we need to be precise by what is meant by the velocity field $\mathbf{v}(\mathbf{r}, t)$. To be specific and also to define a possible measurement procedure we can choose to use the Cosmic Microwave Background (CMB) frame of reference for that purpose, as this is itself easy to establish. However that does not imply that the CMB frame is the local 'quantum-foam' rest frame. Relative to the CMB frame and using the local absolute motion detection techniques described in [2, 9, 10], or more modern techniques

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[2]The remainder of this section has been considerably changed since the September 2003 version of this paper.

that are under development, $\mathbf{v}(\mathbf{r}, t)$ may be measured in the neighbourhood of the observer. Then an 'object' at location $\mathbf{r}_0(t)$ in the CMB frame has velocity $\mathbf{v}_0(t) = d\mathbf{r}_0(t)/dt$ with respect to that frame. We then define

$$\mathbf{v}_R(\mathbf{r}_0(t), t) = \mathbf{v}_0(t) - \mathbf{v}(\mathbf{r}_0(t), t), \tag{14}$$

as the velocity of the object relative to the quantum foam at the location of the object. However this absolute velocity of matter $\mathbf{v}_R(t)$ does not appear in (10), and so not only is that equation lacking vorticity effects, it presumably is only an approximation for when the matter has a negligible speed of absolute motion with respect to the local quantum foam. To introduce the vector $\mathbf{v}_R(t)$ we need to construct a 2nd-rank tensor generalisation of (10), and the simplest form is

$$\frac{dD_{ij}}{dt} + \frac{\delta_{ij}}{3} tr(D^2) + \frac{trD}{2}(D_{ij} - \frac{\delta_{ij}}{3} trD)$$
$$+ \frac{\delta_{ij}}{3} \frac{\alpha}{8}((trD)^2 - tr(D^2)) = -4\pi G\rho(\frac{\delta_{ij}}{3} + \frac{v_R^i v_R^j}{2c^2} + ..), \; i,j = 1,2,3. \tag{15}$$

which uses the total derivative of the D_{ij} tensor in (12). Because of its tensor structure we can now include the direction of absolute motion of the matter density with respect to the quantum foam, with the scale of that given by c, which is the speed of light relative to the quantum foam. The superscript notation for the components of $\mathbf{v}_R(t)$ is for convenience only, and has no other significance. The trace of (15), using the identity

$$(\mathbf{v}.\nabla)(trD) = \frac{1}{2}\nabla^2(\mathbf{v}^2) - tr(D^2) - \frac{1}{2}(\nabla \times \mathbf{v})^2 + \mathbf{v}.\nabla \times (\nabla \times \mathbf{v}), \tag{16}$$

gives, for zero vorticity,

$$\frac{\partial}{\partial t}(\nabla.\mathbf{v}) + \nabla.((\mathbf{v}.\nabla)\mathbf{v}) + C(\mathbf{v}) = -4\pi G\rho(1 + \frac{v_R^2}{2c^2} + ..), \tag{17}$$

which is (10) in the limit $v_R \to 0$. As well the off-diagonal terms, $i \neq j$, are satisfied, to $O(v_R^i v_R^j/c^2)$, for the in-flow velocity field in (8). The conjectured form of the RHS of (17) is, to $O(v_R^2/c^2)$, based on the Lorentz contraction effect for the matter density, with ρ defined as the matter density if the matter were at rest with respect to the quantum foam. Hence, because of (17), (15) is in agreement with Keplerian orbits for the solar system with the velocity field given by (8).

We now consider a further generalisation of (15) to include vorticity effects, namely

$$\frac{dD_{ij}}{dt} + \frac{\delta_{ij}}{3} tr(D^2) + \frac{trD}{2}(D_{ij} - \frac{\delta_{ij}}{3} trD)$$
$$+ \frac{\delta_{ij}}{3} \frac{\alpha}{8}((trD)^2 - tr(D^2)) - (D\Omega - \Omega D)_{ij}$$
$$= -4\pi G\rho(\frac{\delta_{ij}}{3} + \frac{v_R^i v_R^j}{2c^2} + ..), \quad i,j = 1,2,3, \tag{18}$$

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$$\nabla \times (\nabla \times \mathbf{v}) = \frac{8\pi G\rho}{c^2}\mathbf{v}_R, \tag{19}$$

where

$$\Omega_{ij} = \frac{1}{2}\left(\frac{\partial v_i}{\partial x_j} - \frac{\partial v_j}{\partial x_i}\right) = -\frac{1}{2}\epsilon_{ijk}\omega_k = -\frac{1}{2}\epsilon_{ijk}(\nabla \times \mathbf{v})_k \tag{20}$$

is the antisymmetric part of the rate of strain tensor $\partial v_i/\partial x_j$, which is the vorticity vector field ω in tensor form. The term $(D\Omega - \Omega D)_{ij}$ allows the vorticity vector field to be coupled to the symmetric tensor D_{ij} dynamics. Again the vorticity is generated by absolute motion of the matter density with respect to the local quantum foam. Eqns (18) and (19) now permit the time evolution of the velocity field to be determined. Note that the vorticity equation in (19) may be explicitly solved, for it may be written as

$$\nabla(\nabla.\mathbf{v}) - \nabla^2\mathbf{v} = \frac{8\pi G\rho}{c^2}\mathbf{v}_R, \tag{21}$$

which gives, using

$$\nabla^2\left(\frac{1}{|\mathbf{r} - \mathbf{r}'|}\right) = -4\pi\delta(\mathbf{r} - \mathbf{r}'), \tag{22}$$

$$\mathbf{v}(\mathbf{r}, t) = \frac{2G}{c^2}\int d^3r' \frac{\rho(\mathbf{r}', t)}{|\mathbf{r} - \mathbf{r}'|}\mathbf{v}_R(\mathbf{r}', t) - \frac{1}{4\pi}\int d^3r' \frac{1}{|\mathbf{r} - \mathbf{r}'|}\nabla(\nabla.\mathbf{v}(\mathbf{r}', t)). \tag{23}$$

This suggests that $\mathbf{v}(\mathbf{r}, t)$ is now determined solely by the vorticity equation. However (23) is misleading, as (19) only specifies the vorticity, and taking the $\nabla\times$ of (23) we obtain

$$\omega(\mathbf{r}, t) = \nabla \times \mathbf{v}(\mathbf{r}, t) = \frac{2G}{c^2}\int d^3r' \frac{\rho(\mathbf{r}', t)}{|\mathbf{r} - \mathbf{r}'|^3}\mathbf{v}_R(\mathbf{r}', t) \times (\mathbf{r} - \mathbf{r}') + \nabla\psi, \tag{24}$$

which is the Biot-Savart form for the vorticity, with the additional term being the homogeneous solution. The homogeneous term corresponds to (distant) matter densities not explicitly included in $\rho(\mathbf{r}', t)$. Then (18) becomes an integro-differential equation for the velocity field. As discussed in [13] (24) explains the so-called 'frame-dragging' effect in terms of this vorticity in the in-flow, but makes predictions very different from General Relativity. These conflicting predictions will soon be tested by the Gravity Probe B satellite experiment. Of course (18) and (24) only make sense if $\mathbf{v}_R(\mathbf{r}, t)$ for the matter at location $\mathbf{r}$ is specified. We now consider the special case where the matter is subject only to the effects of motion with respect to the quantum-foam velocity-field inhomogeneities and variations in time, which causes a 'gravitational' acceleration.

We note that the first serious attempt to construct a 'flow' theory of gravity was by Kirkwood [15, 16]. However the above theory, as expressed in (18) and (19), is very different to Kirkwood's proposal. We also note that (18) and (19) need to be further generalised to take account of the cosmological-scale effects, namely that the spatial system is compact and growing, as discussed in [2].

3   Geodesics

Process Physics [2] leads to the Lorentzian interpretation of so called 'relativistic effects'. This means that the speed of light is only 'c' with respect to the quantum-foam system, and that time dilation effects for clocks and length contraction effects for rods are caused by the motion of clocks and rods relative to the quantum foam. So these effects are real dynamical effects caused by motion through the quantum foam, and are not to be interpreted as non-dynamical spacetime effects as suggested by Einstein. To arrive at the dynamical description of the various effects of the quantum foam we shall introduce conjectures that essentially lead to a phenomenological description of these effects. In the future we expect to be able to derive this dynamics directly from the Quantum Homotopic Field Theory (QHFT) that describes the quantum foam system [2]. Here we shall conjecture that the path of an object through an inhomogeneous and time-varying quantum-foam is determined, at a classical level, by a variational principle, namely that the travel time is extremised for the physical path $\mathbf{r}_0(t)$. The travel time is defined by

$$\tau[\mathbf{r}_0] = \int dt \left(1 - \frac{\mathbf{v}_R^2}{c^2} \right)^{1/2}, \tag{25}$$

with $\mathbf{v}_R$ given by (14). So the trajectory will be independent of the mass of the object, corresponding to the equivalence principle. Under a deformation of the trajectory $\mathbf{r}_0(t) \to \mathbf{r}_0(t) + \delta\mathbf{r}_0(t)$, $\mathbf{v}_0(t) \to \mathbf{v}_0(t) + \dfrac{d\delta\mathbf{r}_0(t)}{dt}$, and we also have

$$\mathbf{v}(\mathbf{r}_0(t) + \delta\mathbf{r}_0(t), t) = \mathbf{v}(\mathbf{r}_0(t), t) + (\delta\mathbf{r}_0(t).\nabla)\mathbf{v}(\mathbf{r}_0(t)) + ... \tag{26}$$

Then

$$
\begin{aligned}
\delta\tau &= \tau[\mathbf{r}_0 + \delta\mathbf{r}_0] - \tau[\mathbf{r}_0] \\
&= -\int dt \frac{1}{c^2}\mathbf{v}_R.\delta\mathbf{v}_R \left(1 - \frac{\mathbf{v}_R^2}{c^2}\right)^{-1/2} + ... \\
&= \int dt \frac{1}{c^2}\left(\mathbf{v}_R.(\delta\mathbf{r}_0.\nabla)\mathbf{v} - \mathbf{v}_R.\frac{d(\delta\mathbf{r}_0)}{dt}\right)\left(1 - \frac{\mathbf{v}_R^2}{c^2}\right)^{-1/2} + ... \\
&= \int dt \frac{1}{c^2}\left(\frac{\mathbf{v}_R.(\delta\mathbf{r}_0.\nabla)\mathbf{v}}{\sqrt{1 - \frac{\mathbf{v}_R^2}{c^2}}} + \delta\mathbf{r}_0.\frac{d}{dt}\frac{\mathbf{v}_R}{\sqrt{1 - \frac{\mathbf{v}_R^2}{c^2}}}\right) + ... \\
&= \int dt \frac{1}{c^2}\delta\mathbf{r}_0 . \left(\frac{(\mathbf{v}_R.\nabla)\mathbf{v} + \mathbf{v}_R \times (\nabla \times \mathbf{v})}{\sqrt{1 - \frac{\mathbf{v}_R^2}{c^2}}} + \frac{d}{dt}\frac{\mathbf{v}_R}{\sqrt{1 - \frac{\mathbf{v}_R^2}{c^2}}}\right) + ... \tag{27}
\end{aligned}
$$

Hence a trajectory $\mathbf{r}_0(t)$ determined by $\delta\tau = 0$ to $O(\delta\mathbf{r}_0(t)^2)$ satisfies

$$\frac{d}{dt}\frac{\mathbf{v}_R}{\sqrt{1 - \frac{\mathbf{v}_R^2}{c^2}}} = -\frac{(\mathbf{v}_R.\nabla)\mathbf{v} + \mathbf{v}_R \times (\nabla \times \mathbf{v})}{\sqrt{1 - \frac{\mathbf{v}_R^2}{c^2}}}. \tag{28}$$

Let us now write this in a more explicit form. This will also allow the low speed limit to be identified. Substituting $\mathbf{v}_R(t) = \mathbf{v}_0(t) - \mathbf{v}(\mathbf{r}_0(t), t)$ and using

$$\frac{d\mathbf{v}(\mathbf{r}_0(t), t)}{dt} = \frac{\partial\mathbf{v}}{\partial t} + (\mathbf{v}_0.\nabla)\mathbf{v}, \tag{29}$$

we obtain

$$\frac{d}{dt}\frac{\mathbf{v}_0}{\sqrt{1 - \frac{\mathbf{v}_R^2}{c^2}}} = \mathbf{v}\frac{d}{dt}\frac{1}{\sqrt{1 - \frac{\mathbf{v}_R^2}{c^2}}} + \frac{\frac{\partial\mathbf{v}}{\partial t} + (\mathbf{v}.\nabla)\mathbf{v} + (\nabla \times \mathbf{v}) \times \mathbf{v}_R}{\sqrt{1 - \frac{\mathbf{v}_R^2}{c^2}}}. \tag{30}$$

Then in the low speed limit $v_R \ll c$ we obtain

$$\frac{d\mathbf{v}_0}{dt} = \frac{\partial\mathbf{v}}{\partial t} + (\mathbf{v}.\nabla)\mathbf{v} + (\nabla \times \mathbf{v}) \times \mathbf{v}_R, \tag{31}$$

which agrees with the fluid flow form suggested in (5) for zero vorticity ($\nabla \times \mathbf{v} = 0$), but introduces a new vorticity effect for the gravitational acceleration. The last term in (31) is relevant to the 'frame-dragging' effect and to the Allais eclipse effect. Hence (30) is a generalisation of (5) to include Lorentzian dynamical effects, for in (30) we can multiply both sides by the rest mass m_0 of the object, and then (30) involves

$$m(\mathbf{v}_R) = \frac{m_0}{\sqrt{1 - \frac{\mathbf{v}_R^2}{c^2}}}, \tag{32}$$

the so called 'relativistic' mass, and (30) acquires the form

$$\frac{d}{dt}(m(\mathbf{v}_R)\mathbf{v}_0) = \mathbf{F}, \tag{33}$$

where $\mathbf{F}$ is an effective 'force' caused by the inhomogeneities and time-variation of the flow. This is essentially Newton's 2nd Law of Motion in the case of gravity only. That m_0 cancels is the equivalence principle, and which acquires a simple explanation in terms of the flow. Note that the occurrence of $1/\sqrt{1 - \frac{\mathbf{v}_R^2}{c^2}}$ will lead to the precession of the perihelion of elliptical planetary orbits, and also to horizon effects wherever $|\mathbf{v}| = c$: the region where $|\mathbf{v}| < c$ is inaccessible from the region where $|\mathbf{v}| > c$. Also (25) is easily used to determine the clock rate offsets in the GPS satellites, when the in-flow is given by (8). So the fluid flow dynamics in (18) and (24) and the gravitational dynamics for the matter in (28) now form a closed system. This system of equations is a considerable generalisation

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from that of Newtonian gravity, and would appear to be very different from the curved spacetime formalism of General Relativity. However we now show that General Relativity leads to a very similar system of equations, but with one important exception, namely that the 'dark matter' 'quantum-foam' dynamics is missing from the Hilbert-Einstein theory of gravity.

The above may be modified when the 'object' is a massless photon, and the corresponding result leads to the gravitational lensing effect. But not only will ordinary matter produce such lensing, but the effective 'dark matter' density will also do so, and that is relevant to the recent observation by the weak lensing technique of the so-called 'dark matter' networks.

4   General Relativity and the In-Flow Process

Eqn.(25) involves various absolute quantities such as the absolute velocity of an object relative to the quantum foam and the absolute speed c also relative to the foam, and of course absolute velocities are excluded from the General Relativity (GR) formalism. Here we examine GR to point out the key differences with the new theory, but also to indicate why, in the special case of the external-Scharwzschild metric, GR was apparently but misleadingly succesful. In particular we find that the major failing of GR is that it was constructed to agree with the Newtonian theory in the limit of low velocities, and so by default excluded the 'dark matter' effect. However (25) gives (with $t = x_0^0$)

$$d\tau^2 = dt^2 - \frac{1}{c^2}(d\mathbf{r}_0(t) - \mathbf{v}(\mathbf{r}_0(t), t)dt)^2 = g_{\mu\nu}(x_0)dx_0^\mu dx_0^\nu, \tag{34}$$

which is the Panlevé-Gullstrand form of the metric $g_{\mu\nu}$ [17, 18] for GR. We emphasize that the absolute velocity $\mathbf{v}_R$ has been measured, and so the foundations of GR as usually stated are invalid. Here we look closely at the GR formalism when the metric has the form in (34), appropriate to a velocity field formulation of gravity. In GR the metric tensor $g_{\mu\nu}(x)$, specifying the geometry of the spacetime construct, is determined by

$$G_{\mu\nu} \equiv R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} = \frac{8\pi G}{c^2}T_{\mu\nu}, \tag{35}$$

where $G_{\mu\nu}$ is the Einstein tensor, $T_{\mu\nu}$ is the energy-momentum tensor, $R_{\mu\nu} = R^\alpha_{\mu\alpha\nu}$ and $R = g^{\mu\nu}R_{\mu\nu}$ and $g^{\mu\nu}$ is the matrix inverse of $g_{\mu\nu}$. The curvature tensor is

$$R^\rho_{\mu\sigma\nu} = \Gamma^\rho_{\mu\nu,\sigma} - \Gamma^\rho_{\mu\sigma,\nu} + \Gamma^\rho_{\alpha\sigma}\Gamma^\alpha_{\mu\nu} - \Gamma^\rho_{\alpha\nu}\Gamma^\alpha_{\mu\sigma}, \tag{36}$$

where $\Gamma^\alpha_{\mu\sigma}$ is the affine connection

$$\Gamma^\alpha_{\mu\sigma} = \frac{1}{2}g^{\alpha\nu}\left(\frac{\partial g_{\nu\mu}}{\partial x^\sigma} + \frac{\partial g_{\nu\sigma}}{\partial x^\mu} - \frac{\partial g_{\mu\sigma}}{\partial x^\nu}\right). \tag{37}$$

In this formalism the trajectories of test objects are determined by

$$\Gamma^\lambda_{\mu\nu}\frac{dx^\mu}{d\tau}\frac{dx^\nu}{d\tau} + \frac{d^2x^\lambda}{d\tau^2} = 0, \tag{38}$$

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which is equivalent to extremising the functional

$$\tau[x] = \int dt \sqrt{g^{\mu\nu} \frac{dx^\mu}{dt} \frac{dx^\nu}{dt}}, \qquad (39)$$

with respect to the path $x[t]$. This is precisely equivalent to (25).

In the case of a spherically symmetric mass M the well known solution of (35) outside of that mass is the external-Schwarzschild metric

$$d\tau^2 = (1 - \frac{2GM}{c^2 r})dt^2 - \frac{1}{c^2}r^2(d\theta^2 + \sin^2(\theta)d\phi^2) - \frac{dr^2}{c^2(1 - \frac{2GM}{c^2 r})}. \qquad (40)$$

This solution is the basis of various experimental checks of General Relativity in which the spherically symmetric mass is either the sun or the earth. The four tests are: the gravitational redshift, the bending of light, the precession of the perihelion of Mercury, and the time delay of radar signals.

However the solution (40) is in fact completely equivalent to the in-flow interpretation of Newtonian gravity. Making the change of variables $t \to t'$ and $\mathbf{r} \to \mathbf{r'} = \mathbf{r}$ with

$$t' = t + \frac{2}{c}\sqrt{\frac{2GMr}{c^2}} - \frac{4GM}{c^2}\tanh^{-1}\sqrt{\frac{2GM}{c^2 r}}, \qquad (41)$$

the Schwarzschild solution (40) takes the form

$$d\tau^2 = dt'^2 - \frac{1}{c^2}(dr' + \sqrt{\frac{2GM}{r'}}dt')^2 - \frac{1}{c^2}r'^2(d\theta'^2 + \sin^2(\theta')d\phi'), \qquad (42)$$

which is exactly the Panlevé-Gullstrand form of the metric $g_{\mu\nu}$ [17, 18] in (34) with the velocity field given exactly by the Newtonian form in (8). In which case the geodesic equation (38) of test objects in the Schwarzschild metric is equivalent to solving (30). This choice of coordinates corresponds to a particular frame of reference in which the test object has velocity $\mathbf{v}_R = \mathbf{v} - \mathbf{v}_0$ relative to the in-flow field $\mathbf{v}$, as seen in (25). This results shows that the Schwarzschild metric in GR is completely equivalent to Newton's inverse square law: GR in this case is nothing more than Newtonian gravity in disguise. So the so-called 'tests' of GR were nothing more than a test of the geodesic equation, where most simply this is seen to determine the motion of an object relative to an absolute local frame of reference - the quantum foam frame.

It is conventional wisdom for practitioners in General Relativity to regard the choice of coordinates or frame of reference to be entirely arbitrary and having no physical significance: no observations should be possible that can detect and measure $\mathbf{v}_R$. This 'wisdom' is based on two beliefs (i) that all attempts to detect $\mathbf{v}_R$, namely the detection of absolute motion, have failed, and that (ii) the existence of absolute motion is incompatible with the many successes of both the Special Theory of Relativity and of the General Theory of Relativity. Both of these beliefs are demonstrably false, see [2, 8].

The results in this section suggest, just as for Newtonian gravity, that the Einstein General Relativity is nothing more than the dynamical equations for a velocity flow field $\mathbf{v}(\mathbf{r},t)$, but that both are not the best such theory, as both missed the 'dark matter' dynamical effect, and also the absolute motion effect, as now manifested on the RHS of (18) and (19). Hence the non-flat spacetime construct appears to be merely an unnecessary artifact of the Einstein measurement protocol, which in turn was motivated by the mis-reporting of the results of the Michelson-Morley experiment [2, 9]. The putative successes of General Relativity should thus be considered as an incomplete insight into the fluid flow dynamics of the quantum foam system, rather than as any confirmation of the validity of the spacetime formalism, and it was this insight that in [2, 8] led, in part, to the flow dynamics in (18) and (19). Nevertheless let us show that GR reduces to a 'flow' formalism for a restricted class of metrics, namely those that involve a velocity field. To that end we substitute the metric

$$d\tau^2 = g_{\mu\nu}dx^\mu dx^\nu = dt^2 - \frac{1}{c^2}(d\mathbf{r}(t) - \mathbf{v}(\mathbf{r}(t),t)dt)^2, \tag{43}$$

into (35) using (37) and (36). This metric involves the arbitrary time-dependent velocity field $\mathbf{v}(\mathbf{r},t)$. The various components of the Einstein tensor are then found to be

$$
\begin{aligned}
G_{00} &= \sum_{i,j=1,2,3} v_i \mathcal{G}_{ij} v_j - c^2 \sum_{j=1,2,3} \mathcal{G}_{0j} v_j - c^2 \sum_{i=1,2,3} v_i \mathcal{G}_{i0} + c^2 \mathcal{G}_{00}, \\
G_{i0} &= - \sum_{j=1,2,3} \mathcal{G}_{ij} v_j + c^2 \mathcal{G}_{i0}, \qquad i = 1,2,3. \\
G_{ij} &= \mathcal{G}_{ij}, \qquad i,j = 1,2,3.
\end{aligned}
\tag{44}
$$

where the $\mathcal{G}_{\mu\nu}$ are given by

$$
\begin{aligned}
\mathcal{G}_{00} &= \frac{1}{2}((trD)^2 - tr(D^2)), \\
\mathcal{G}_{i0} &= \mathcal{G}_{0i} = -\frac{1}{2}(\nabla \times (\nabla \times \mathbf{v}))_i, \qquad i = 1,2,3. \\
\mathcal{G}_{ij} &= \frac{d}{dt}(D_{ij} - \delta_{ij}trD) + (D_{ij} - \frac{1}{2}\delta_{ij}trD)trD \\
&\quad -\frac{1}{2}\delta_{ij}tr(D^2) - (D\Omega - \Omega D)_{ij}, \qquad i,j = 1,2,3.
\end{aligned}
\tag{45}
$$

In vacuum, with $T_{\mu\nu} = 0$, we find from (35) and (44) that $G_{\mu\nu} = 0$ implies that $\mathcal{G}_{\mu\nu} = 0$. This system of equations is thus very similar to the in-flow dynamics in (18) and (19), except that in vacuum GR, for the Panlevé-Gullstrand metric, demands that

$$((trD)^2 - tr(D^2)) = 0. \tag{46}$$

This simply corresponds to the fact that GR does not permit the 'dark matter' effect, namely that $\rho_{DM} = 0$, according to (13), and this happens because GR was forced to agree with Newtonian gravity, in the appropriate limits, and that theory also has no such

effect. As well in GR the energy-momentum tensor $T_{\mu\nu}$ is not permitted to make any reference to absolute linear motion of the matter; only the relative motion of matter or absolute rotational motion is permitted.

It is very significant to note that the above exposition of the GR formalism for the Panlevé-Gullstrand metric is exact. Then taking the trace of the $\mathcal{G}_{ij}$ equation in (45) we obtain, also exactly, and again using the identity in (16), and in the case of zero vorticity, and outside of matter so that $T_{\mu\nu} = 0$,

$$\frac{\partial}{\partial t}(\nabla.\mathbf{v}) + \nabla.((\mathbf{v}.\nabla)\mathbf{v}) = 0, \qquad (47)$$

which is the Newtonian 'velocity field' formulation of Newtonian gravity outside of matter. This should have been expected as it corresponds to the previous observation that 'Newtonian in-flow' velocity field is exactly equivalent to the external Schwarzschild metric. So again we see the extreme paucity of new physics in the GR formalism: all the key tests of GR are now seen to amount to a test *only* of $\delta\tau[x]/\delta x^{\mu} = 0$, when the in-flow field is given by (45), and which is nothing more than Newtonian gravity. Of course Newtonian gravity was itself merely based upon observations within the solar system, and this was too special to have revealed key aspects of gravity. Hence, despite popular opinion, the GR formalism is based upon very poor evidence. Indeed there is only one definitive confirmation of the GR formalism apart from the misleading external-Schwarzschild metric cases, namely the observed decay of the binary pulsar orbital motion, for only in this case is the metric non-Schwarzschild, and therefore non-Newtonian. However the new theory of gravity also leads to the decay of orbits, and on the grounds of dimensional analysis we would expect comparable predictions. So GR is not unique in predicting orbital decay.

5   Apparent Invariance of c

The quantum foam induces actual dynamical time dilations and length contractions in agreement with the Lorentz interpretation of special relativistic effects. As a consequence of this observers in uniform motion 'through' the foam will on measurement of the speed of light obtain always the same numerical value c, so long as they do not adjust their observational data to take account of these dynamical effects. So the special relativistic effects are very much an aspect of physical reality, but nevertheless the absolute motion causing these effects is observable.

To see this explicitly consider how various observers $P, P', ..$ moving with different speeds through the foam, might measure the speed of light. They each acquire a standard rod and an accompanying standardised clock. That means that these standard rods would agree if they were brought together, and at rest with respect to the quantum foam they would all have length Δl_0, and similarly for the clocks. Observer P and accompanying rod are both moving at speed v_R relative to the quantum foam, with the rod longitudinal to that motion, for simplicity. P then measures the time Δt_R, with the clock at end A

of the rod, for a light pulse to travel from end A to the other end B and back again to A. The light travels at speed c relative to the quantum-foam. Let the time taken for the light pulse to travel from $A \rightarrow B$ be t_{AB} and from $B \rightarrow A$ be t_{BA}, as measured by a clock at rest with respect to the quantum foam. The length of the rod moving at speed v_R is contracted to

$$\Delta l_R = \Delta l_0 \sqrt{1 - \frac{v_R^2}{c^2}}. \tag{48}$$

In moving from A to B the light must travel an extra distance because the end B travels a distance $v_R t_{AB}$ in this time, thus the total distance that must be traversed is

$$ct_{AB} = \Delta l_R + v_R t_{AB}, \tag{49}$$

Similarly on returning from B to A the light must travel the distance

$$ct_{BA} = \Delta l_R - v_R t_{BA}. \tag{50}$$

Hence the total travel time Δt_0 is

$$\Delta t_0 = t_{AB} + t_{BA} \quad = \quad \frac{\Delta l_R}{c - v_R} + \frac{\Delta l_R}{c + v_R} \tag{51}$$

$$= \quad \frac{2\Delta l_0}{c \sqrt{1 - \frac{v_R^2}{c^2}}}. \tag{52}$$

Because of the time dilation effect for the moving clock

$$\Delta t_R = \Delta t_0 \sqrt{1 - \frac{v_R^2}{c^2}}. \tag{53}$$

Then for the moving observer the speed of light is defined as the distance the observer believes the light travelled ($2\Delta l_0$) divided by the travel time according to the accompanying clock (Δt_R), namely $2\Delta l_0 / \Delta t_R = c$. So the speed v_R of the observer through the quantum foam is not revealed by this procedure, and the observer is erroneously led to the conclusion that the speed of light is always c. This *invariance of c* follows from two or more observers in manifest relative motion all obtaining the same speed c by this procedure. Despite this failure this special effect is actually the basis of the spacetime measurement protocol. That this protocol is blind to the absolute motion has led to enormous confusion within physics. However it is possible to overcome the 'blindness' of this procedure and to manifestly reveal an observer's absolute velocity of motion v_R. Several demonstrated techniques were given in [2].

6   The Lorentz Transformation

Here we show that the real dynamical effects of absolute moton results in certain special observational data being related by the Lorentz transformation. This involves the use of

the radar measurement protocol for acquiring observational space and time data of distant events, and subsequently displaying that data in a spacetime construct. In this protocol the observer records the time of emission and reception of radar pulses ($t_r > t_e$) travelling through the space of quantum foam, and then retrospectively assigns the time and distance of a distant event B according to (ignoring directional information for simplicity)

$$T_B = \frac{1}{2}(t_r + t_e), \quad D_B = \frac{c}{2}(t_r - t_e), \tag{54}$$

where each observer is now using the same numerical value of c. The event B is then plotted as a point in an individual geometrical construct by each observer, known as a spacetime record, with coordinates (D_B, T_B). This is no different to a historian recording events according to some agreed protocol. We now show that because of this protocol and the quantum foam dynamical effects, observers will discover on comparing their historical records of the same events that the expression

$$\tau_{AB}^2 = T_{AB}^2 - \frac{1}{c^2} D_{AB}^2, \tag{55}$$

is an invariant, where $T_{AB} = T_A - T_B$ and $D_{AB} = D_A - D_B$ are the differences in times and distances assigned to events A and B using the above measurement protocol (54), so long as both are sufficiently small compared with the scale of inhomogeneities in the velocity field.
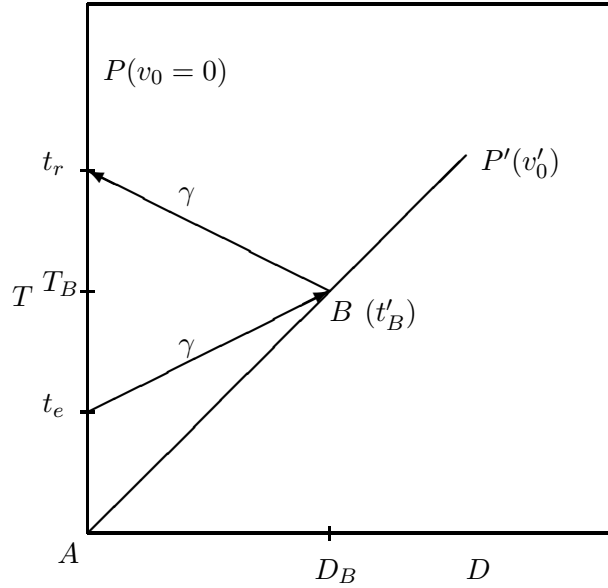

Figure 1: Here $T - D$ is the spacetime construct (from the measurement protocol) of a special observer P *at rest* wrt the quantum foam, so that $v_0 = 0$. Observer P' is moving with speed v_0' as determined by observer P, and therefore with speed $v_R' = v_0'$ wrt the quantum foam. Two light pulses are shown, each travelling at speed c wrt both P and the quantum foam. Event A is when the observers pass, and is also used to define zero time for each for convenience.

To confirm the invariant nature of the construct in (55) one must pay careful attention to observational times as distinct from protocol times and distances, and this must be done separately for each observer. This can be tedious. We now demonstrate this for the situation illustrated in Fig.1.

By definition the speed of P' according to P is $v'_0 = D_B/T_B$ and so $v'_R = v'_0$, where T_B and D_B are the protocol time and distance for event B for observer P according to (54). Then using (55) P would find that $(\tau^P_{AB})^2 = T_B^2 - \frac{1}{c^2}D_B^2$ since both $T_A = 0$ and $D_A = 0$, and whence $(\tau^P_{AB})^2 = (1 - \frac{v'^2_R}{c^2})T_B^2 = (t'_B)^2$ where the last equality follows from the time dilation effect on the P' clock, since t'_B is the time of event B according to that clock. Then T_B is also the time that P' would compute for event B when correcting for the time-dilation effect, as the speed v'_R of P' through the quantum foam is observable by P'. Then T_B is the 'common time' for event B assigned by both observers. For P' we obtain directly, also from (54) and (55), that $(\tau^{P'}_{AB})^2 = (T'_B)^2 - \frac{1}{c^2}(D'_B)^2 = (t'_B)^2$, as $D'_B = 0$ and $T'_B = t'_B$. Whence for this situation

$$(\tau^P_{AB})^2 = (\tau^{P'}_{AB})^2, \tag{56}$$

and so the construction (55) is an invariant.

While so far we have only established the invariance of the construct (55) when one of the observers is at rest wrt to the quantum foam, it follows that for two observers P' and P'' both in motion wrt the quantum foam it follows that they also agree on the invariance of (55). This is easily seen by using the intermediate step of a stationary observer P:

$$(\tau^{P'}_{AB})^2 = (\tau^P_{AB})^2 = (\tau^{P''}_{AB})^2. \tag{57}$$

Hence the measurement protocol and Lorentzian effects result in the construction in (55) being indeed an invariant in general. This is a remarkable and subtle result. For Einstein this invariance was a fundamental assumption, but here it is a derived result, but one which is nevertheless deeply misleading. Explicitly indicating small quantities by Δ prefixes, and on comparing records retrospectively, an ensemble of nearby observers agree on the invariant

$$\Delta\tau^2 = \Delta T^2 - \frac{1}{c^2}\Delta D^2, \tag{58}$$

for any two nearby events. This implies that their individual patches of spacetime records may be mapped one into the other merely by a change of coordinates, and that collectively the spacetime patches of all may be represented by one pseudo-Riemannian manifold, where the choice of coordinates for this manifold is arbitrary, and we finally arrive at the invariant

$$\Delta\tau^2 = g_{\mu\nu}(x)\Delta x^\mu \Delta x^\nu, \tag{59}$$

with $x^\mu = \{T, D_1, D_2, D_3\}$. For flat metrics (59) is invariant under the well known Lorentz transformation,

$$x^\mu = L(\mathbf{v})^\mu_{\ \nu}x'^\nu, \tag{60}$$

where, for motion only in the x-direction,

$$
\begin{aligned}
x &= \gamma(x' - \beta ct') \\
ct &= \gamma(ct' - \beta x') \\
y &= y' \\
z &= z'
\end{aligned}
\tag{61}
$$

where $\beta = v/c$ and $\gamma = 1/\sqrt{1 - \beta^2}$. Here, in general, $\mathbf{v}$ is the relative velocity of the two observers, determined by using the measurement protocol. The special feature of this mapping between the observer's spacetime records is that it does *not* involve the absolute velocity of either observer relative to the quantum-foam substratum - their absolute velocities. This feature was responsible, essentially, for the Einsetin assumption about 'c' being invariant for all observers in uniform motion. This feature has caused enormous confusion in physics. It erroneously suggests that absolute motion is incompatible with relativistic effects - that the observation of absolute motion must be in conflict with the observation of relativistic effects. For that reason reports of the ongoing detection of absolute motion has been banned in physics for nearly 100 years. However to the contrary absolute motion *and* special relativistic effects are both needed to understand and analyse the extensive experimental data reported in [9]. The key insight is that absolute motion dynamically causes the time dilation and length contraction effects. Without absolute motion there would be no special relativistic effects. This insight runs counter to nearly 100 years of conventional wisdom within physics.

7   The 'Dark Matter' Effect

Because of the α dependent term (18) and (19) would predict that the Newtonian inverse square law would not be applicable to systems such as spiral galaxies. A detailed analysis and comparison with experimental and observational data is given in [11, 12]. Of course attempts to retain this law, despite its manifest failure, has led to the spurious introduction of the notion of 'dark matter' within spiral galaxies, and also at larger scales. Here we merely note the basic idea that the 'dark matter' effect is indeed a dynamical effect of space itself. From

$$
\mathbf{g} = \frac{1}{2}\nabla(\mathbf{v}^2) + \frac{\partial \mathbf{v}}{\partial t},
\tag{62}
$$

which is (5) for irrotational flow and in the limit $R \to 0$, and in that case we see that (18) and (19) give (10), which implies that

$$
\nabla.\mathbf{g} = -4\pi G\rho - C(\mathbf{v}),
\tag{63}
$$

and taking running time averages to account for turbulence

$$
\nabla.<\mathbf{g}> = -4\pi G\rho - <C(\mathbf{v})>,
\tag{64}
$$

18

and writing the extra term as $<C(\mathbf{v})>= 4\pi G\rho_{DM}$ we see that ρ_{DM}, introduced in (13), would act as an effective matter density, and it is now clear, as shown in [11, 12], that it is the consequences of this term which have been misinterpreted as 'dark matter'. We thus see that this effect is actually the consequence of quantum foam effects within the new proposed dynamics for gravity, and which becomes apparent particularly in spiral galaxies. Note that (10) for $\nabla \times \mathbf{v} = \mathbf{0}$ becomes an equation for the velocity potential $u(\mathbf{r}, t)$,

$$\nabla^2 \left(\frac{\partial u}{\partial t} + \frac{1}{2}(\nabla u)^2 \right) = -4\pi G\rho - C(\nabla u(\mathbf{r})). \tag{65}$$

Then noting (22) we see that (65) has the non-linear integro-differential equation form

$$\frac{\partial u(\mathbf{r}, t)}{\partial t} = -\frac{1}{2}(\nabla u(\mathbf{r}, t))^2 + \frac{1}{4\pi} \int d^3r' \frac{C(\nabla u(\mathbf{r}', t))}{|\mathbf{r} - \mathbf{r}'|} - \Phi(\mathbf{r}, t), \tag{66}$$

where Φ is the Newtonian gravitational potential

$$\Phi(\mathbf{r}, t) = -G \int d^3r' \frac{\rho(\mathbf{r}', t)}{|\mathbf{r} - \mathbf{r}'|}. \tag{67}$$

Hence the Φ field acts as the source term for the velocity potential. Note that in the Newtonian theory of gravity one has the choice of using either the acceleration field $\mathbf{g}$ or the velocity field $\mathbf{v}$. However in the new theory of gravity this choice is no longer available: the fundamental dynamical degree of freedom is necessarily the $\mathbf{v}$ field, again because of the presence of the $C(\mathbf{v})$ term, which obviously cannot be written in terms of $\mathbf{g}$. If we were to ignore time-dependent behaviour (66) gives

$$|\mathbf{v}(\mathbf{r})|^2 = \frac{2}{4\pi} \int d^3r' \frac{C(\mathbf{v}(\mathbf{r}'))}{|\mathbf{r} - \mathbf{r}'|} - 2\Phi(\mathbf{r}). \tag{68}$$

This non-linear equation clearly cannot be solved for $\mathbf{v}(\mathbf{r})$ as its direction is not specified. This form makes it clear that we should expect gravitational waves, but certainly not waves travelling at the speed of light as c does not appear in (66). Note that (66) involves 'action-at-a-distance' effects, as there is no time-delay in the denominators. This was a feature of Newton's original theory of gravity. Here it is understood to be caused by the underlying quantum-foam dynamics (QHFT) which reaches this classical 'flow' description by ongoing non-local and instantaneous wavefunctional collapses, as discussed in [2]. Contrary to popular belief even GR has this 'action-at-a-distance' feature, as the reformulation of GR via the Panlevé-Gullstrand metric leads also to an equation of the form in (65), but with the $C(\mathbf{v})$ term absent.

8   Observations of Absolute Motion and Gravitational In-Flows

An extensive analysis of numerous experimental observations of absolute motion has been reported in [7, 9]. Absolute motion is motion relative to space itself. It turns out that

Michelson and Morley [19] in their historic experiment of 1887 did detect absolute motion, but rejected their own findings because, using a flawed model for the operation of the interferometer, the analysis of their data led to a speed of some 8 km/s, which was less than the 30 km/s orbital speed of the earth. Key aspects missing from their theory were, in addition to the known geometrical effect of the different path lengths when in translation, the Fitzgerald-Lorentz contraction and the effect of the gas in slowing the speed of the light (the refractive index effect). The data to the contrary clearly indicated evidence of absolute motion and, furthermore, that the theory for the operation of the Michelson interferometer was not adequate. Rather than reaching this conclusion Michelson and Morley came to the incorrect conclusion that their results amounted to the failure to detect absolute motion, even though the data clearly showed a signal with the expected signature, namely an 180^0 period on rotating the interferometer. This had an enormous impact on the development of physics, for as is well known Einstein adopted the absence of absolute motion effects as one of his fundamental assumptions. By the time Miller [20] had finally figured out how to use and properly analyse data from his Michelson interferometer absolute motion had become a forbidden concept within physics, as it still is at present. The experimental observations by Miller and others of absolute motion has continued to be scorned and rejected by the physics community. Fortunately as well as revealing absolute motion the experimental data also reveals evidence in support of a new theory of gravity.

In ref.[7, 9] the analysis of data from six experiments demonstrated that absolute motion relative to space has been observed by Michelson and Morley [19], Miller [20], Illingworth [21], Jaseja *et al* [22], Torr and Kolen [23], and by DeWitte [24], contrary to common belief within physics that absolute motion has never been observed. The Dayton Miller also reveals via the analysis in [9], the in-flow of space past the earth into the sun. The direction of the cosmic absolute velocity is found to be different to that of the CMB due to the in-flow into the Milky Way and the local galactic cluster, see Sect.12. The Miller experimental data also suggests that the in-flow manifests turbulence, as does the DeWitte data, which amounts to the observation of a gravitational wave phenomena.

The extensive experimental data shows that absolute motion is consistent with relativistic effects. Indeed relativistic effects are caused by dynamical effects associated with absolute motion, as proposed by Lorentz, and relativistic effects are required in understanding the gas-mode Michelson interferometer experiments. The Lorentz transformation is seen to be a consequence of absolute motion dynamics. Vacuum Michelson interferometer experiments or its equivalent [25, 26, 27, 28, 29] cannot detect absolute motion, but their null results do support this interpretation and form a part of the experimental predictions of the new physics.

9 The Velocity Superposition Principle

Despite being non-linear (18)-(19) possess an approximate superposition principle[3], which explains why the existence of absolute motion and as well the presence of the $C(\mathbf{v})$ term appears to have escaped attention in the case of gravitational experiments and observations near the earth, despite the fact, in the case of the $C(\mathbf{v})$ term, that the presence of the earth breaks the spherical symmetry of the matter distribution of the sun.

First note that in analysing (18)-(19) we need to recognise two distinct effects: (i) the effect of a change of description of the flow when changing between observers, and (ii) the effects of absolute motion of the matter with respect to the quantum foam substratum. Whether the matter is at rest or in absolute motion with respect to this substratum does have a dynamical effect, albeit very small. While the Newtonian theory and GR both offer an account of the first effect, and different accounts at that, neither have the second dynamical effect, as this is a unique feature of the new theory of gravity. Let us consider the first effect, as this is somewhat standard. It basically comes down to noting that under a change of observer (18)-(19) transform covariantly under a Galilean transformation. Suppose that according to one observer O the matter density is specified by a form $\rho_O(\mathbf{r}, t)$, and that (18)-(19) has a solution $\mathbf{v}_O(\mathbf{r}, t)$, and then with acceleration $\mathbf{g}_O(\mathbf{r}, t)$ given by (30)[4]. Then for another observer O' (and for simplicity we assume that the observers use coordinate axes that have the same orientation, and that at time $t = 0$ they coincide), moving with uniform velocity $\mathbf{V}$ relative to observer O, observer O' describes the matter density with the form $\rho_{O'}(\mathbf{r}, t) = \rho_O(\mathbf{r} + \mathbf{V}t, t)$. Then, as we now show, the corresponding solution to (18)-(19) for O' is *exactly*

$$\mathbf{v}_{O'}(\mathbf{r}, t) = \mathbf{v}_O(\mathbf{r} + \mathbf{V}t, t) - \mathbf{V}. \tag{69}$$

This is easily established by substitution of (69) into (18)-(19), and noting that the LHS leads to a RHS where the density has the different form noted above, but that $\mathbf{v}_R$ is *invariant* under this change of observer, for each observer agrees on the absolute velocity of each piece of matter with respect to the local quantum foam. Under the change of observers, from O to O', (69) gives

$$D_{ij}(\mathbf{r}, t) \rightarrow D_{ij}(\mathbf{r} + \mathbf{V}t, t) \quad \text{and} \quad \Omega_{ij}(\mathbf{r}, t) \rightarrow \Omega_{ij}(\mathbf{r} + \mathbf{V}t, t). \tag{70}$$

Then for the total or Euler fluid derivative in (18) we have for observer O'

$$
\begin{aligned}
\frac{dD_{ij}(\mathbf{r} + \mathbf{V}t, t)}{dt} &\equiv \frac{\partial D_{ij}(\mathbf{r} + \mathbf{V}t, t)}{\partial t} + (\mathbf{v}_O(\mathbf{r} + \mathbf{V}t, t) - \mathbf{V}).\nabla D_{ij}(\mathbf{r} + \mathbf{V}t, t), \\
&= \left. \frac{\partial D_{ij}(\mathbf{r} + \mathbf{V}t', t)}{\partial t'} \right|_{t' \rightarrow t} + \left. \frac{\partial D_{ij}(\mathbf{r} + \mathbf{V}t, t''))}{\partial t''} \right|_{t'' \rightarrow t} + \\
& \quad (\mathbf{v}_O(\mathbf{r} + \mathbf{V}t, t) - \mathbf{V}).\nabla D_{ij}(\mathbf{r} + \mathbf{V}t, t),
\end{aligned}
$$

---

[3]This section has been considerably changed since the September 2003 version of this paper.
[4]Note that here and in the following, except where indicated, the subscripts are O and not 0.

$$
\begin{aligned}
&= \quad (\mathbf{V}.\nabla)D_{ij}(\mathbf{r}+\mathbf{V}t,t) + \left.\frac{\partial D_{ij}(\mathbf{r}+\mathbf{V}t,t''))}{\partial t''}\right|_{t''\to t} + \\
&\qquad (\mathbf{v}_O(\mathbf{r}+\mathbf{V}t,t)-\mathbf{V}).\nabla D_{ij}(\mathbf{r}+\mathbf{V}t,t), \\
&= \quad \left.\frac{\partial D_{ij}(\mathbf{r}+\mathbf{V}t,t''))}{\partial t''}\right|_{t''\to t} + \mathbf{v}_O(\mathbf{r}+\mathbf{V}t,t).\nabla D_{ij}(\mathbf{r}+\mathbf{V}t,t), \\
&= \quad \left.\frac{dD_{ij}(\mathbf{r},t))}{dt}\right|_{\mathbf{r}\,\to\,\mathbf{r}+\mathbf{V}t}
\end{aligned}
\tag{71}
$$

as there is a key cancellation of two terms in (71). Clearly then all the terms on the LHS of (18)-(19) have the same transformation property. Then, finally, from the form of the LHS, both equations give the density dependent RHS, but which now involves the form $\rho_O(\mathbf{r},t)|_{\mathbf{r}\,\to\,\mathbf{r}+\mathbf{V}t}$, and this is simply $\rho_{O'}(\mathbf{r},t)$ given above. If the observers coordinate axes do not have the same orientation then a time-independent orthogonal similarity transformation $D \to SDS^T$, $\Omega \to S\Omega S^T$, and $v_R^i \to \sum_j S_{ij}v_R^j$ arises as well. Hence the description of the flow dynamics for observers in uniform relative motion is Galilean covariant. While the transformation rule for the Euler derivative is not a new result, there are some subtleties in the analysis, as seen above. The subtlety arises because the change of coordinate variables necessarily introduces a time dependence in the observer descriptions, even if the flow is inherently stationary. Finally, using an analogous argument to that in (71), we see explicitly that the acceleration is also Galilean covariant under the above change of observer, $\mathbf{g}(\mathbf{r},t) \to \mathbf{g}(\mathbf{r}+\mathbf{V}t,t)$ (in the case of observer axes with the same orientation). This simply asserts that all observers actually agree on the gravitational acceleration.

We now come to item (ii) above, namely the more subtle but experimentally significant *approximate* velocity superposition principle. This approximate effect relates to the change in the form of the solutions of (18)-(19) when the matter density is in motion, as a whole, with respect to the quantum-foam substratum, as compared to the solutions when the matter is, as a whole, at rest. Already even these descriptions involve a subtlety. Consider the case when a star, say, is 'at rest' with respect to the substratum. Then the flow dynamics in (18)-(19) will lead to a position and time dependent flow solution $\mathbf{v}(\mathbf{r},t)$. But that flow leads to a position and time dependent $\mathbf{v}_R(\mathbf{r},t) = \mathbf{v}_0(\mathbf{r},t) - \mathbf{v}(\mathbf{r},t)$ on the RHS of (18)-(19), where $\mathbf{v}_0(\mathbf{r},t)$ is the velocity of the matter at position $\mathbf{r}$ and time t according to some specific observer's frame of reference[5]. Hence the description of the matter being 'at rest' or 'in motion' relative to the substratum is far from simple. In general, with time-dependent flows, none of the matter will ever be 'at rest' with respect to the substratum, and this description is covariant under a change of observer. In the case of a well isolated star exisitng in a non-turbulent substratum we could give the terms 'at rest as a whole' or 'moving as whole' a well defined meaning by deciding how the star as a whole, considered as a rigid body, was moving relative to the more distant unperturbed substratum. Despite these complexities the solutions of (18)-(19) have, under certain

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[5]Here the subscript is 0 and not an O. $\mathbf{v}_R(\mathbf{r},t)$ was defined in (14). For matter described by a density distribution it is appropriate to introduce the field $\mathbf{v}_0(\mathbf{r},t)$.

conditions, an approximate dynamical velocity superposition princple, namely that if the flow is $\mathbf{v}_O(\mathbf{r}, t)$, according to some observer O, when the matter is 'at rest as a whole', then when the same matter density is 'moving as a whole' with velocity $\mathbf{V}$, then the flow solution becomes *approximately* $\mathbf{v}'_O(\mathbf{r}, t) \approx \mathbf{v}_O(\mathbf{r} - \mathbf{V}t, t)$, according to the same observer. Then if we want the flow field for the observer O' travelling at the same velocity as the star relative to the quantum foam, then using the *exact* Galilean transformation in (69) in conjunction with $\mathbf{r} \to \mathbf{r} + \mathbf{V}t$, we obtain $\mathbf{v}'_{O'}(\mathbf{r}, t) \approx \mathbf{v}_O(\mathbf{r}, t) - \mathbf{V}$. That is the observer moving with the star sees approximately the vector sum of the in-flow field that the star would have when 'at rest as a whole' and the 'flow' $-\mathbf{V}$ caused by the star and observer moving through the substratum with velocity $\mathbf{V}$ that the observer would detect in the absence of the star. To be more explicit about the signs we note that if we move in a southerly direction, say, against the substratum, then the substratum appears to be flowing though or past us in a northerly direction. To see why, dynamically, the above velocity superposition approximation is valid note that the effect of absolute motion of matter forming the star, with respect to the local substratum, as specified by $\mathbf{v}_R(\mathbf{r}, t)$, arises at order $(v_R/c)^2$, and also with strength G, which together makes the RHS of (18) very insensitive to the absolute motion of the matter, and with a similar argument for the vorticity in (19). So only at the centre of stars, for example, where v_R does become large because of the gravitational attractor effect (*viz* the black hole effect), see [12], will this approximate superposition principle breakdown. It then follows that the derived acceleration field $\mathbf{g}(\mathbf{r}, t)$ is also approximately unchanged, up to a Galilean transformation corresponding to an observer dependent change of description, by the 'motion as a whole' of the matter through the substratum.

Hence the gravitational acceleration, say of the earth, will only be affected, by its observed absolute motion, at order $(v_R/c)^2$, and this has the approximate value of 10^{-6}. Note that this approximate dynamical velocity superposition principle is completely different to what would occur if a solid object were moving through a normal classical fluid, for in this case we obviously would not see any such superposition effect. For earth based gravitational phenomena the motion of the earth takes place within the inhomogeneous velocity in-flow towards the sun, and the velocity superposition is only approximately valid as now $\mathbf{V} \to \mathbf{V}(\mathbf{r}, t)$ and no longer corresponds to uniform translation, and manifests turbulence. To be a valid approximation the inhomogeneity of $\mathbf{V}(\mathbf{r}, t)$ must be much smaller than that of $\mathbf{v}(\mathbf{r} - \mathbf{V}t, t)$, which it is, as the earth's centripetal acceleration about the sun is approximately $1/1000$ that of the earth's gravitational acceleration at the surface of the earth. Of course the inhomogeneity of the flow towards the sun is what keeps the earth in its orbit about the sun, and indeed that component of the flow is now understood to be present in the Miller absolute motion data [9]. So the validity of this velocity superposition approximation demonstrates that the detection of a cosmic absolute motion and of the in-flow theory of gravity are consistent with the older methods of computing gravitational forces. This is why both the presence of the $C(\mathbf{v})$ term, the in-flow and the absolute motion have gone almost unnoticed in earth based gravitational experiments, except for

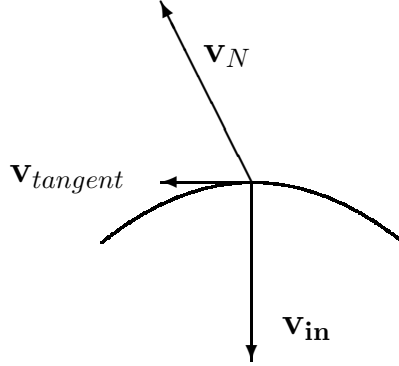the so-called various 'anomalies'; see Sect.11.

Figure 2: Orbit of earth about the sun with tangential orbital velocity $\mathbf{v}_{tangent}$ and quantum-foam in-flow velocity $\mathbf{v}_{in}$. Then $\mathbf{v}_N = \mathbf{v}_{tangent} - \mathbf{v}_{in}$ is the velocity of the earth relative to the quantum foam, after subtracting $\mathbf{v}_{cosmic}$. Alternatively this diagram also represents the various velocities associated with a satellite in orbit about the earth.

This approximate velocity superposition principle is the key to understanding the operation of the earth based detections of absolute motion [9]. There are four velocities that contribute to the total velocity of an observer through space:

$$\mathbf{v} \approx \mathbf{v}_{cosmic} + \mathbf{v}_{tangent} - \mathbf{v}_{in} - \mathbf{v}_E. \tag{72}$$

Here $\mathbf{v}_{cosmic}$ is the velocity of the solar system through space, while the other three are local effects: (i) $\mathbf{v}_{tangent}$ is the tangential orbital velocity of the earth about the sun, (ii) $\mathbf{v}_{in}$ is a quantum-foam radial in-flow past the earth towards the sun, and (iii) the corresponding quantum-foam in-flow into the earth is $\mathbf{v}_E$ and makes no contribution to a horizontally operated interferometer. In constructing (72) we have asumed the validity of the velocity superposition principle, namely that $\mathbf{v}_{cosmic}$, $\mathbf{v}_{in}$ and $\mathbf{v}_E$ may be approximately combined vectorially. The minus signs in (72) arise because, for example, the in-flow towards the sun requires the earth to have an outward directed velocity component against that in-flow in order to maintain a fixed distance from the sun, as shown in Fig.2. For circular orbits $v_{tangent}$ and v_{in} are given by

$$v_{tangent} = \sqrt{\frac{GM}{R}}, \tag{73}$$

$$v_{in} = \sqrt{\frac{2GM}{R}}, \tag{74}$$

while the net speed v_N of the earth from the vector sum $\mathbf{v}_N = \mathbf{v}_{tangent} - \mathbf{v}_{in}$ is

$$v_N = \sqrt{\frac{3GM}{R}}, \tag{75}$$

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where M is the mass of the sun, R is the distance of the earth from the sun, and G is Newton's gravitational constant. G is essentially a measure of the rate at which matter effectively 'dissipates' the quantum-foam. The gravitational acceleration of the earth towards the sun arises from inhomogeneities in the v_{in} flow component. These expressions give $v_{tangent} = 30$km/s, $v_{in} = 42.4$km/s and $v_N = 52$km/s. As discussed in [9] v_{in} is extractable from Miller's 1925/26 air-mode Michelson interferometer experiment, and so provided the first confirmation of the new 'flow' theory of gravity. As noted above the velocity superposition approximation implies that the gravitational entrainment or 'drag effects' are very small. Nevertheless they are present and the Gravity Probe B satellite experiment was designed to detect just such a vorticity effect. Of course the magnitude of this vorticity effect predicted by the new theory of gravity [11] is much larger than that predicted by General Relativity, for in this theory only *rotation* has an absolute meaning, whereas in the new theory both rotation and linear motion with respect to the substratum have an absolute meaning, and generate observable vorticity effects. As well the absolute linear velocity of the earth through the substratum also has a larger effect on the so-called geodetic precession of the GP-B gyroscopes, than predicted by General Relativity.

10   Gravitational In-Flow and the GPS

We show here that the new in-flow theory of gravity and the observed absolute velocity of motion of the solar system through space are compatible with the operation of the Global Positioning System (GPS), and that the new theory of gravity finally provides a theory for the operation of the GPS, that is, that the account given by General Relativity was actually only fortuitously correct. Given the developments above this turns out to be an almost trivial exercise. As usual in this system the effects of the sun and moon are neglected. Various effects need to be included as the system relies upon extremely accurate atomic clocks in the satellites forming the GPS constellation. Within both the new theory and General Relativity these clocks are effected by both their speed and the gravitational effects of the earth. As well the orbits of these satellites and the critical time delays of radio signals from the satellites need to be computed. For the moment we assume spherical symmetry for the earth. The effects of non-sphericity will be discussed below. In General Relativity the orbits and signalling time delays are determined by the use of the geodesic equation (38) and the Schwarzschild metric (40). However these two equations are equivalent to the orbital equation (32) and the velocity field (69), with a velocity $\mathbf{V}$ of absolute motion, and with the in-flow given by (8), noting the result in Sect.9. For EM signalling the elapsed time in (25) requires careful treatment. Hence the two systems are mathematically completely equivalent: the computations within the new system may most easily be considered by relating them to the mathematically equivalent General Relativity formalism. We can also see this by explicitly changing from the CMB

frame to a non-rotating frame co-moving with the earth by means of the change of variables

$$
\begin{aligned}
\mathbf{r} &= \mathbf{r}' + \mathbf{V}t, \qquad\qquad\qquad\qquad (76)\\
t &= t',\\
\mathbf{v} &= \mathbf{v}' + \mathbf{V},
\end{aligned}
$$

which lead to the relationships of differentials

$$
\begin{aligned}
\nabla' &= \nabla, \qquad\qquad\qquad\qquad\qquad (77)\\
\frac{\partial}{\partial t'} &= \frac{\partial}{\partial t} + \mathbf{V}.\nabla
\end{aligned}
$$

These expressions then lead to the demonstration of the covariance of (18)-(19). Then in the earth co-moving frame the absolute cosmic velocity $\mathbf{V}$ only appears on the RHS of these equations, and as noted in the previous section, has an extremely small dynamical effect.

There are nevertheless two differences between the two theories. One is their different treatment of the non-sphericity of the earth via the $C(\mathbf{v})$ term, and the second difference is the effects of the in-flow turbulence. In the operation of the GPS the density $\rho(\mathbf{r})$ of the earth is not used. Rather the gravitational potential $\Phi(\mathbf{r})$ is determined observationally. In the new gravity theory the determination of such a gravitational potential via (18)-(19) and $\Phi(\mathbf{r}) = -\frac{1}{2}\mathbf{v}^2(\mathbf{r})$ would involve the extra $C(\mathbf{v})$ term. Hence because of this phenomenological treatment the effects of the $C(\mathbf{v})$ term are not checkable. However the gravitational wave effect is expected to affect the operation of the GPS, and the GPS constellation would offer a worldwide network which would enable the investigation of the spatial and temporal correlations of these gravitational waves.

There is also a significant interpretational difference between the two theories. For example in General Relativity the relativistic effects involve both the 'special relativity' orbital speed effect via time dilations of the satellite clocks together with the General Relativity 'gravitational potential energy' effect on the satellite clocks. In the new theory there is only one effect, namely the time dilation effect produced by the motion of the clocks through the quantum foam, and the speeds of these clocks involves the vector sum of the orbital velocity and the velocity caused by the in-flow of the quantum foam into the earth. This is illustrated by Fig.2, where now the orbit refers to that of a satellite about the earth.

As well as providing a platform for studying the new gravitational waves, the GPS is already used for accurate time transfers. But because General Relativity and the new theory of gravity are fundamentally different there will be differences at higher orders in v_R/c. A systematic study of these corrections should be undertaken with the possibility that they will permit the establishment of more accurate global time standards.

11   Gravitational Anomalies

Gravitational anomalies are those observed effects which are apparently inconsistent with either the Newtonian theory of gravity or General Relativity. The 'dark matter' effect is in fact one such anomaly. These anomalies are in the low speed/low mass regime appropriate to the Newtonian theory, but since General Relativity was constructed to agree with Newtonian theory in this regime these anomalies are common to both theories. Here we note that these anomalies appear to be explainable within the new theory of gravity, and are indicators of the failure of Newtonian gravity and hence General Relativity.

As noted in Sect.2 Newton's Inverse Square Law of Gravitation may only be strictly valid in cases of spherical symmetry. The theory that gravitational effects arise from inhomogeneities in the quantum foam flow implies that there is no 'universal law of gravitation' because the inhomogeneities are determined by non-linear 'fluid equations' and the solutions have no form which could be described by a 'universal law'. Fundamentally there is no generic fluid flow behaviour. The Inverse Square Law is then only an approximation, with large deviations expected in the case of spiral galaxies. Nevertheless Newton's gravitational constant G will have a definite value as it quantifies the effective rate at which matter dissipates the information content of space.

From these considerations it follows that the measurement of the value of G will be difficult as the measurement of the forces between two of more objects, which is the usual method of measuring G, will depend on the geometry of the spatial positioning of these objects in a way not previously accounted for because the Newtonian Inverse Square Law has always been assumed, or in some case a specified change in the form of the law has been used. But in all cases a 'law' has been assumed, and this may have been the flaw in the analysis of data from such experiments. This implies that the value of G from such experiments will show some variability as a systematic effect has been neglected in analysing the experimental data, for in none of these experiments is spherical symmetry present. So experimental measurements of G should show an unexpected contextuality. As well the influence of surrounding matter has also not been properly accounted for. Of course any effects of turbulence in the inhomogeneities of the flow has presumably also never even been contemplated. The first measurement of G was in 1798 by Cavendish using a torsional balance. As the precision of experiments increased over the years and a variety of techniques used the disparity between the values of G has actually increased [54]. Fig.3 shows the results from precision measurements of G over the last 60 years. As can be seen one indication of the contextuality is that measurements of G produce values that differ by nearly 40 times their individual error estimates. In 1998 CODATA increased the uncertainty in G from 0.013% to 0.15%. It is predicted that these G anomalies will only be resolved when the new theory of gravity is used in analysing the data from these experiments.

There are additional gravitational anomalies that are not well-known in physics, presumably because their existence is incompatible with the Newtonian or the Hilbert-
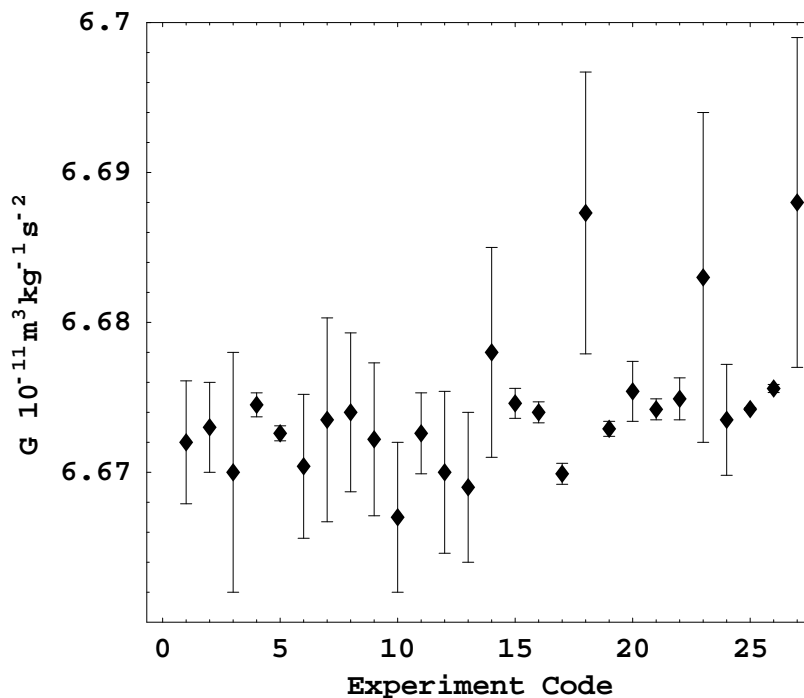
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Figure 3: Results of precision measurements of G published in the last sixty years in which the Newtonian theory was used to analyse the data. These results show the presence of a systematic effect not in the Newtonian theory. **1:** Gaithersburg 1942 [30], **2:** Magny-les-Hameaux 1971 [31], **3:** Budapest 1974 [32], **4;** Moscow 1979 [33], **5:** Gaithersburg 1982 [34], **6-19:** Fribourg Oct 84, Nov 84, Dec 84, Feb 85 [35], **10:** Braunschweig 1987 [36], **11:** Dye 3 Greenland 1995 [37], **12:** Gigerwald Lake 1994 [38], **13-14:** Gigerwald lake19 95 112m, 88m [39], **15:** Lower Hutt 1995 MSL [40], **16:** Los Alamos 1997 [41], **17:** Wuhan 1998 [42], **18:** Boulder JILA 1998 [43], **19:** Moscow 1998 [44], **20:** Zurich 1998 [45], **21:** Lower Hutt MSL 1999 [46], **22:** Zurich 1999 [47], **23:** Sevres 1999 [48], **24:** Wuppertal 1999 [49], **25:** Seattle 2000 [50], **26:** Sevres 2001 [51], **27:** Lake Brasimone 2001 [52]. Data compilation adapted from [53].

Einstein gravity theories. The most significant of these anomalies is the Allais effect [55, 56]. In June 1954 Allais reported that a short Foucault pendulum, known as a paraconical pendulum, exhibited peculiar rates of precession at the time of a solar eclipse. Allais was recording the precession of the pendulum in Paris. Coincidently during the 30 day observation period a partial solar eclipse occurred at Paris on June 30. During the eclipse the precession of the pendulum was seen to be disturbed. Similar results were obtained during another solar eclipse on October 29 1959. There have been other repeats of the Allais experiment with varying results.

Another anomaly was reported by Saxl and Allen [57] during the solar eclipse of March 7 1970. Significant variations in the period of a torsional pendulum were observed both during the eclipse and as well in the hours just preceding and just following the eclipse. The effects seem to suggest that an "apparent wavelike structure has been observed over

the course of many years at our Harvard laboratory", where the wavelike structure is present and reproducible even in the absence of an eclipse.

Again Zhou and Huang [58] report various time anomalies occuring during the solar eclipses of September 23 1987, March 18 1988 and July 22 1990 observed using atomic clocks.

All these anomalies and others not discussed here would suggest that gravity has aspects to it that are not within the prevailing theories, but that the in-flow theory discussed above might well provide an explanation, and indeed these anomalies may well provide further phenomena that could be used to test the new theory. The effects associated with the solar eclipses could presumably follow from the alignment of the sun, moon and the earth causing enhanced turbulence. The Saxl and Allen experiment of course suggests, like the other experiments analysed in [9], that the turbulence is always present. To explore these anomalies detailed numerical studies of (18)-(19) are underway with particular emphasis on the effect of the position of the moon.

12   Galactic In-flow and the CMB Frame

Absolute motion (AM) of the Solar system has been observed in the direction ($\alpha = 17.5^h, \delta = 65^0$), up to an overall sign to be sorted out, with a speed of 417 ± 40 km/s. This is the velocity after removing the contribution of the earth's orbital speed and the sun in-flow effect [2, 9]. It is significant that this velocity is different to that associated with the Cosmic Microwave Background (CMB) relative to which the Solar system has a speed of 369 km/s in the direction ($\alpha = 11.20^h, \delta = -7.22^0$), see [14]. This CMB velocity is obtained by finding the preferred frame in which this thermalised 3^0K radiation is isotropic, that is by removing the dipole component. The CMB velocity is a measure of the motion of the Solar system relative to the universe as a whole, or atleast a shell of the universe some 14Gyrs away, and indeed the near uniformity of that radiation in all directions demonstrates that we may meaningfully refer to the spatial structure of the universe. The concept here is that at the time of decoupling of this radiation from matter that matter was on the whole, apart from small observable fluctuations, at rest with respect to the quantum-foam system that is space. So the CMB velocity is the motion of the Solar system with respect to space *universally*, but not necessarily with respect to the *local* space. Contributions to this global CMB velocity arise from the orbital motion of the earth in the solar system (this contribution is apparent in the CMB observational data and is actually removed in the analysis), the orbital motion of the Solar system within the Milky Way galaxy, giving a speed of some 230 km/s giving together with local motion of the Solar system in the Milky Way, a net speed of some 250 km/s, and contributions from the motion of the Milky Way within the local cluster, and so on to perhaps larger clusters.

On the other hand the AM velocity is a vector sum of this *global* velocity and the net velocity associated with the *local* gravitational in-flows into the Milky Way and into the

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local cluster. This is because the observation of the CMB velocity does not pick up the local gravitational in-flows. Only gravitational lensing could affect that result, and that is an extremely small effect within the Milky Way. If the CMB velocity had been identical to the AM velocity then the in-flow interpretation of gravity would have been proven wrong. We therefore have three pieces of experimental evidence for this interpretation (i) the refractive index anomaly discussed previously in connection with the Miller data, (ii) the turbulence seen in all detections of absolute motion, and now (iii) that the AM velocity is different in both magnitude and direction from that of the CMB velocity.

That the AM and CMB velocities are different contributes to the explanation offered herein for the resolution of the 'dark matter' problem. Rather than the galactic velocity anomalies being caused by undiscovered 'dark matter' we see that the in-flow into non spherical galaxies, such as the spiral Milky Way, will be non-Newtonian. As well it will be interesting to determine, at least theoretically, the scale of turbulence expected in galactic systems, particularly as the magnitude of the turbulence seen in the AM velocity is somewhat larger than might be expected from the sun in-flow alone. Any theory for the turbulence effect will certainly be checkable within the Solar system as the time scale of this is suitable for detailed observation.

13   Gravitational Waves

The velocity flow-field equation is expected to have solutions possessing turbulence, that is, fluctuations in both the magnitude and direction of the gravitational in-flow component of the velocity flow-field. Indeed all the gas-mode Michelson interferometer experiments and coaxial cable experiments showed evidence of such turbulence. The first clear evidence was from the Miller experiment, as shown in the analysis in [2, 9]. Miller offered no explanation for these fluctuations but in his analysis of that data he did running time averages. Miller may have in fact have simply interpreted these fluctuations as purely instrumental effects. While some of these fluctuations may be partially caused by weather related temperature and pressure variations, the bulk of the fluctuations appear to be larger than expected from that cause alone. Even the original Michelson-Morley data in shows variations in the velocity field and supports this interpretation. However it is significant that the non-interferometer DeWitte [9] data also shows evidence of turbulence in both the magnitude and direction of the velocity flow field. Just as the DeWitte data agrees with the Miller data for speeds and directions the magnitude fluctuations are very similar in absolute magnitude.

It therefore becomes clear that there is strong evidence for these fluctuations being evidence of physical turbulence in the flow field. The magnitude of this turbulence appears to be somewhat larger than that which would be caused by the in-flow of quantum foam towards the sun, and indeed following on from Sect.12 some of this turbulence may be associated with galactic in-flow into the Milky Way. This in-flow turbulence is a form of gravitational wave and the ability of gas-mode Michelson interferometers to detect absolute

motion means that experimental evidence of such a wave phenomena has been available for a considerable period of time.

14   Conclusions

Previous analysis [2, 9] of extensive data from both interferometric and non-interferometric experiments has produced distinctive evidence for the existence of a quantum-foam substratum to space. Effects of motion through this substratum as well as flows related to gravity are evident in this experimental data. The evidence suggests that in fact the special relativity effects, which are well established by experiment, are being caused by absolute motion of systems through this quantum foam that is space. Process Physics in conjunction with this data leads to a new theory of gravity which is shown to be mathematically consistent with the Newtonian and General Relativity theories in those cases where these theories have been thoroughly tested. The new theory of gravity has a fundamentally different interpretation and ontology. However the new theory of gravity implies that the Newtonian theory of gravity is only strictly applicable to cases of high spherical symmetry, and that this limitation of the Newtonian theory was inherited by General Relativity in its formulation by Hilbert and Einstein. The failure of these theories in cases of highly non-spherical systems, such as spiral galaxies, has resulted in the spurious introduction of concepts like 'dark matter'. However in the case of the Global Positioning System the earth-satellite system has high spherical symmetry and in this case the new theory and General Relativity are mathematically equivalent, and so the obvious success of General Relativity in modelling the quite complex operations of the GPS is also equally applicable to the new gravity theory. The failure of General Relativity in cases of high non-spherical symmetry implies that the explanation of the operation offered by General Relativity for the GPS was essentially accidental, and certainly involved an incorrect interpretation and ontology.

15   References

References

[1] N. Ashby *Relativity in the Global Positioning System*, *Living Reviews in Relativity*, January 2003; www.livingreviews.org/Articles/Volume6/2003-1Ashby.

[2] R.T. Cahill, *Process Physics: From Information Theory to Quantum Space and Matter*, (Nova Science Pub., NY 2004), in book series *Contemporary Fundamental Physics*, edited by V.V. Dvoeglazov.

[3] R.T. Cahill, *Process Physics: Inertia, Gravity and the Quantum*, Gen. Rel. and Grav. **34**(2002)1637-1656.

[4] R.T. Cahill and C.M. Klinger, *Self-Referential Noise and the Synthesis of Three-Dimensional Space*, Gen. Rel. and Grav. **32**(3)(2000)529.

[5] R.T. Cahill and C.M. Klinger *Self-Referential Noise as a Fundamental Aspect of Reality*, Proc. 2nd Int. Conf. on Unsolved Problems of Noise and Fluctuations (UPoN'99), Eds. D. Abbott and L. Kish, Adelaide, Australia, 11-15th July 1999, **Vol. 511**(2003) p. 43 (American Institute of Physics, New York).

[6] R.T. Cahill, C.M. Klinger and K. Kitto, *Process Physics: Modelling Reality as Self-Organising Information*, The Physicist **37**(6)(2000)191.

[7] R.T. Cahill and K. Kitto, *Michelson-Morley Experiments Revisited and the Cosmic Background Radiation Preferred Frame*, Apeiron **10**, No.2.(2003)104-117.

[8] R.T. Cahill, *Gravity as Quantum Foam In-Flow*, Apeiron, **11**, No.1, pp. 1-52(2004).

[9] R.T. Cahill, *Absolute Motion and Gravitational Effects*, Apeiron, **11**, No.1, pp. 53-111(2004).

[10] R.T. Cahill, *Quantum Foam, Gravity and Gravitational Waves*, in *Relativity, Gravitation, Cosmology*, pp. 168-226, eds. V. V. Dvoeglazov and A. A. Espinoza Garrido (Nova Science Pub., NY, 2004).

[11] R.T. Cahill, *Gravitation, the 'Dark Matter' Effect and the Fine Structure Constant*, physics/0401047.

[12] R.T. Cahill, *'Dark Matter' as a Quantum Foam In-Flow Effect*, in *Progress In Dark Matter Research*, (Nova Science Pub., NY to be pub. 2004), physics/0405147.

[13] R.T. Cahill, *Novel Gravity Probe B Frame-Dragging Effect*, physics/0406121.

[14] C. Lineweaver et al. *Astrophysics J.* **470**(1996)38

[15] R.L. Kirkwood *The Physical Basis of Gravitation*, Phys. Rev. **92**(6)(1953)1557.

[16] R.L. Kirkwood *Gravitational Field Equations*, Phys. Rev. **95**(4)(1954)1051.

[17] P. Panlevé *C. R. Acad. Sci.*, **173**(1921)677.

[18] A. Gullstrand *Ark. Mat. Astron. Fys.*, **16**(1922)1.

[19] A.A. Michelson and E.W. Morley 1887 *Philos. Mag.* S.5, **24**, No. 151(1987)449-463.

[20] D.C. Miller *Rev. Mod. Phys.* **5**(1933)203-242.

[21] K.K. Illingworth *Phys. Rev.* **30**(1927)692-696.

[22] T.S. Jaseja, A. Javan, J. Murray and C.H. Townes *Test of Special Relativity or Isotropy of Space by Use of Infrared Masers*, Phys. Rev. **A 133**(1964)1221.

[23] D.G. Torr and P. Kolen *Precision Measurements and Fundamental Constants*, B.N. Taylor and W.D. Phillips, Eds. *Natl. Bur. Stand.(U.S.), Spec. Publ.* **617**(1984)675.

[24] R. DeWitte http://www.ping.be/∼pin30390/

[25] G. Joos *Ann. d. Physik* [5], **7**(1930)385.

[26] H.P. Kennedy and E.M. Thorndike *Phys. Rev.* **42**(1932)400-418.

[27] A. Brillet and J.L. Hall *Phys. Rev. Lett.* **42**, No.9(1979)549-552.

[28] C. Braxmaier, H. Müller, O. Pradl, J. Mlynek, A. Peters and S. Schiller *Phys. Rev. Lett.* **88**(2002)010401.

[29] J.A. Lipa, J.A. Nissen, S. Wang, D.A. Striker and D. Avaloff *Phys. Rev. Lett.* **90**(2003)060403-1.

[30] P.R. Heyl and P. Chrzanowski, *J. Res. Nat. Bur. Standards* **29**(1942)1.

[31] L. Facy and C. Pontikis, *Comptes Rendus des Scéances de l'Académie des Sciences de Paris* **272**, Série B, (1971)1397.

[32] J. Renner, in *Determination of Gravity Constant and Measurement of Certain Fine Gravity Effects*, Y. D. Boulanger and M. U. Sagitov (Eds.), (National Aeronautics and Space Administration, Washington, 1974), pp. 26-31

[33] M.U. Sagitov *et al.*, *Dok. Acad. Nauk SSSR* **245**(1979)567.

[34] G.G. Luther and W. Towler, *Phys. Rev. Letters* **48**(1982)121.

[35] J.-Cl. Dousse and Ch. Rhême, *Am. J. Phys.* **55**(1987)706.

[36] H. de Boer, H. Haars and W. Michaelis, *Metrologia* **24**(1987)171.

[37] M.A. Zumberge *et al.*, *J. Geophys. Res.* **95**(1990)15483.

[38] A. Cornaz, B. Hubler and W. Kündig, *Phys. Rev. Letters* **72**(1994)1152.

[39] B. Hubler, A. Cornaz and W. Kündig, *Phys. Rev.* **D51**(1995)4005.

[40] M.P. Fitzgerald and T.R. Armstrong, *IIIE Trans. Instrum. Meas.* **44**(1995)494.

[41] C.H. Bagley and G.G. Luther, *Phys. Rev. Letters* **78**(1997)3047.

[42] J. Luo *et al.*, *Phys. Rev.* **D59**(1998) 042001.

[43] J. P. Schwarz *et al.*, 1998, *Science* **282**(1998)2230.

[44] O.V. Karagioz, V.P. Izmaylov and G.T. Gillies, *Grav. Cosmol.* **4**(1998)239.

[45] J. Schurr, F. Nolting and W. Kündig, *Phys. Rev. Letters* **80**(1998)1142.

[46] M.P. Fitzgerald and T.R. Armstrong, *Meas. Sci. Technol.* **10**(1999)439

[47] F. Nolting, J. Schurr, S. Schlamminger and W. Kündig, *Meas. Sci. Technol.* **10**(1999)487.

[48] S.J. Richman, T.J. Quinn, C.C. Speake and R.S. Davis, *Meas. Sci. Technol.* **10**(1999)460.

[49] U. Kleinevoss, H. Meyer, A. Schumacher and S. Hartmann, *Meas. Sci. Technol.* **10**(1999)492.

[50] J. H.Gundlach and S.M. Merkowitz, *Phys. Rev. Letters* **85**(2000)2869 and SISSA preprint gr-qc/0006043.

[51] T.J. Quinn, C. C. Speake, S. J. Richman, R. S. Davis and A. Picard, *Phys. Rev. Letters* **87**(2001)111101.

[52] P. Baldi *et al.*, *Phys. Rev.* **D64**(2001)082001.

[53] J.P. Mbelek and M. Lachièze-Rey, *Grav. Cosmol.* **8**(2002)331-338.

[54] G.T. Gillies, *The Newtonian Gravitational Constant: Recent Measurements and Related Studies*, *Rep. Prog. Phys.* **60**(1997)151-225.

[55] M. Allais, *AeroSpace Eng.*, Sept.-Oct. **18**(1959)46; http://allais.maurice.free.fr/English/Science.htm.

[56] M. Allais, A memoir prepared for NASA in 1999. English translation by T. Goodey available at http://www.flyingkettle.com/allais.htm

[57] E.J. Saxl and M. Allen, *1970 Solar Eclipse as "Seen" by a Torsional Pendulum*, *Phys. Rev.*, **D3**(1971)823.

[58] S.W. Zhou and B.J. Huang, *Abnormalities of the Time Comparisons of Atomic Clocks during the Solar Eclipses*, *Il Nuovo Cimento*, **15C**, N.2(1992)133.