Gravity as Quantum Foam In-Flow

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Newtonian Gravity and General Relativity are plagued by gravitational anomalies - phenomena not accounted for by either theory. It is shown that both may be re-written in a 'fluid in-flow' formalism, but that a simple generalisation of this formalism leads to a new theory of gravity that resolves the anomalies. In the accompanying paper 'Absolute Motion and Gravitational Effects' various experimental observations of absolute motion and of the in-flow into the sun are analysed. The in-flow displays gravitational waves, and these are manifest in experimental data. Newtonian gravity is flawed, and the flaw was 'inherited' by General Relativity.

Keywords: In-flow gravity, absolute motion, gravitational anomalies, gravitational waves, process physics.

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Contents

1 Introduction

The new information-theoretic *Process Physics* [1, 2, 3, 4, 5, 6, 7, 8, 9, 10] provides for the first time an explanation of space as

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a quantum foam system in which gravity is an inhomogeneous flow of the quantum foam into matter.

An analysis [6, 7] of data from various experiments has demonstrated that absolute motion relative to space has been observed by Michelson and Morley (1887) [11], Miller (1925/26) [12], Illingworth (1927) [13], Joos (1930) [14], Jaseja *et al.* (1963) [15], Torr and Kolen (1981) [16], and by DeWitte (1991) [17], contrary to common belief within physics that absolute motion has never been observed. The first five of these were Michelson interferometer experiments operating with a gas, while the last two were coaxial cable RF travel-time experiments using atomic clocks. Amazingly no-one had ever analysed the fringe shift data from the interferometer experiments using the two overlooked key effects namely the Fitzgerald-Lorentz contraction effect and the refractive index effect which slows down the speed of light in the gas. The Dayton Miller data also reveals the in-flow of space into the sun which manifests as gravity [7]. The experimental data indicates that the in-flow manifests turbulence [7], which amounts to the observation of a gravitational wave phenomena.

Absolute motion is consistent with special relativistic effects, which are caused by actual dynamical effects of absolute motion through the quantum foam. The Lorentzian interpretation of relativistic effects is seen to be essentially correct. Vacuum Michelson interferometer experiments or its equivalent [18, 19, 20, 21] cannot detect absolute motion, as discussed in [6, 7]. The various gas-mode Michelson interferometer data cannot be analysed unless the special relativistic effects are taken into account, and indeed these experiments demonstrate the validity and reality of the Fitzgerald-Lorentz contraction effect.

A new in-flow theory of gravity in the classical limit is presented. It passes all the standard tests of both the Newtonian and the General Relativity theories of gravity. This new theory explain the spiral galaxy rotation-velocity anomaly without invoking dark matter, together with the recent discovery that the 'dark matter' effect is essentially absent in elliptical galaxies. Other gravitational anomalies also now appear to be capable of being explained, and in particular the mine/borehole g anomaly is finally explained here.

It turns out that the Newtonian theory of gravity was deeply flawed from the very beginning - the solar system was simply too special a case to have revealed the full picture of gravitational phenomena. In turn General Relativity is also deeply flawed, not because of the 'special relativistic effects', which remain valid, but because General Relativity 'inherited' the fundamental flaws of Newtonian gravity.

2 A New Theory of Gravity

2.1 Classical Effects of Quantum Foam In-Flow

We begin here the analysis that reveals the new theory and explanation of gravity. In this theory gravitational effects are caused solely by an inhomogeneous 'flow' of the quantum foam. The new information-theoretic concepts underlying this physics were discussed in [1, 2, 3]. Essentially matter effectively acts as a 'sink' for that quantum foam. It is important to realise that this is not a flow of 'something' through space; rather it is ongoing structural changes in space - a fluctuating and classicalising quantum foam, but with those changes most easily described as a 'flow', though such a flow is only evident from distributed observers. The Newtonian theory of gravity was based on observations of planetary motion within the solar system. It turns out that the solar system was too special, as the planets acted as test objects in orbit about a spherically symmetric matter distribution - the sun. As soon as we depart from such spherical symmetry, and even within a spherically symmetric matter distribution problems appear. Only the numerous, so-far unexplained, gravitational anomalies are actually providing clues as the the real nature of gravity. The Newtonian theory was originally formulated in terms of a force field, the gravitational acceleration $\mathbf{g}(\mathbf{r}, t)$, but as will be shown here it is much closer to the truth if we re-formulate it as a 'fluid-flow' system. The gravitational acceleration $\mathbf{g}$ in the Newtonian theory is determined by the matter density $\rho(\mathbf{r}, t)$ according to

$$\nabla.\mathbf{g} = -4\pi G\rho. \quad (1)$$

For $\nabla \times \mathbf{g} = 0$ this gravitational acceleration $\mathbf{g}$ may be written as the gradient of the gravitational potential $\Phi(\mathbf{r}, t)$

$$\mathbf{g} = -\nabla\Phi, \quad (2)$$

where the gravitational potential is now determined by $\nabla^2\Phi = 4\pi G\rho$. Here, as usual, G is the gravitational constant. Now as $\rho \geq 0$ we can choose to have $\Phi \leq 0$ everywhere if $\Phi \rightarrow 0$ at infinity. So we can introduce $\mathbf{v}^2 = -2\Phi \geq 0$ where $\mathbf{v}(\mathbf{r}, t)$ is some velocity vector field. Here the value of $\mathbf{v}^2$ is specified, but not the direction of $\mathbf{v}$. Then

$$\mathbf{g} = \frac{1}{2}\nabla(\mathbf{v}^2) = (\mathbf{v}.\nabla)\mathbf{v}, \quad (3)$$

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when $\mathbf{v} \times (\nabla \times \mathbf{v}) = 0$. For irrotational flow $\nabla \times \mathbf{v} = \mathbf{0}$. 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

$$\mathbf{g} = (\mathbf{v}.\nabla)\mathbf{v} + \frac{\partial \mathbf{v}}{\partial t}. \tag{4}$$

This equation is then to be accompanied by the 'Newtonian equation' for the flow field

$$\frac{1}{2}\nabla^2(\mathbf{v}^2) = -4\pi G\rho. \tag{5}$$

To be consistent with (1) in the case of a time-dependent matter density this equation must be generalised to

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

Of course within the fluid flow interpretation (4) and (6) are together equivalent to the Universal Inverse Square Law for Gravity. Indeed for a spherically symmetric distribution of matter of total mass M the velocity field outside of the matter

$$\mathbf{v}(\mathbf{r}) = -\sqrt{\frac{2GM}{r}}\hat{\mathbf{r}}, \tag{7}$$

satisfies (6) and reproduces the inverse square law form for $\mathbf{g}$ using (4):

$$\mathbf{g} = -\frac{GM}{r^2}\hat{\mathbf{r}}. \tag{8}$$

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The in-flow direction $-\hat{\mathbf{r}}$ in (7) may be replaced by any other direction, in which case however the direction of $\mathbf{g}$ in (8) remains radial.

As we shall see of the many new effects predicted by the generalisation of (6) one is that this ‘Inverse Square Law’ is only valid outside of spherically symmetric matter systems. Then, for example, the ‘Inverse Square Law’ is expected to be inapplicable to spiral galaxies. The incorrect assumption of the universal validity of this law led to the notion of ‘dark matter’ in order to reconcile the faster observed rotation velocities of matter within such galaxies compared to that predicted by the above law.

To arrive at the new in-flow theory of gravity we require that the velocity field $\mathbf{v}(\mathbf{r},t)$ be specified and measurable with respect to a suitable frame of reference. We shall use the Cosmic Microwave Background (CMB) frame of reference for that purpose [22]. Then a ‘test object’ has velocity $\mathbf{v}_0(t) = d\mathbf{r}_0(t)/dt$ with respect to that CMB frame, where $\mathbf{r}_0(t)$ is the position of the object wrt that frame. We then define

$$\mathbf{v}_R(t) = \mathbf{v}_0(t) - \mathbf{v}(\mathbf{r}_0(t),t), \qquad (9)$$

as the velocity of the test object relative to the quantum foam at the location of the object.

Process Physics [1] leads to the Lorentzian interpretation of so called ‘relativistic effects’. This means that the speed of light is only ‘c’ wrt 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 the quantum foam, and are not to be interpreted as spacetime effects as suggested by Einstein. To arrive at the dynamical

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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 formalism.

First we shall conjecture that the path of an object through an inhomogeneous and time-varying quantum-foam is determined by a variational principle, namely the path $\mathbf{r}_0(t)$ minimises the travel time

$$\tau[\mathbf{r}_0] = \int dt \left(1 - \frac{\mathbf{v}_R^2}{c^2}\right)^{1/2}, \tag{10}$$

with $\mathbf{v}_R$ given by (9). 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

$$\mathbf{v}(\mathbf{r}_0(t) + \delta\mathbf{r}_0(t), t) = \mathbf{v}(\mathbf{r}_0(t), t) + (\delta\mathbf{r}_0(t).\nabla)\mathbf{v}(\mathbf{r}_0(t)) + ... \tag{11}$$

Then

$$\begin{aligned}
\delta\tau &= \tau[\mathbf{r}_0 + \delta\mathbf{r}_0] - \tau[\mathbf{r}_0] \\
&= -\int dt\, \frac{1}{c^2}\mathbf{v}_R.\delta\mathbf{v}_R \left(1 - \frac{\mathbf{v}_R^2}{c^2}\right)^{-1/2} + ... \\
&= \int dt \frac{1}{c^2}\left(\mathbf{v}_R.(\delta\mathbf{r}_0.\nabla)\mathbf{v} - \mathbf{v}_R.\frac{d(\delta\mathbf{r}_0)}{dt}\right)\left(1 - \frac{\mathbf{v}_R^2}{c^2}\right)^{-1/2} + ... \\
&= \int dt \frac{1}{c^2}\left(\frac{\mathbf{v}_R.(\delta\mathbf{r}_0.\nabla)\mathbf{v}}{\sqrt{1 - \frac{\mathbf{v}_R^2}{c^2}}} + \delta\mathbf{r}_0.\frac{d}{dt}\frac{\mathbf{v}_R}{\sqrt{1 - \frac{\mathbf{v}_R^2}{c^2}}}\right) + ...
\end{aligned} \tag{12}$$

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$$= \int dt\, \frac{1}{c^2}\delta\mathbf{r}_0 \,.\left(\frac{(\mathbf{v}_R.\nabla)\mathbf{v} + \mathbf{v}_R \times (\nabla \times \mathbf{v})}{\sqrt{1-\frac{\mathbf{v}_R^2}{c^2}}} + \frac{d}{dt}\frac{\mathbf{v}_R}{\sqrt{1-\frac{\mathbf{v}_R^2}{c^2}}} \right) + .. \tag{13}$$

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

$$\frac{d}{dt}\frac{\mathbf{v}_R}{\sqrt{1-\frac{\mathbf{v}_R^2}{c^2}}} = -\frac{(\mathbf{v}_R.\nabla)\mathbf{v} + \mathbf{v}_R \times (\nabla \times \mathbf{v})}{\sqrt{1-\frac{\mathbf{v}_R^2}{c^2}}}. \tag{14}$$

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

$$\frac{d\mathbf{v}(\mathbf{r}_0(t), t)}{dt} = (\mathbf{v}_0.\nabla)\mathbf{v} + \frac{\partial \mathbf{v}}{\partial t}, \tag{15}$$

we obtain

$$\frac{d}{dt}\frac{\mathbf{v}_0}{\sqrt{1-\frac{\mathbf{v}_R^2}{c^2}}} = \mathbf{v}\frac{d}{dt}\frac{1}{\sqrt{1-\frac{\mathbf{v}_R^2}{c^2}}} + \frac{(\mathbf{v}.\nabla)\mathbf{v} - \mathbf{v}_R \times (\nabla \times \mathbf{v}) + \frac{\partial \mathbf{v}}{\partial t}}{\sqrt{1-\frac{\mathbf{v}_R^2}{c^2}}}. \tag{16}$$

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

$$\frac{d\mathbf{v}_0}{dt} = (\mathbf{v}.\nabla)\mathbf{v} + \frac{\partial \mathbf{v}}{\partial t} + (\nabla \times \mathbf{v}) \times \mathbf{v}_R, \tag{17}$$

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which agrees with the 'Newtonian' form (4) for zero vorticity ($\nabla \times \mathbf{v} = 0$). Hence (16) is a generalisation of (4) to include Lorentzian dynamical effects, for in (16) we can multiply both sides by the rest mass m_0 of the object, and then (16) involves

$$m(\mathbf{v}_R) = \frac{m_0}{\sqrt{1 - \frac{\mathbf{v}_R^2}{c^2}}}, \tag{18}$$

the so called 'relativistic' mass, and (16) acquires the form

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

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 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 (10) is easily used to determine the clock rate offsets in the GPS satellites, when the in-flow is given by (7).

Eqn.(10) 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. However (10) gives (with $t = x_0^0$)

$$d\tau^2 = dt^2 - \frac{1}{c^2}(d\mathbf{r}_0(t) - \mathbf{v}(\mathbf{r}_0(t), t)dt)^2 = g_{\mu\nu}(x_0)dx_0^\mu dx_0^\nu, \tag{19}$$

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which is the Panlevé-Gullstrand form of the metric $g_{\mu\nu}$ [23, 24] for GR. All of the above is very suggestive that useful information for the flow dynamics may be obtained from GR by restricting the choice of metric to the Panlevé-Gullstrand form. We emphasize that the absolute velocity $\mathbf{v}_R$ has been measured [7], and so the foundations of GR as usually stated are invalid. As we shall now see the GR formalism involves two phenomena, namely (i) the use of an unnecessarily restrictive Einstein measurement protocol and (ii) the Lorentzian quantum-foam dynamical effects. Later we shall remove this measurement protocol from GR and discover that the GR formalism reduces to explicit fluid flow equations. However to understand the GR formalism we need to explicitly introduce the troublesome Einstein measurement protocol and the peculiar effects that it induces in the observer's historical records.

2.2 The Einstein Measurement Protocol

The quantum foam, it is argued, induces actual dynamical time dilations and length contractions in agreement with the Lorentz interpretation of special relativistic effects. Then observers in uniform motion 'through' the foam will on measurement of the speed of light obtain always the same numerical value c. To see this explicitly consider how various observers $P, P', ..$ moving with different speeds through the foam, 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

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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. 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[1]. The length of the rod moving at speed v_R is contracted to

$$\Delta l_R = \Delta l_0 \sqrt{1 - \frac{v_R^2}{c^2}}. \tag{20}$$

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

$$c t_{AB} = \Delta l_R + v_R t_{AB}, \tag{21}$$

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

$$c t_{BA} = \Delta l_R - v_R t_{BA}. \tag{22}$$

Hence the total travel time Δt_0 is

$$\Delta t_0 = t_{AB} + t_{BA} = \frac{\Delta l_R}{c - v_R} + \frac{\Delta l_R}{c + v_R} \tag{23}$$

$$= \frac{2\Delta l_0}{c\sqrt{1 - \frac{v_R^2}{c^2}}}. \tag{24}$$

[1] Not all clocks will behave in this same 'ideal' manner.

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Because of the time dilation effect for the moving clock

$$\Delta t_R = \Delta t_0 \sqrt{1 - \frac{v_R^2}{c^2}}. \tag{25}$$

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 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 Einstein measurement protocol. That this protocol is blind to the absolute motion has led to enormous confusion within physics. In [7] we see how various experimental techniques may be used to overcome the 'blindness' of this procedure, and so manifestly reveal an observer's v_R.

To be explicit the Einstein measurement protocol actually inadvertently uses this special effect by using the radar method for assigning historical spacetime coordinates to an event: 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)

$$T_B = \frac{1}{2}(t_r + t_e), \quad D_B = \frac{c}{2}(t_r - t_e), \tag{26}$$

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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 an historian recording events according to some agreed protocol. Unlike historians, who don't confuse history books with reality, physicists do so. 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

$$\tau_{AB}^2 = T_{AB}^2 - \frac{1}{c^2} D_{AB}^2, \tag{27}$$

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 Einstein measurement protocol (26), so long as both are sufficiently small compared with the scale of inhomogeneities in the velocity field.

To confirm the invariant nature of the construct in (27) 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 (26). Then using (27) P would find that $(\tau_{AB}^P)^2 = T_B^2 - \frac{1}{c^2} D_B^2$ since both $T_A = 0$ and D_A=0, and whence $(\tau_{AB}^P)^2 = (1 - \frac{v_R'^2}{c^2}) T_B^2 = (t'_B)^2$ 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

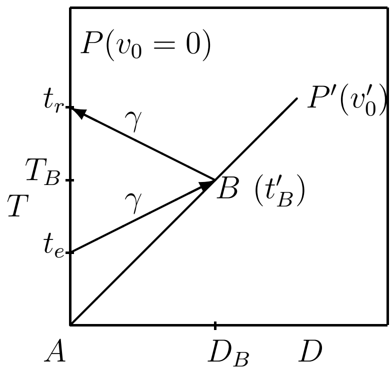

Figure 1: Here $T - D$ is the spacetime construct (from the Einstein measurement protocol) of a special observer P *at rest* wrt the quantum foam, so that $v_0 = 0$. Observer P' is moving with speed v'_0 as determined by observer P, and therefore with speed $v'_R = v'_0$ wrt the quantum foam. Two light pulses are shown, each travelling at speed c wrt both P and the quantum foam. As we see later these one-way speeds for light, relative to the quantum foam, are equal by observation. Event A is when the observers pass, and is also used to define zero time for each for convenience.

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[2]. For P' we obtain directly, also from (26) and (27), 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

[2]Because of gravitational in-flow effects this 'common time' is not the same as a 'universal' or 'absolute time'; see later.

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this situation

$$(\tau_{AB}^{P})^2 = (\tau_{AB}^{P'})^2, \tag{28}$$

and so the construction (27) is an invariant.

While so far we have only established the invariance of the construct (27) 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 (27). This is easily seen by using the intermediate step of a stationary observer P:

$$(\tau_{AB}^{P'})^2 = (\tau_{AB}^{P})^2 = (\tau_{AB}^{P''})^2. \tag{29}$$

Hence the protocol and Lorentzian effects result in the construction in (27) 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

$$\Delta\tau^2 = \Delta T^2 - \frac{1}{c^2}\Delta D^2, \tag{30}$$

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

$$\Delta\tau^2 = g_{\mu\nu}(x)\Delta x^\mu \Delta x^\nu, \tag{31}$$

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with $x^\mu = \{T, D_1, D_2, D_3\}$.

2.3 The Origins of General Relativity

Above it was seen that the Lorentz symmetry of the spacetime construct would arise if the quantum foam system that forms space affects the rods and clocks used by observers in the manner indicated. The effects of absolute motion with respect to this quantum foam are in fact easily observed, and so the velocity $\mathbf{v}_R$ of each observer is measurable. However if we work only with the spacetime construct then the effects of the absolute motion are hidden. Einstein was very much misled by the reporting of the experiment by Michelson and Morley of 1887, as now [6, 7] it is apparent that this experiment, and others since then, revealed evidence of absolute motion. The misunderstanding of the Michelson-Morley experiment had a major effect on the subsequent development of physics. One such development was the work of Hilbert and Einstein in finding an apparent generalisation of Newtonian gravity to take into account the apparent absence of absolute motion. Despite the deep error in this work the final formulation, known as General Relativity, has had a number of successes including the perihelion precession of mercury, the bending of light and gravitational red shift. Hence despite the incorrect treatment of absolute motion the formalism of general relativity apparently has some validity. In the next section we shall *deconstruct* this formalism to discover its underlying physics, but here we first briefly outline the GR formalism.

The spacetime construct is a static geometrical non-processing

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historical record, and is nothing more than a very refined history book, with the shape of the manifold encoded in a metric tensor $g_{\mu\nu}(x)$. However in a formal treatment by Einstein the SR formalism and later the GR formalism is seen to arise from three fundamental assumptions:

(1) **The laws of physics have the same form in all inertial reference frames.**

(2) **Light propagates through empty space with a definite speed c independent of the speed of the source or observer.**

(3) **In the limit of low speeds the new formalism should agree with Newtonian gravity.** (32)

There is strong experimental evidence that all three of these assumptions are in fact wrong, see [7] (except for the 2nd part of (2)). Nevertheless there is something that is partially correct within the formalism, and that part needs to be extracted and saved, with the rest discarded. From the above assumptions Hilbert and Einstein guessed the equation which specifies the metric tensor $g_{\mu\nu}(x)$, namely the geometry of the spacetime construct,

$$G_{\mu\nu} \equiv R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} = \frac{8\pi G}{c^2}T_{\mu\nu}, \tag{33}$$

where $G_{\mu\nu}$ is known as 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

$$R^{\rho}_{\mu\sigma\nu} = \Gamma^{\rho}_{\mu\nu,\sigma} - \Gamma^{\rho}_{\mu\sigma,\nu} + \Gamma^{\rho}_{\alpha\sigma}\Gamma^{\alpha}_{\mu\nu} - \Gamma^{\rho}_{\alpha\nu}\Gamma^{\alpha}_{\mu\sigma}, \tag{34}$$

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

$$\Gamma^{\alpha}_{\mu\sigma} = \frac{1}{2}g^{\alpha\nu}\left(\frac{\partial g_{\nu\mu}}{\partial x^{\sigma}} + \frac{\partial g_{\nu\sigma}}{\partial x^{\mu}} - \frac{\partial g_{\mu\sigma}}{\partial x^{\nu}}\right). \tag{35}$$

In this formalism the trajectories of test objects are determined by

$$\Gamma^{\lambda}_{\mu\nu}\frac{dx^{\mu}}{d\tau}\frac{dx^{\nu}}{d\tau} + \frac{d^2x^{\lambda}}{d\tau^2} = 0, \tag{36}$$

which is equivalent to minimising the functional

$$\tau[x] = \int dt\sqrt{g^{\mu\nu}\frac{dx^{\mu}}{dt}\frac{dx^{\nu}}{dt}}, \tag{37}$$

wrt to the path $x[t]$.

For the case of a spherically symmetric mass a solution of (33) for $g_{\mu\nu}$ outside of that mass M is the Schwarzschild metric

$$d\tau^2 = (1 - \frac{2GM}{c^2r})dt^2 - \frac{1}{c^2}r^2(d\theta^2 + \sin^2(\theta)d\phi^2) - \frac{dr^2}{c^2(1 - \frac{2GM}{c^2r})}. \tag{38}$$

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 (38) is in fact completely equivalent to the in-flow interpretation of Newtonian gravity. Making the

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change of variables $t \to t'$ and $\mathbf{r} \to \mathbf{r}' = \mathbf{r}$ with

$$t' = t + \frac{2}{c}\sqrt{\frac{2GMr}{c^2}} - \frac{4GM}{c^2}\tanh^{-1}\sqrt{\frac{2GM}{c^2 r}}, \tag{39}$$

the Schwarzschild solution (38) takes the form

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

which is exactly the Panlevé-Gullstrand form of the metric $g_{\mu\nu}$ [23, 24] in (19) with the velocity field given exactly by the Newtonian form in (7). In which case the trajectory equation (36) of test objects in the Schwarzschild metric is equivalent to solving (16). Thus the minimisation (37) is equivalent to that of (10). 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 (10).

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.

The results in this section suggest, just as for Newtonian gravity, that the Einstein General Relativity is nothing more

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than the dynamical equations for a velocity flow field $\mathbf{v}(\mathbf{r}, t)$. Hence the 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. The successes of General Relativity should thus be considered as an insight into the fluid flow dynamics of the quantum foam system, rather than any confirmation of the validity of the spacetime formalism. In the next section we shall deconstruct General Relativity to extract a possible form for this dynamics.

2.4 Deconstruction of General Relativity

Here we deconstruct the formalism of General Relativity by removing the obscurification produced by the unnecessarily restricted Einstein measurement protocol. To do this we adopt the Panlevé-Gullstrand form of the metric $g_{\mu\nu}$ as that corresponding to the observable quantum foam system, namely to an observationally detected special frame of reference. This form for the metric involves a general velocity field $\mathbf{v}(\mathbf{r}, t)$ where for precision we consider the coordinates $\mathbf{r}, t$ as that of observers at rest with respect to the CMB frame. Note that in this frame $\mathbf{v}(\mathbf{r}, t)$ is not necessarily zero, for mass acts as a sink for the flow. We therefore merely substitute the metric

$$d\tau^2 = g_{\mu\nu} dx^\mu dx^\nu = dt^2 - \frac{1}{c^2}(d\mathbf{r}(t) - \mathbf{v}(\mathbf{r}(t), t)dt)^2, \qquad (41)$$

into (33) using (35) and (34). This metric involves the arbitrary time-dependent velocity field $\mathbf{v}(\mathbf{r}, t)$. This is a very tedious computation and the results below were obtained by using the

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symbolic mathematics capabilities of *Mathematica*. The various components of the Einstein tensor are then

$$\begin{aligned} G_{00} &= \sum_{i,j=1,2,3} v_i \mathcal{G}_{ij} v_j - c^2 \sum_{j=1,2,3} \mathcal{G}_{0j} v_j - c^2 \sum_{i=1,2,3} v_i \mathcal{G}_{i0} + c^2 \mathcal{G}_{00}, \\ G_{i0} &= -\sum_{j=1,2,3} \mathcal{G}_{ij} v_j + c^2 \mathcal{G}_{i0}, \qquad i = 1,2,3. \\ G_{ij} &= \mathcal{G}_{ij}, \qquad i,j = 1,2,3. \end{aligned} \tag{42}$$

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

$$\begin{aligned} \mathcal{G}_{00} &= \frac{1}{2}((trD)^2 - tr(D^2)), \\ \mathcal{G}_{i0} &= \mathcal{G}_{0i} = -\frac{1}{2}(\nabla \times (\nabla \times \mathbf{v}))_i, \qquad i = 1,2,3. \\ \mathcal{G}_{ij} &= \frac{d}{dt}(D_{ij} - \delta_{ij} trD) + (D_{ij} - \frac{1}{2}\delta_{ij} trD) trD \\ &\quad -\frac{1}{2}\delta_{ij} tr(D^2) - (D\Omega - \Omega D)_{ij}, \qquad i,j = 1,2,3. \end{aligned} \tag{43}$$

Here

$$D_{ij} = \frac{1}{2}(\frac{\partial v_i}{\partial x_j} + \frac{\partial v_j}{\partial x_i}) \tag{44}$$

is the symmetric part of the rate of strain tensor $\frac{\partial v_i}{\partial x_j}$, while the antisymmetric part is

$$\Omega_{ij} = \frac{1}{2}(\frac{\partial v_i}{\partial x_j} - \frac{\partial v_j}{\partial x_i}). \tag{45}$$

In vacuum, with $T_{\mu\nu} = 0$, we find from (33) and (42) that $G_{\mu\nu} = 0$ implies that $\mathcal{G}_{\mu\nu} = 0$. It is then easy to check that the

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in-flow velocity field (7) satisfies these equations. This simply expresses the previous observation that this 'Newtonian in-flow' is completely equivalent to the Schwarzschild metric. We note that the vacuum equations $\mathcal{G}_{\mu\nu} = 0$ do not involve the speed of light; it appears only in (42). It is therefore suggested that (42) amounts to the separation of the Einstein measurement protocol, which involves c, from the supposed dynamics of gravity within the GR formalism, and which does not involve c. However the details of the vacuum dynamics in (43) have not actually been tested. All the key tests of GR are now seen to amount to a test *only* of $\delta\tau[x]/\delta x^\mu = 0$, which is the minimisation of (10), when the in-flow field is given by (42), and which is nothing more than Newtonian gravity. Of course Newtonian gravity was itself merely based upon observations within the solar system, and this may have been too special to have revealed key aspects of gravity. Hence, despite popular opinion, the GR formalism is apparently based upon rather poor evidence.

2.5 The New Theory of Gravity

Despite the limited insight into gravity which GR is now seen to amount to, here we look for possible generalisations of Newtonian gravity and its in-flow interpretation by examining some of the mathematical structures that have arisen in (43). For the case of zero vorticity $\nabla \times \mathbf{v} = 0$ we have $\Omega_{ij} = 0$ and also that we may write $\mathbf{v} = \nabla u$ where $u(\mathbf{r}, t)$ is a scalar field, and only one equation is required to determine u. To that end we consider

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the trace of $\mathcal{G}_{ij}$. Note that $tr(D) = \nabla.\mathbf{v}$, and that

$$\frac{d(\nabla.\mathbf{v})}{dt} = (\mathbf{v}.\nabla)(\nabla.\mathbf{v}) + \frac{\partial(\nabla.\mathbf{v})}{\partial t}. \tag{46}$$

Then using the identity

$$(\mathbf{v}.\nabla)(\nabla.\mathbf{v}) = \frac{1}{2}\nabla^2(\mathbf{v}^2) - tr(D^2) - \frac{1}{2}(\nabla\times\mathbf{v})^2 + \mathbf{v}.\nabla\times(\nabla\times\mathbf{v}), \tag{47}$$

and imposing

$$\sum_{i=1,2,3}\mathcal{G}_{ii} = -8\pi G\rho, \tag{48}$$

we obtain

$$\frac{\partial}{\partial t}(\nabla.\mathbf{v}) + \frac{1}{2}\nabla^2(\mathbf{v}^2) + \frac{\alpha}{8}((trD)^2 - tr(D^2)) = -4\pi G\rho. \tag{49}$$

with $\alpha = 2$. However GR via (43) also stipulates that $\frac{1}{4}((trD)^2 - tr(D^2)) = 0$ in vacuum, implying that overall $\alpha = 0$ in GR. So (49) with $\alpha \neq 0$ is not equivalent to GR. Nevertheless this is seen to be a possible generalisation of the Newtonian equation (6) that includes the new term $C(\mathbf{v}) = \dfrac{\alpha}{8}((trD)^2 - tr(D^2))$. It appears that the existence and significance of this new term has gone unnoticed for some 300 years. Its presence explains the many known gravitational anomalies, as we shall see. Eqn.(49) describes the flow of space and its self-interaction. The value of α should be determined from both the underlying theory and also by analysis of experimental data[3]; see Sects.2.9 and 2.11.

[3] As footnoted in Sect.2.11 the value of α has been discovered to be the fine structure constant [9].

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We also note that because of the $C(\mathbf{v})$ term G does not necessarily have the same value as the value G_N determined by say Cavendish type experiments.

The most significant aspect of (49) is that the new term $C(\mathbf{v}) = 0$ only for the in-flow velocity field in (7), namely only outside of a spherically symmetric matter distribution.

Hence (49) in the case of the solar system is indistinguishable from Newtonian gravity, or the Schwarzschild metric within the General Relativity formalism so long as we use (10), in being able to determine trajectories of test objects. Hence (49) is automatically in agreement with most of the so-called checks on Newtonian gravity and later General Relativity. Note that (49) does not involve the speed of light c. Nevertheless we have not derived (49)) from the underlying Quantum Homotopic Field Theory, and indeed it is not a consequence of GR, as the $\mathcal{G}_{00}$ equation of (43) requires that $C(\mathbf{v}) = 0$ in vacuum. Eqn.(49) at this stage should be regarded as a conjecture which will permit the exploration of possible quantum-flow physics and also allow comparison with experiment.

However one key aspect of (49) should be noted here, namely that being a non-linear fluid-flow dynamical system we would expect the flow to be turbulent, particularly when the matter is not spherically symmetric or inside even a spherically symmetric distribution of matter, since then the $C(\mathbf{v})$ term is non-zero and it will drive that turbulence. In [7] we see that the experiments that reveal absolute motion also reveal evidence of such turbulence - a new form of gravitational wave predicted by the new theory of gravity.

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2.6 The 'Dark Matter' Effect

Because of the $C(\mathbf{v})$ term (49) would predict that the Newtonian inverse square law would not be applicable to systems such as spiral galaxies, because of their highly non-spherical distribution of matter. 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. From

$$\mathbf{g} = (\mathbf{v}.\nabla)\mathbf{v} + \frac{\partial \mathbf{v}}{\partial t}, \tag{50}$$

we see that (49) gives

$$\nabla.\mathbf{g} = -4\pi G\rho - C(\mathbf{v}), \tag{51}$$

and taking running time averages to account for turbulence

$$\nabla.<\mathbf{g}>= -4\pi G\rho- <C(\mathbf{v})>, \tag{52}$$

and writing the extra term as $<C(\mathbf{v})>= 4\pi G\rho_{DM}$ we see that ρ_{DM} would act as an effective matter density, and it is suggested that it is the consequences of this term which have been misinterpreted as 'dark matter'. Here we 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. Because $\nabla \times \mathbf{v} = 0$ we can write (49) in the form

$$\mathbf{v}(\mathbf{r},t) = \int^{t} dt' \int d^3r'(\mathbf{r}-\mathbf{r}')\frac{\frac{1}{2}\nabla^2(\mathbf{v}^2(\mathbf{r}',t')) + 4\pi G\rho(\mathbf{r}',t') + C(\mathbf{v}(\mathbf{r}',t'))}{4\pi|\mathbf{r}-\mathbf{r}'|^3}, \tag{53}$$

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which allows the determination of the time evolution of $\mathbf{v}$.

In practice it is easier to compute the vortex-free velocity field from a velocity potential according to $\mathbf{v}(\mathbf{r},t) = \nabla u(\mathbf{r},t)$, and we find the integro-differential equation for $u(\mathbf{r},t)$

$$\frac{\partial u(\mathbf{r},t)}{\partial t} = -\frac{1}{2}(\nabla u(\mathbf{r},t))^2 + \frac{1}{4\pi}\int d^3r' \frac{C(\nabla u(\mathbf{r}',t))}{|\mathbf{r}-\mathbf{r}'|} - \Phi(\mathbf{r},t), \tag{54}$$

where Φ is the Newtonian gravitational potential

$$\Phi(\mathbf{r},t) = -G\int d^3r' \frac{\rho(\mathbf{r}',t)}{|\mathbf{r}-\mathbf{r}'|}. \tag{55}$$

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 $\mathbf{g}$.

The new flow dynamics encompassed in (49) thus accounts for most of the known gravitational phenomena, but will lead to some very clear cut experiments that will distinguish it from the two previous attempts to model gravitation. It turns out that these two attempts were based on some key 'accidents' of history. In the case of the Newtonian modelling of gravity the prime 'accident' was of course the solar system with its high degree of spherical symmetry. In each case we had test objects, namely the planets, in orbit about the sun, or we had test object in orbit about the earth. In the case of the General Relativity modelling

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the prime 'accident' was the mis-reporting of the Michelson-Morley experiment, and the ongoing belief that the so called 'relativistic effects' are incompatible with absolute motion, and of course that GR was constructed to agree with Newtonian gravity in the 'non-relativistic' limit, and so 'inherited' the flaws of that theory. We shall consider in detail later some further anomalies that might be appropriately explained by this new modelling of gravity. Of course that the in-flow has been present in various experimental data is also a significant argument for something like (49) to model gravity[4].

2.7 In-Flow Superposition Approximation

We consider here why the existence of absolute motion and as well the consequences and so 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 if we have a matter distribution $\rho(\mathbf{r})$ at rest in the space of quantum foam, and that (49) has solution $\mathbf{v}_0(\mathbf{r}, t)$, with $\mathbf{g}_0(\mathbf{r}, t)$ given by (50), then when the same matter distribution is uniformly translating at velocity $\mathbf{V}$, that is $\rho(\mathbf{r}) \to \rho(\mathbf{r} - \mathbf{V}t)$, then a solution to (49) is

$$\mathbf{v}(\mathbf{r}, t) = \mathbf{v}_0(\mathbf{r} - \mathbf{V}t, t) + \mathbf{V}. \tag{56}$$

[4]As reported in [9] the quantum-foam in-flow theory of gravity has been validated by explaining the borehole g anomaly and the spiral galaxy 'dark matter' effect. Both sets of data reveal α to be the fine structure constant.

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Note that this is a manifestly time-dependent process and the time derivative in (4) or (16) and (49) plays an essential role. As well the result is nontrivial as (49) is a non-linear equation. The solution (56) follows because (i) the expression for the acceleration $\mathbf{g}(\mathbf{r},t)$ gives, and this expression occurs in (49),

$$\begin{aligned}
\mathbf{g}(\mathbf{r},t) &= \frac{\partial \mathbf{v}_0(\mathbf{r}-\mathbf{V}t,t)}{\partial t} + \\
&\quad + ((\mathbf{v}_0(\mathbf{r}-\mathbf{V}t,t)+\mathbf{V}).\nabla)(\mathbf{v}_0(\mathbf{r}-\mathbf{V}t,t)+\mathbf{V}), \\
&= \left.\frac{\partial \mathbf{v}_0(\mathbf{r}-\mathbf{V}t',t)}{\partial t'}\right|_{t'\to t} + \\
&\quad + \mathbf{g}_0(\mathbf{r}-\mathbf{V}t,t) + (\mathbf{V}.\nabla)\mathbf{v}_0(\mathbf{r}-\mathbf{V}t,t), \\
&= -(\mathbf{V}.\nabla)\mathbf{v}_0(\mathbf{r}-\mathbf{V}t,t) + \\
&\quad + \mathbf{g}_0(\mathbf{r}-\mathbf{V}t,t) + (\mathbf{V}.\nabla)\mathbf{v}_0(\mathbf{r}-\mathbf{V}t,t), \\
&= \mathbf{g}_0(\mathbf{r}-\mathbf{V}t,t),
\end{aligned} \tag{57}$$

as there is a key cancellation of two terms in (57), and (ii) clearly $C(\mathbf{v}_0(\mathbf{r}-\mathbf{V}t,t)+\mathbf{V}) = C(\mathbf{v}_0(\mathbf{r}-\mathbf{V}t,t))$, and so this term is also simply translated. Hence apart from the translation effect the acceleration is the same. Hence the velocity vector addition rule in (56) is valid for generating the vector flow field for the translating matter distribution. This is why the large absolute motion velocity of some 400 km/s of the solar system [7] does not interfere with the usual computation and observation of gravitational forces.

For earth based gravitational phenomena the motion of the earth takes place within the velocity in-flow towards the sun, and the velocity sum rule (56) 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

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the inhomogeneity of $\mathbf{V}(\mathbf{r},t)$ must be much smaller than that of $\mathbf{v}_0(\mathbf{r}-\mathbf{V}t,t)$, 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. Nevertheless turbulence associated with the $C(\mathbf{v})$ term is apparent in experimental data [7]. The validity of this approximation demonstrates that the detection of a cosmic absolute motion and 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 various anomalies; see section 2.9.

2.8 Gravitational In-Flow and the GPS

It has been extensively argued that the very successful operation of the Global Positioning System (GPS) [25] 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 show here that the new in-flow theory of gravity together with the observed absolute velocity of motion of the solar system through space are together compatible with the operation of the Global Positioning System (GPS). 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.

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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 affected 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 (36) and the Schwarzschild metric (38). However these two equations are equivalent to the orbital equation (18) and the velocity field (56), with a velocity $\mathbf{V}$ of absolute motion, and with the in-flow given by (7), noting the result in section 2.7. For EM signalling the elapsed time in (10) requires careful treatment. Hence the two systems are completely mathematically 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

$$\begin{aligned} \mathbf{r} &= \mathbf{r}' + \mathbf{V}t', \\ t &= t', \\ \mathbf{v} &= \mathbf{v}' + \mathbf{V}, \end{aligned} \tag{58}$$

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which lead to the relationships of differentials

$$\begin{aligned} \nabla' &= \nabla, \\ \frac{\partial}{\partial t'} &= \frac{\partial}{\partial t} + \mathbf{V}.\nabla \end{aligned} \tag{59}$$

These expressions then lead to the demonstration of the invariance of (49). Then in the earth co-moving frame the absolute velocity $\mathbf{V}$ does not appear in (49). Then another change of variables, as in (39), permits (49) to be written in the form of General Relativity with a Schwarzschild metric.

The consistency between the absolute motion velocity $\mathbf{V}$ and General Relativity may also be directly checked by showing explicitly, using say *Mathematica*, that the metric

$$d\tau^2 = g_{\mu\nu}dx^\mu dx^\nu = dt^2 - \frac{1}{c^2}(d\mathbf{r}(t) - ((\mathbf{v}(\mathbf{r} - \mathbf{V}t) + \mathbf{V})dt)^2, \tag{60}$$

is a solution to (33) for $T_{\mu\nu} = 0$, ie outside matter, where $\mathbf{v}(\mathbf{r})$ is the in-flow velocity field in (7). This metric is a generalisation of the Panlevé-Gullstrand metric to include the absolute motion effect. This emphasises yet again that for a spherically symmetric matter distribution the Schwarzschild metric, which is equivalent to the Panlevé-Gullstrand metric, is physically identical to Newtonian gravity.

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

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potential $\Phi(\mathbf{r})$ is determined observationally. In the new gravity theory the determination of such a gravitational potential via (49) 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.

The relations in (59) are those of Galilean Relativity. However together with these go the real absolute motion effects of time dilations and length contractions for moving material systems. Then the data from observers in absolute motion may be related by the Lorentz transformation, so long as their data is not corrected for the effects of absolute motion. So the new Process Physics brings together transformations that were, in the past, regarded as mutually exclusive.

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2.9 Measurements of G

As noted in Sect.2.1 Newton's Inverse Square Law of Gravitation is strictly valid only in cases of spherical symmetry, and then only outside of such a matter distribution. 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 cases 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

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properly accounted for. Of course any effects of turbulence in the inhomogeneities of the flow has presumably 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. In 1998 CODATA increased the uncertainty in G from 0.013% to 0.15%. One indication of the contextuality is that measurements of G produce values that differ by nearly 40 times their individual error estimates [26]. 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.

2.10 Gravitational Anomalies

In Sect.2.9 anomalies associated with the measurement of G were briefly discussed and it was pointed out that these were probably explainable within the new in-flow theory of gravity. There are in-fact additional gravitational anomalies that are not well-known in physics, presumably because their existence is incompatible with the Newtonian or the Hilbert-Einstein gravity theories.

The most significant of these anomalies is the Allais effect [27]. In June 1954 Allais[5] reported that a Foucault pendulum exhibited peculiar movements at the time of a solar eclipse. Allais was recording the precession of a Foucault pendulum in Paris. Coincidently during the 30 day observation period a partial so-

[5]Maurice Allais won the Noble Prize for Economics in 1988.

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lar 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 [28] 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 [29] report various time anomalies occurring during the solar eclipses of September 23 1987, March 18 1988 and July 22 1990 observed using atomic clocks.

Another anomaly is associated with the rotational velocities of objects in spiral galaxies, which are larger than could be maintained by the apparent amount of matter in such galaxies. This anomaly led to the introduction of the 'dark matter' concept - but with no such matter ever having been detetected, despite extensive searches. This anomaly was compounded when recently observations of the rotational velocities of objects within elliptical galaxies was seen to require very little 'dark matter'. Of course this is a simple consequence of the new theory of gravity. The 'dark matter' effect is nothing more than an aspect of the self-interaction of space that is absent in both the Newtonian and General Relativity theories. As a system becomes closer to being spherically symmetric, such as in the transition from spiral to elliptical galaxies, the new $C(\mathbf{v})$ term becomes less effective.

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All these anomalies, including the g anomaly in sect.2.11, and others such as the Pioneer 10/11 de-acceleration anomaly and the solar neutrino flux deficiency problem, 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, that the turbulence is always present. To explore these anomalies detailed numerical studies of (49) are required with particular emphasis on the effect on the position of the moon.

2.11 The Borehole g Anomaly

Stacey and others [30, 31, 32, 33, 34] have found evidence for non-Newtonian gravitation from gravimetric measurements (Airy experiments) in mines and boreholes. The discovery was that the measured value of g down mines and boreholes became greater than that predicted by the Newtonian theory, given the density profile $\rho(r)$ implied by sampling, and so implying a defect in Newtonian gravity, as shown in Fig.2 for the Hilton mine. The results were interpreted and analysed using either a value of G different to but larger than that found in laboratory experiments or by assuming a short range Yukawa type force in addition to the Newtonian 'inverse-square law'. Numerous experiments were carried out in which g was measured as a func-

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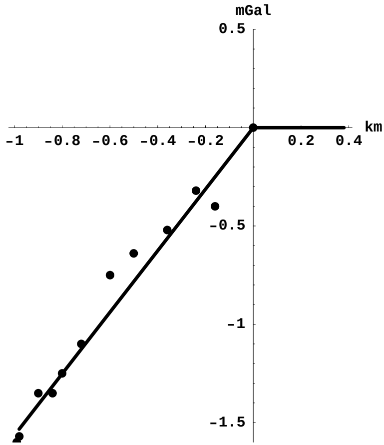

Figure 2: The data shows the gravity residuals for the Hilton mine profile, from Ref.[33], defined as $\Delta g(r) = g_{Newton} - g_{observed}$, and measured in mGal ($1\text{mGal} = 10^{-3}$ cm/s^2) plotted against depth in km. The theory curve shows $\Delta g(r) = g_{Newton} - g_{InFlow}$ from solving (61) and (62) for a density $\rho = 2760$ kg/m^3 appropriate to the Hilton mine, a coefficient $\alpha = 0.01$ and $G = 0.99935 G_N$.

tion of depth, and also as a function of height above ground level using towers. The tower experiments [35, 36] did not indicate any non-Newtonian effect, and so implied that the extra Yukawa force explanation was not viable. The combined results appeared to have resulted in confusion and eventually the experimental effect was dismissed as being caused by erroneous density sampling. However the new theory of gravity predicts such an effect, and in particular that the effect should manifest within the earth but not above it, as was in fact observed. Essentially this effect is caused by the new $C(\mathbf{v})$ term in the in-flow theory of gravity which, as we have noted earlier, is active whenever there is a lack of complete spherical symmetry, or even within matter when there is spherical symmetry - this being the case here.

The Newtonian in-flow equation (6) for a time-independent velocity field becomes for systems with spherical symmetry

$$2\frac{vv'}{r} + (v')^2 + vv'' = -4\pi\rho(r)G_N, \tag{61}$$

where $v = v(r)$ and $v' = \frac{dv(r)}{dr}$. The value of v at the earth's surface is approximately 11 km/s. This formulation is completely equivalent to the conventional formulation of Newtonian gravity,

In the new gravity theory the in-flow equation (49) has the additional $C(\mathbf{v})$ term which, in the case of time-independent flows and spherical symmetry, becomes the term in the brackets in (62) with coefficient α,

$$2\frac{vv'}{r} + (v')^2 + vv'' + \frac{\alpha}{2}(\frac{v^2}{2r^2} + \frac{vv'}{r}) = -4\pi\rho(r)G. \tag{62}$$

It is important to note that the value of G is not necessarily the same as the conventional value denoted as G_N. Both of these equations may be integrated in from the surface, assuming that the in-flow velocity field at or above the surface is given by

$$v(r) = \sqrt{\frac{2G_NM}{r}}, \tag{63}$$

so that it corresponds to the observed surface value of g. In (61) M is the total matter content of the earth, but in (62) M is the

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sum of the matter content and the effective total 'dark matter' content of the earth. Then above the surface, where $\rho = 0$, both flow equations have (63) as identical solutions, since for this velocity field the additional bracketed term in (62) is identically zero. This explains why the tower experiments found no non-Newtonian effects. The in-flow equations may be numerically integrated inward from the surface using as boundary conditions the continuity of $v(r)$ and $v'(r)$ at the surface. For each the $g(r)$ is determined. Fig.2 shows the resulting difference $\Delta g(r) = g_{Newton} - g_{InFlow}$ compared with the measured anomaly $\Delta g(r) = g_{Newton} - g_{observed}$. Assuming $\alpha = 0.01$ the value of G was adjusted to agree with the data, giving $G = 0.99935 G_N$, as shown in Fig.2. A fully self-consistent solution is necessary which integrates the equation to the centre of the earth, and so would appear to require a full knowledge of the earth's density profile. Then the only unknown is the value of α. It should be noted that the data in Fig.2 was adjusted for density irregularities using Newtonian gravity, and this is now seen to be an invalid procedure. Nevertheless the results imply that a repeat of the borehole measurements would be very useful in contributing to the testing of the new theory of gravity, or perhaps even a re-analysis of existing data could be possible[6] The key signature of the effect, as shown in Fig.2, is the discontinuity in $d\Delta g(r)/dr$ at the surface, and which is a consequence of the special prop-

[6] A full analysis of the Greenland borehole data [34] has now been carried out [9] and it has been discovered that α has the value of the fine structure constant $\alpha = e^2/\hbar c$, and hence the choice of notation. The same value for α resulted also from analysing the rotation velocity curves of spiral galaxies. This confirms that gravity is indeed a quantum-foam in-flow effect, and that quantum gravity effects are much larger then expected.

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erty of the $C(\mathbf{v})$ term. Of course using a Yukawa force added to Newtonian gravity cannot produce this key signature, as such a force results in $d\Delta g(r)/dr$ being continuous at the surface.

2.12 Galactic In-flow

Absolute motion (AM) of the solar system has been observed [7] in the direction $(\alpha, \delta) = (5.2^h, -67^0)$, up to an overall sign to be sorted out, with a speed of 433 km/s [7]. 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 $(\alpha, \delta) = (11.20^h, -7.22^0)$, see [22]. 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 at least a shell of the universe some 15Gyrs 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 velocity would arise from the orbital motion of the solar system within the Milky Way galaxy, which has a speed of some

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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 *universal* CMB velocity and the net velocity associated with the *local* gravitational in-flows into the Milky Way and the local cluster. 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, and that this velocity does not display the turbulence seen in the AM velocity.

That the AM and CMB velocities are different amounts to the discovery of the resolution to the 'dark matter' conjecture. Rather than the galactic velocity anomalies being caused by such undiscovered 'dark matter' we see that the in-flow into non spherical galaxies, such as the spiral Milky Way, will be non-Newtonian [7]. 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.

It is also clear that the time of observers at rest with respect to the CMB frame is absolute or universal time. This interpretation of the CMB frame has of course always been rejected by supporters of the SR/GR formalism. As for space we note that

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it has a differential structure, in that different regions are in relative motion. This is caused by the gravitational in-flow effect locally, and as well by the growth of the universe.

2.13 Turbulence and Gravitational Waves

The velocity flow-field equation (49) 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 Michelson interferometer experiments showed evidence of such turbulence. The first clear evidence was from the Miller experiment, as shown discussed in [7]. 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, plotted in [7] shows variations in the velocity field and supports this interpretation. However it is significant that the non-interferometer DeWitte [7] 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 as well.

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 some-

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what larger than that which would be caused by the in-flow of quantum foam towards the sun, and indeed following on from Sect.2.12 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, but suppressed along with the detection of absolute motion itself. Of course flow equations do not exhibit those gravitational waves of the form that have been predicted to exist based on the Einstein equations, and which are supposed to propagate at the speed of light. All this means that gravitational wave phenomena is very easy to detect and amounts to new physics that can be studied in much detail, particularly using the new 1st-order interferometer discussed in [7].

2.14 Absolute Motion and Quantum Gravity

Absolute rotational motion had been recognised as a meaningful and observable phenomena from the very beginning of physics. Newton had used his rotating bucket experiment to illustrate the reality of absolute rotational motion, and later Foucault and Sagnac provided further experimental proof. But for absolute linear motion the history would turn out to be completely different. It was generally thought that absolute linear motion was undetectable, at least until Maxwell's electromagnetic theory appeared to require it. In perhaps the most bizarre sequence of events in modern science it turns out that absolute linear mo-

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tion has been apparent within experimental data for over 100 years. It was missed in the first experiment designed to detect it and from then on for a variety of sociological reasons it became a concept rejected by physicists and banned from their journals despite continuing new experimental evidence. Those who pursued the scientific evidence were treated with scorn and ridicule. Even worse was the impasse that this obstruction of the scientific process resulted in, namely the halting of nearly all progress in furthering our understanding of the phenomena of gravity. For it is clear from all the experiments that were capable of detecting absolute motion that there is present in that data evidence of turbulence within the velocity field. Both the in-flow itself and the turbulence are manifestations at a classical level of what is essentially quantum gravity processes, for these processes imply that space has structure.

Process Physics has given a unification of explanation and description of physical phenomena based upon the limitations of formal syntactical systems which had nevertheless achieved a remarkable encapsulation of many phenomena, albeit in a disjointed and confused manner, and with a dysfunctional ontology attached for good measure. As argued in [2] space is a quantum system continually classicalised by on-going non-local collapse processes. The emergent phenomena is foundational to existence and experientialism. Gravity in this system is caused by differences in the rate of processing of the cellular information within the network which we experience as space, and consequentially there is a differential flow of information which can be affected by the presence of matter or even by space itself. Of course the motion of matter including photons with respect to that spatial information content is detectable because it affects the

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geometrical and chronological attributes of that matter, and the experimental evidence for this has been exhaustively discussed in [7]. What has become very clear is that the phenomena of gravity is only understandable once we have this unification of the quantum phenomena of matter and the quantum phenomena of space itself. In Process Physics the difference between matter and space is subtle. It comes down to the difference between informational patterns that are topologically preserved and those information patterns that are not. One outcome of this unification is that as a consequence of having a quantum phenomena of space itself we obtain an informational explanation for gravity, and which at a suitable level has an emergent quantum description. In this sense we have an emergent quantum theory of gravity. Of course no such quantum description of gravity is derivable from quantising Einsteinian gravity itself. This follows on two counts, one is that the Einstein gravity formalism fails on several levels, as discussed previously, and second that quantisation has no validity as a means of uncovering deeper physics. Most surprising of all is that having uncovered the logical necessity for gravitational phenomena it also appears that even the seemingly well-founded Newtonian account of gravity has major failings. The denial of this possibility has resulted in an unproductive search for dark matter. Indeed like dark matter and spacetime much of present day physics has all the hallmarks of another episode of Ptolemy's epicycles, namely concepts that appear to be well founded but in the end turn out to be illusions, and ones that have acquired the status of dogma.

If the Michelson-Morley experiment had been properly analysed and the phenomena revealed by the data exposed, and this would have required in 1887 that Newtonian physics be altered,

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then as well as the subsequent path of physics being very different, physicists would almost certainly have discovered both the gravitational in-flow effect and associated gravitational waves.

It is clear then that observation and measurement of absolute motion leads directly to a changed paradigm regarding the nature and manifestations of gravitational phenomena. There are two aspects of such an experimental program. One is the characterisation of the turbulence and its linking to the new non-linear term in the velocity field theory. This is a top down program. The second aspect is a bottom-up approach where the form of the velocity field theory, or its modification, is derived from the deeper informational process physics. This is essentially the quantum gravity route. The turbulence is of course essentially a gravitational wave phenomena and networks of 1st-order interferometers will permit spatial and time series analysis. There are a number of other gravitational anomalies which may also now be studied using such an interferometer network, and so much new physics can be expected to be uncovered.

3 Conclusions

Here a new theory of gravity has been proposed. It passes all the key existing tests, including the operation of the GPS, and also appears to be capable of explaining numerous gravitational anomalies. The phenomena present in these anomalies provide opportunities for further tests of the new gravitational physics, as illustrated here by the mine/borehole g anomaly. This new theory explains why elliptical galaxies display a very small 'dark matter' effect, in comparison with the large effect for the spi-

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ral galaxies. This new theory is supported by the Miller, Torr and Kolen, and DeWitte absolute motion experiments in that they reveal the turbulent in-flow of space associated with gravity, namely the discovery of those gravitational waves predicted by the new theory, as well as the existence of absolute motion itself. This clearly refutes the fundamental postulates of the Einstein reinterpretation of the relativistic effects that had been developed by Lorentz and others. Indeed these experiments are consistent with the Lorentzian interpretation of the special relativitistic effects in that reality displays both absolute motion effects *and* relativistic effects. It is absolute motion that causes the special relativistic effects. Both General Relativity and the Newtonian theory, for which GR was constructed to agree with in the low speed limit, are refuted by these experiments. It turns out that the early observations of planteary motion in the solar system were too special to have revealed all the phenomena associated with gravity - the solar system has too much spherical symmtery to have revealed these phenomena. We saw that the Galilean transformation together with the absolute motion effects of time dilations and length contractions for moving material systems leads to the data from observers in absolute motion being related by the Lorentz transformation, so long as their data is not corrected for the effects of absolute motion. So the new Process Physics brings together transformations that were, in the past, regarded as mutually exclusive. Essentially the quantum foam system that is space generates phenomena that are more subtle than currently considered in physics.

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