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General relativity as a unified fluid and field theory

H A Múnera

International Centre for Physics (CIF), Bogota, Colombia
E-mail: hmunera@hotmail.com

Abstract. Einstein's dream for a unified field theory of Nature is attained with a classical fluid theory founded on space, time and spin, rather than on Einstein's spacetime. An invariant quantum theory for the primordial fluid obeys the homogeneous Klein-Gordon equation, which is the same three-dimensional classical wave equation (CWE) initially tried by Schrödinger to formulate quantum mechanics (QM), but abandoned by linear superposition considerations. Primordial fluid pervades universe, obeys energy and momentum conservation, and is formed by sagions: energy-like, discrete, extended Planck-size objects of finite size, carriers of linear momentum and spin, moving in absolute 3D-curved space with speed C along straightest path. We briefly describe our novel non-harmonic and inherently quantized solutions for CWE in spherical coordinates, discovered in 1995. Solutions include a steady-state background field (possibly related to the CMB, to non-locality, and to action-at-a-distance), quantized helices, and inherently quantized functions exhibiting stable dynamic equilibrium, and isomorphism under many transformations, including the classical Doppler case, and the relativistic Lorentz, Poincaré, and Einstein transformations. Isomorphism pre-empts *ab initio* a few interpretative issues regarding relativistic and classical transformations. Mathematical fields represent the realistic physical temporal evolution of the primordial fluid in curved 3D-space.

1. Introduction: controversial questions in classical and quantum descriptions of Nature

Besides unprecedented technological progress, 20th century is characterized for abandoning cherished and fundamental notions rooted in Ancient Greece: logic, causality, space, and a careful distinction between the container and what is contained; inherently contradictory notions — as a vacuum with physical properties — are now common currency. Special relativity (SR) and quantum mechanics (QM) attributed an overemphasized role to the observer, leading to theories about how an observer sees Nature, rather than to how Nature behaves when the observer is not there as it was the case until the turn of 20th century. For Aristotle Earth was at the center of Ancient Cosmos, but a modern competitor has stronger claims: the anthropic principle places humankind at the center of universe, conveniently forgetting that tomorrow, on the geological scale, a collision with an asteroid may erase earth and humankind from the universe — event that would hardly affect the rest of cosmos.

According to some views, the main open question in physics today is compatibility of quantum and gravity theories. Einstein dreams were more ambitious: only one Nature with all interactions described by a single theory. In the recent opinion of Gerard 'tHooft, a unified theory should also address the question of "*how matter behaves*" [1]. Present paper outlines an approach that works: an objective, causal and Cartesian unified fluid and field theory, (hopefully) free of internal inconsistencies.

As general context, let us mention two controversial aspects in Newton's Principia [2]: (a) circular definition of mass, and (b) the notion of non-contact forces, in particular the notorious omission of a mechanism for generation and propagation of gravitational force. The latter omission led to the widely spread belief that Newton introduced action-at-a-distance (AAAD) in physics. Due to the high

predictive capability of Newtonian mechanics, defects (a) and (b) were pragmatically accepted or tolerated. Unfortunately, it is not generally known that in his private letters [3] Newton perseveringly and strongly argued for an ether (be it material, or immaterial) to explain gravity propagation [4].
An economic solution for issues (a) and (b) is provided by a Cartesian approach based on conservation of quantity of motion as a primitive notion [5-6] ― thus downgrading force and mass from the role they have in Newtonian mechanics. A consistent kinematic definition of mass was proposed by Barré de Saint Venant around 1850 [7-8]. Without mentioning him, the method of Saint Venant is implemented in some modern textbooks [9]: stroboscopic photography to measure average velocity of two interacting bodies before and after a collision upon a pneumatic table. In contrast, the better-known operational definition of mass proposed by Mach around 1870 is based on mutually induced accelerations during the interaction of two bodies [8,10]. In criticizing the notions of instant velocity and instant acceleration fields, Russell [11] noted that to measure average velocity two observations at separate intervals of time are required, while an estimate for average acceleration requires at least three observations. From Ockham's razor, Saint Venant's more economical method is preferable to Mach's approach. Our energy-like primordial fluid (PF) is a modern version of ether, which inherently carries an indestructible quantity of motion, thereby explaining propagation of the derived notion of force — which merely is the average exchange of quantity of motion in a collision. Such PF provides a causal and physically objective basis for the mathematical notion of field [4,12-13].
Passing now to open questions in QM, the completeness issue noted by Einstein still is there. Secondly, the Copenhagen interpretation of QM accepts the existence of undefined states of Nature between being and not-being —as the iconic Schrödinger's cat, and Wigner's friend. To stress the philosophical absurdity of the latter, Einstein used to pose the rhetoric question of whether the Moon existed when an observer was not looking at her! The Einstein-Podolsky-Rosen paradox and the ensuing Bell theorem are common knowledge. This writer agrees [14] with Einstein's views on causality and objectivity. Finally, there is Born's interpretation of the QM-wave-function as a probability. Since Jacob Bernoulli's Ars Conjectandi (circa 1713), it is well-known that probability is not a physical magnitude, but a mere mathematical construct of human mind [15]. Further, present writer posits that the rest of Nature — as far as known on earth — does not conjecture about outcomes of forthcoming events. If there is little information, probability is subjective and is a mere (non-) informed guess; probability is less subjective if there is symmetry, or when it is viable to enumerate the (hopefully) complete list of physical trajectories leading to an outcome, as in Feynman's continuous path integrals, or in discrete decision trees [16]. When long-term observations or controlled experimentation are viable, objective frequency-based probability is obtained. However, in any of the three previous scenarios probability is not a physical object.
In 1952 Louis de Broglie recalled [17] a distinction he made in the mid-1920s between the continuous solutions of the linear QM-equations and its interaction with a localized (presumably material) corpuscle in such wave field, leading to an objective and causal "*dual solution*", that foreshadowed t'Hooft remarks [1] for eighty years. Since this mathematically coupled problem was difficult to solve, de Broglie settled for a simpler pilot-wave model: motion of a material corpuscle is controlled by the wave function Ψ. However, he also abandoned this proposal after realizing what we already said in previous paragraph: "Ψ *certainly is not a physical reality... it only is a representation of probabilities dependent upon the state of our knowledge*" [17] (our literal translation from French, page 266). As alternative to the Copenhagen view of QM, de Broglie suggested in the 1950s a stochastic interpretation, where Schrödinger's linear equation represents fluctuations of a fluid [18], but the fluid itself was proposed much earlier by Madelung [19-20].
The five-dimensional universe suggested by Klein in 1926, led de Broglie in 1927 [21] to an alternative for Schrödinger's linear equation: the non-linear wave equation known today as Klein-Gordon equation (KGE). De Broglie also entered the long-standing controversy between Cartesians and Newtonians [3], and pointed out that a most appealing aspect of general relativity (GR) was to eliminate "*the metaphysical concept of force from gravitational theory*" [21]. In 1962 de Broglie insisted once again on non-linearity: "*agreeing with some deep remarks by Einstein, all exchanges of*

energy and linear momentum between corpuscles probably arise from transitory non-linear processes, whose description is beyond current linear theories" [22] (our translation from French, p 425). De Broglie also used a KGE in relativistic thermodynamics [23], soliton solutions of KGE are reported in [24], and a summary of de Broglie's pilot-wave theory is in [25].

De Broglie consistently noted that all waves in his theory had physical reality, thus requiring an underlying physical fluid, often identified with Dirac's ether [26]. In 1999 present author proposed a primordial fluid (PF) [27] similar to Dirac's, but with two conceptual differences: (a) an unidirectional arrow of time from past to future, thus excluding reversibility, and science-fiction travels to the past, and (b) the fluid constituents were material 3D-extended preons. From Leibniz continuity principle stating that a change from state A to B has to go through all intermediate states, and considering the controversy on impenetrability of matter [28-30], we concluded that matter should have structure at all scales, so that the smallest bit of matter is divisible, but its components cannot possibly be material. So, instead of material preons, it is postulated here that the primordial fluid is formed by energy-like sagions, described as discrete, 3D-extended, spherical and Planck-size objects of radius R, carrying quantity of motion P, spin S, and moving with speed C along the straightest path [12]. Our fluid theory agrees with de Broglie's relativistic QM and with the notion that matter has electromagnetic origin. In our theory the simplest entity of Nature is an energy-like sagion, rather than a material object as in the Leucippus and Democritus atom.

2. Reinterpretation of empirical evidence usually cited to support Einsteinian relativity

Next question: where does the primordial fluid exist? In a Newtonian context the sagion moves with speed C in absolute space, described in 1590 by Francesco Patrizi as physical space Σ [31-32]. For Gauss, the geometrical nature of space was an empirical question, tackled by measuring the angles of a triangle defined by three mountain peaks in Germany. Gauss found a locally flat space up to his empirical accuracy. However, the observation of light-bending by Eddington in the 1919 solar eclipse suggests that, at a larger cosmological scale, space is positively curved.

2.1. On the two different principles of equivalence

In contrast, for Einstein light-bending was a strong support for GR [33]. In his correspondence during the Swiss years [34], Einstein mentions three possible methods to confirm GR: (1) examination of existing solar photographs, (2) observation of stars near the sun in full daylight, idea suggested by astronomer Erwin Freundlich-Finlay (EFF) of Berlin Observatory, and (3) observation of star light during the 1914 solar eclipse in an expedition of EFF to Russia that was abruptly ended by the outbreak of World War I [35]. Einstein mentions light-bending in a letter to EFF dated September 1/1911 from Prague (L281 = letter 281 in [34]); correspondence with EFF on this subject continued on September 21/1911 (L287), January 8/1912 (L336), October 27/1912 (L420), mid-August 1913 (L468), August 26/1913 (L472), December 7/1913 (L492), and January 20/1914 (L506). Einstein also corresponded on light-bending with astronomer George Hale on October 16/1913 (L477) and November 8/1913 (L483).

In L448 sent to Ernst Mach in June 25/1913 Einstein stated [34]: "*Next year, during the solar eclipse, we shall learn whether light rays are deflected by the sun, or in other words, whether the underlying fundamental assumption of the equivalence of the acceleration of the reference system, on the one hand, and the gravitational field, on the other hand, is really correct*". This is a clear statement of Einstein's principle of equivalence of acceleration and gravity (EP-A henceforth) mentioned by Einstein five years before in a letter to Arnold Sommerfeld dated January 5/1908 (L72 in [34]). According to Ginzburg [36-37] EP-A was formulated in 1907 [38]. In the opinion of the present writer, EP-A contains the deepest physical and philosophical implications of Einstein's GR, and has everyday manifestations easily seen in the laboratory [39]. Hence, there is no need to invoke light-bending as empirical proof for EP-A.

There is a different, although related, question: is the ratio between inertial mass and gravitational mass a constant, independent of the composition of matter? This is the equivalence principle for mass

EP-M. For Newton, EP-M was an empirical question that he answered with pendulum experiments described in book III, proposition VI of the Principia [2] (see p 108 in [3]). For Einstein EP-M was also an empirical question, and in July 10/1912 he asked help from Prof. Wilhelm Wien to carry out two "*quite easy*" experiments involving (a) two pendulums, and (b) a torsion balance (L413, p 319-320 in [34]). It seems that Einstein was unaware of the earlier experiment by Eötvös involving torsion balances carried out in Hungary in the 1890s [40], and published around 1910 [41]. A re-analysis of Eötvös data by the Fischbach group in 1986 [42-44] shows that gravitational mass depends on the number and distribution of protons and neutrons in the atomic nucleus. Fischbach fitted the dashed line in Figure 1 to Eötvös observations with their Yukawa-type gravity model, and the correlation was poor. The anomaly remained unexplained [41] until in 2011 present writer separately analyzed the Pt-series and the Cu-series in Eötvös experiments (Figure 1a). Taking into account orbital electrons plus the binding energy of protons and neutrons in the nucleus, an atomic-like pushing gravity model was obtained [45-46], which is consistent with Eötvös data at 92% correlation coefficient (Figure 1b). The only adjustable parameter turned out to be, as expected, the electron/proton mass ratio.
Summarizing, EP-A and EP-M are two different questions; this may clarify some controversies regarding Einstein's equivalence principle [36-37, 47-49]; also note that Einstein suggested different and separate empirical methods to verify EP-A and EP-M. In our view, EP-A is locally valid, but EP-M is not. We also depart from Einstein's interpretation of star light-bending; instead, it is curvature of absolute 3D-space in the local region from star to earth.

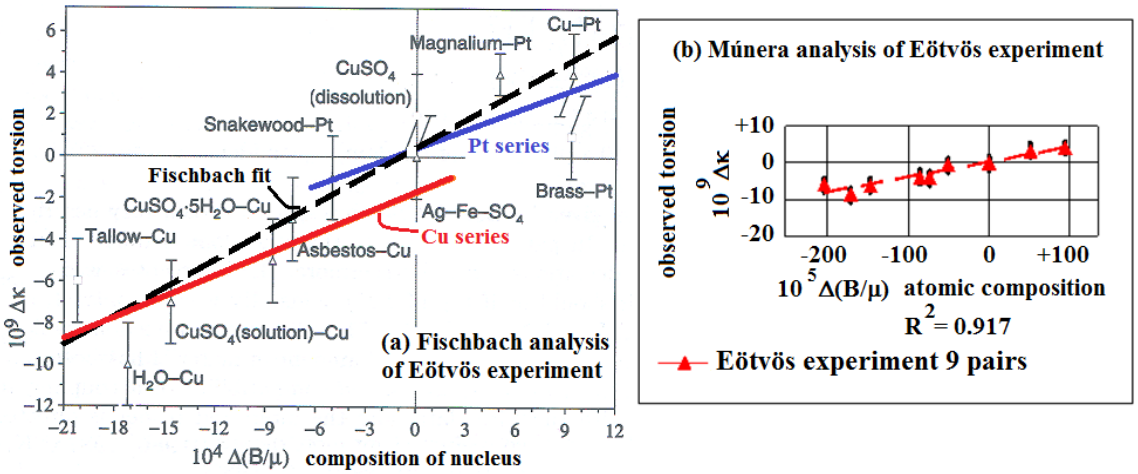

Figure 1. Relative torsion in Eötvös experiment depends on composition: (a) nuclear composition effect analysed by Fischbach [42-44], (b) atomic composition effect analysed by Múnera [45-46].

2.2. On the evidence against absolute space

Einstein rightly rejected the far-fetched properties of electromagnetic ether models in the second half of the 19th century, but he erred in his 1905 general dismissal of ether, including Newton's [2] (possibly immaterial) fluid-like ether [4]. In our view, when Einstein formulated EP-A in 1907 [38] he immediately sensed that he was a prisoner of his 1905 dismissal. Indeed, in L73 to Sommerfeld dated January 14/1908 Einstein wrote from Bern [34]: "*If the Michelson-Morley experiment had not put us in the worst predicament, no one would have perceived the relativity theory as a (half) salvation*". In L448 to Mach dated June 1913 Einstein considered the physics inside a shell rotating "*relative to the fixed stars ('Restsystem')*", which to an unaware reader sounds very similar to Newton's ideas.
According to Kostro [50], Einstein reintroduced ether around 1916, but it seems that the seeds for such reinstatement were planted around 1907. At any rate, Einstein explicitly said at Leyden in 1920: "*Newton might no less well have called his absolute space 'Ether'; what is essential is merely that besides observable objects, another thing, which is not perceptible, must be looked upon as real, to*

enable acceleration or rotation to be looked upon as something real" [51]. Surprisingly, Einstein did not distinguish between the container (absolute space) and its contents (ether).

In the mid-1990s present author uncovered several weaknesses in Michelson-Morley experiment (MMX) [52]. Most significant was that only the fractional part of the fringe-shift was recorded, leading to under-estimation of fringe-shift amplitude [53], which should be of several fringes as calculated with modern values of solar velocity [54]. This prompted us to repeat the MM experiment at CIF in Bogota (Colombia) in a continuous manner during two years (2003-2005). As usual in second-order experiments, two velocities of sun relative to a preferred frame were obtained from our data: (a) CIF-S: VS = 500 km/s, R.A. = 16h-40m, Dec = -75º (southern celestial hemisphere) [55], and (b) CIF-N: VS = 365 km/s, R.A. = 5h-24m, Dec = 79º (northern celestial hemisphere) [56]. Our solar velocities are compatible with other observations supporting absolute motion [57].

Of significant interest is the compatibility of our results with two contemporary experiments: (1) de Haan [58] experiments involving standing waves and a Fabry-Perot interferometer, and (2) Lipa vertical interferometer at Stanford in 2002 [59], temperature controlled to a micro-Kelvin accuracy, that was interpreted as a "null" MMX. Applying procedure described in [54], absolute velocity of surface of earth at Stanford University (Palo Alto, California) was calculated for dates of Lipa's experiment using our CIF-S value for solar velocity. Figure 2 shows projection of our calculated absolute velocity upon Lipa's laboratory floor for May 30/2002. The observed frequency variations recorded by Lipa on same date [59] exhibit correlation coefficients at 99.8% with absolute speed, and 99.1% with absolute direction of motion, which imply that EM frequency may be affected by absolute motion, contrary to Lipa's interpretation. The paradox is easy to explain: Lipa attributed observed frequency variations to unexplained "*mechanical disturbances*", subtracted them, and obtained a noise of zero amplitude. Hence, they got the reported "null" result!

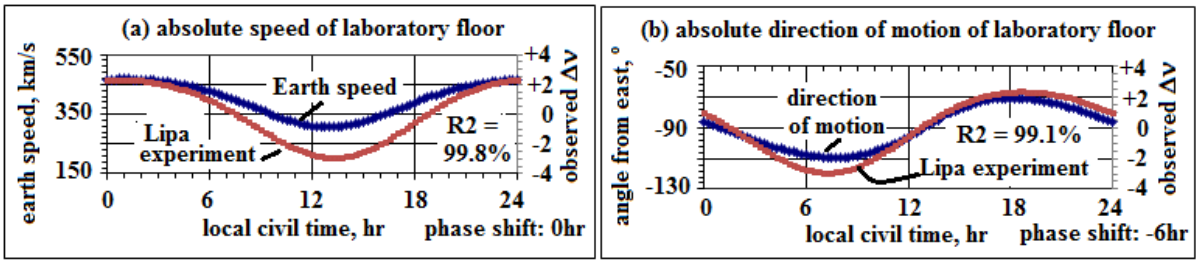

Figure 2. Projection of absolute velocity on the floor of the laboratory at Stanford University in May 30/2002. Observed frequency variations on same day [59] are highly correlated with absolute motion.

3. New solutions for the homogeneous Klein-Gordon equation or classical wave equation

Empirical evidence sketched in previous section implies absence of evidence against absolute space; in Einsteinian mood, the *Michelson-Morley experiment no longer puts us in any predicament*. It is postulated that a primordial fluid entirely pervades the curved 3D-absolute space Σ, and that it obeys conservation of total energy, and linear and angular momentum. In regions of universe devoid of matter, the fluid is locally described by the homogeneous Klein-Gordon equation (1), which is the same classical wave equation; the physical potential field $\Pi \equiv (\phi, \mathrm{A})$ contains a scalar potential ϕ (conservation of total energy) and a vector potential A (conservation of linear momentum), whose dimensions $ML^{-1}T^{-2}$ correspond to density of total energy, and to flow of linear momentum per unit area (or, equivalently, density of angular momentum flow) respectively. Equation (1) represents De Broglie's pilot wave [21-23], and also complies with classical electrodynamics [60]:

$$\Box \Pi = \left(\frac{\partial^2}{\partial^2 w} - \nabla^2 \right) \Pi = 0 \text{, where } w \equiv C^* t \text{, } \Pi \equiv (\phi, \mathrm{A}). \qquad (1)$$

Time is treated as length *w* with *C** being the local average speed of primordial fluid. In presence of matter, right hand side is non-zero due to elastic and inelastic sagion-matter interactions; a complete

(3+1+1) formulation requires Dirac's equations containing spin, characterized by a positive/negative absolute sense of rotation: counterclockwise/clockwise. In isotropic absolute space all directions (θ,φ) are equivalent, and linear motion becomes one-dimensional along arbitrary ray (r,t), or (r,w). Thus, we use spherical coordinates (r,w,θ,φ) to solve equation (1). The standard separation of variables in equation (2) leads to harmonic solutions, with $F(r,w)$ being the one-dimensional travelling wave equation found by D'Alembert in the 18th century:

$$\Pi(r,w,\theta,\varphi)=F(r,w)D(\theta,\varphi),\ F(r,w)=R(r)T(w),\ D(\theta,\varphi)=Y(\theta,\varphi;\ell,m),$$
$$\text{where } \ell>m,\ m^2\geq 0. \tag{2}$$

Directional component $D(\theta,\varphi)$ is the same for the linear non-relativistic Schrödinger equation and for the relativistic Klein-Gordon equation (1). Thus, the Lorentz invariance of the KGE is fully contained in the one-dimensional motion $F(r,w)$ along arbitrary ray r, which is equivalent to Einstein's special relativity motion along arbitrary X-axis (axes Y and Z being ignored in practice). In QM, directional solution $D(\theta,\varphi)$ is restricted to $m^2\geq 0$, and reduces to usual spherical harmonics $Y(.,.)$. In the mid-1990s we studied the (usually neglected) inherently quantized helicoidal functions $H(\theta,\varphi)$ that appear for $m^2<0$ [12, 61-64]. There are two families of helices spiraling inward/outward on the surface of quantized cones shown in Figure 3. Inward growth has been observed in circular micro-pyramids of $YBa_2Cu_3O_7$ at the 125 nanometer scale [65], and silicon carbide crystals at the 100 micrometer scale [66]; at a larger scale, swirls, tornados and hurricanes are everyday examples. On the contrary, snail- and sea-shells display outward spiral growth. Whether spiral galaxies grow inwards or outwards is left open.

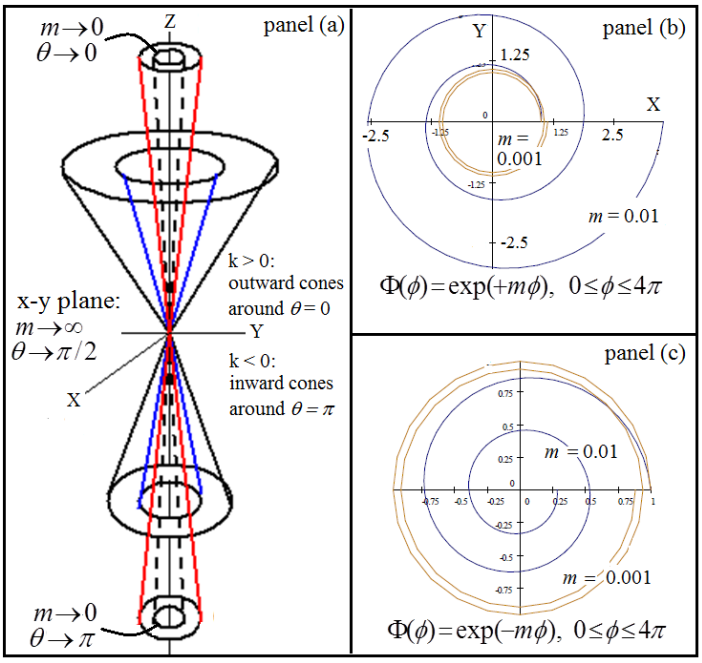

Figure 3. Helicoidal solutions for equation (1) with $m^2<0$ for counter-clockwise upward motion.
Panel (a): Two families of cones around Z-axis; the vertex angle is inherently quantized.
Panel (b): Outward spirals grow from $x=1$ outwards.
Panel (c): Inward spirals grow from $x=1$ inwards towards the Z-axis.

Searching for longitudinal non-harmonic solutions for $F(r,w)$ in electromagnetic contexts, we re-wrote the one-dimensional travelling wave as $M(r,q)$, where the novel independent variable q intermingles spatial distance (r) and time (w) in an intimate un-separable manner. But, in contrast to

SR, variable q is a mere mathematical manipulation of physical magnitudes without ontological implications regarding space and time, which remain two separate notions:

$$\Pi(r,w,\theta,\phi) = M(r,q)D(\theta,\phi) = \big(N(r)+Q(q)\big)D(\theta,\phi) = B(r,\theta,\phi)+U(q,\theta,\phi), \quad q \equiv w/r. \tag{3}$$

Separation of functions $N(r)$ and $Q(q)$ in the differential equation for $M(r,q)$ generates a new quantum number η that appears in the generic solution for $Q(q)$ in terms of Q-functions of the first, second and third kind, related to associate Legendre functions. Q-functions were first described in [61], further details appear in [12, 62-63]:

$$B(r,\theta,\varphi) = N(r)D(\theta,\varphi), \quad U(q,\theta,\varphi) = Q(q)D(\theta,\varphi),\ Q(q) = A_1Q_1(q;\ell)+A_2Q_2(q;\ell)+\eta Q_3(q;\ell). \tag{4}$$

As usual in the theory of time-dependent differential equations, the background field $B(r,\theta,\varphi)$ in equation (3) is a particular solution of equation (1). This time-independent steady-state background may provide an alternative interpretation to the origin of cosmic microwave background radiation, and yield a causal explanation for action-at-a-distance and non-locality features in QM and EM theory, along the lines discussed in [67]. New universal field $U(q,\theta,\varphi)$ depends on only three explicit dimensionless ratios of length, viewed as cosines of time (q) and spatial direction (θ,φ). Then, velocity dependent function $f(\beta)$ cancels in numerator and denominator of any transformation of moving coordinates leading to the remarkable property of isomorphism, outlined in equations (5):

$$s \to s' = f(\beta)(s-\beta w), \quad w \to w' = f(\beta)(w-\beta r),\ s = x,y,z,r, \text{ where } \beta = V/C.$$

$$\text{Isomorph: } \left(\frac{w}{r},\frac{s}{r}\right) = (q,\cos\theta) \to (q',\cos\theta') = \left(\frac{w-\beta r}{r-\beta w},\frac{s-\beta w}{r-\beta w}\right), \text{ where } \cos\theta = s/r, \tag{5}$$

$$\text{Doppler: } f(\beta)=1,\ \text{Lorentz: } f(\beta)=\gamma,\ \text{Pointcaré: } f(\beta)=\gamma l(\beta), \quad \text{where } \gamma = \left(1-\beta^2\right)^{-1/2}.$$

The practical implication is that four competing transformations are equivalent: (1) Doppler formed by the classical Galilei transformation for distance *r*, and the local time defined by Voigt in 1887 [68], and also mentioned by Poincaré in 1900 [69], (2) Poincaré [70-71], (3) Lorentz [72], (4) Einstein [72].

There is a four-fold repetitive pattern in $Q_1(q,l)$ functions (see Figure 4) according to $l = 4n-1, 4n, 4n+1, 4n+2$, where *n* is the number of stable spherical surfaces of dynamic equilibrium [12]. The latter easily explain atomic structure [73], and Titius-Bode rule in both solar and exoplanetary systems with coefficients of correlation usually above 99% [74-75]. In far-field $(r \to \infty)$ Q_1 is monotonous and tends asymptotically to nonzero for odd-l.

The attractive non-zero far field of the $l = 4n-1$ group easily explains the flat rotation rate of galaxies, without ad hoc dark matter, while the repulsive non-zero far field of the $l = 4n+1$ group is similar to nuclear and sub-nuclear confining forces. The far field is zero for even-l, for $l = 4n$ it is attractive as in Newton and Coulomb forces, and for $l = 4n+2$ it is repulsive as in Coulomb force between equal sign charges. Q_1-functions are very similar to Boscovich unified force [76], which is inherently quantized in near field $(r \to 0)$ as Thomson [77] noted before inception of QM. Spherical surfaces of dynamic equilibrium lead to a simple method to solve the three-body problem, and to construct Trojans orbits [74].

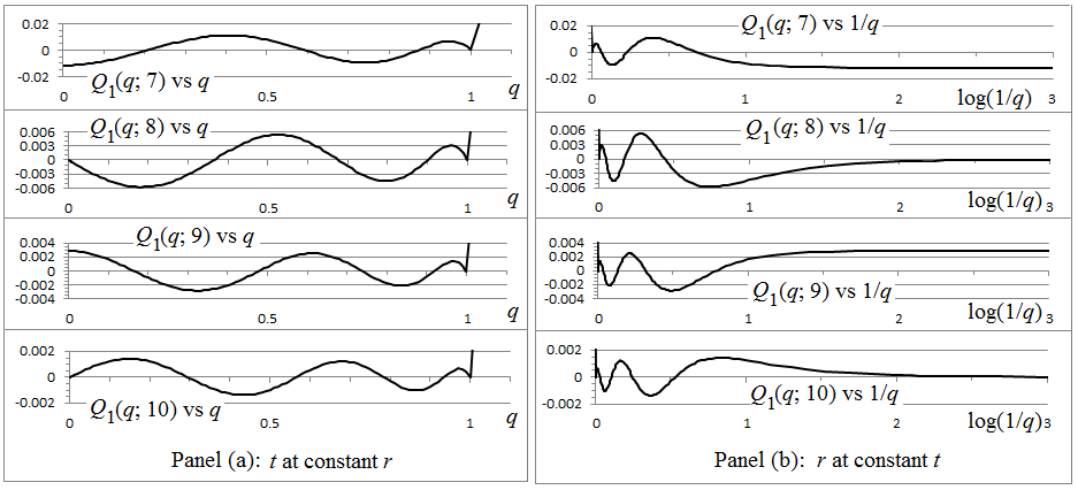

Figure 4. Function Q_1 for $n = 2$. Note stable intercepts along horizontal axis for the gravitational potential $\ell = 4n = 8$ (graphs plotted by C E Cedeño).

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