Article

Symmetry of galactic structure

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Abstract: It is hypothesized that due to mass-energy equivalence there exist transverse fields caused by energy flows that are analogous to gravitomagnetic fields generated by mass flows. Relativistically correct equations describing energy flow are derived by using the action integral of a Lagrangian and assuming that the properties of energy, when described four-dimensionally with time, are independent of the material system which supports them. The equations allow the electromagnetic and gravitational energy flows to be compared revealing an underlying symmetry of galactic structure.

Keywords: gravitomagnetics; mass-energy equivalence; quantum mechanics; relativity theory; symmetry; uncertainty; conjugate variables; time; non-inertial reference systems; causality

1. Introduction

It is not possible to make a direct comparison of gravitational fields to electromagnetic fields. Not only are they of vastly different strengths, but gravitational potentials do not share differences in polarity that are characteristic of electric charge. Despite glaring differences in their gross outward physical appearance, there are similarities that exist on a more subtle level. The kinetic flow of mass whether linear or rotational creates a transversely directed gravitational field that is analogous to the transverse magnetic field caused by current flow. The induced gravitomagnetic field, or force is directed perpendicular to the mass flow and has been used to explain properties of relativistic jets emanating from the cores of quasars and other active galactic nuclei [1]. It is postulated here that due to mass-energy equivalence an analogous transversely directed force also occurs in response to energy flow. However, the energy flow emanating from stars, galaxies, and other celestial objects is quantum mechanical in origin, which treats energy as an observable. We require a theory of the emission of radiation that is derived from first principles at the quantum level, treats energy as a flow rather than an observable, and exhibits transverse fields analogous to those of gravitomagnetics; in other words, a theory of quantum gravity.

The overriding difficulty in formulating a theory of quantum gravity is the need to resolve the differences between the discrete nature of quanta and the curved geometry of space-time. The solutions that have been proposed, such as string theory and loop quantum gravity, are not motivated by theoretical insight rather they are superficial attempts to explain at a fundamental level what appear to be irreconcilable differences. There is an underlying flaw to their introductory principles; however, because they are attempts to combine discrete aspects of nonrelativistic quantum mechanics with a relativistic theory of gravity that according to the equivalence principle *must treat space-time continuously*. Conflicting assertions about the relationship of atomic structure to space-time first emerged in experimental interpretations of more than a hundred years ago and have since evolved into a vast chasm dividing the work of theoretical physicists into two philosophical camps, or belief systems. To resolve these long-standing differences what is needed is not a new interpretation of old concepts, but a completely new physical model.

Soon after the Bohr model of the atom was proposed in 1913 the assumption was made that the effects of gravitational fields on an atom during the emission and absorption of radiation was so small that they could be neglected. At the time there were very few objections and no hard evidence to the contrary. The uncertainty principle was introduced upon further development of the quantum mechanical formalism providing "proof" and it contributed to the popular belief that a nonrelativistic formulation of quantum mechanics for atomic structure is both sufficient and complete. This caused the dynamic, classically inspired geometry of relativity theory to be set aside in favor of Hilbert space, an abstract complex linear vector space that is rigid. Because quantum theory is limited to applications in inertial systems there was no immediate need for it to be extended to non-inertial geometries. However, in recent years new and totally unexpected experimental techniques have been developed that can link 10,000 atoms in a lattice that functions as a single quantum oscillator and atomic clock [2]. This allows error due to thermal radiation to be essentially eliminated from studies of atomic structure and extremely precise measurements of time to be performed. Quantum oscillators of this type are able to detect differences in the earth's gravitational potential as small as one centimeter suggesting that time coordinates are to be treated the same as spatial coordinates with a different value at each point in space [3]. It means that the influence of gravity in the background space of quantum systems cannot be ignored and that in fact, *all systems of reference are non-inertial*.

2. Gravitational perturbation theory

It would be possible theoretically to study gravitational fields at the quantum level by the detection of gravitons, but an experimental procedure that is possible to perform in practice has never been developed. An alternate method is to study the behavior of physical systems at the quantum level by perturbing them with a barely detectable gravitational field. A light beam that alters direction under the influence of a gravitational field is an example of a "spatial perturbation". Another example occurs when a quantum oscillator, or atomic clock, changes its rate due to a slight difference in gravitational potential.

2.1. Gravitational perturbation of space

In general relativity theory the space-time geometry curves in response to the influence of matter immersed in it, which is thought to represent a background independent formulation. However, measurements are not performed in curved space-time. The curvature at any point is determined by measuring the angle of deviation with respect to an orthogonal set of measuring rods. It means that curved space-time geometry is falsely claimed to act as a "background" for quantum phenomena because it is itself mapped with respect to Euclidean space. An imaginary framework of orthogonally configured measuring rods is used in practice to determine how a gravitational field causes light rays to bend but it is then discounted as a simple calculational device. If the underlying flat space were nonexistent measurements could not be performed in practice and theory would become untestable.

Astronomers depend heavily upon the linearity of electromagnetic radiation in flat space-time in order to perform measurements over the vast expanses of empty space. Red shifts are used to determine the distance of luminous objects, their relative age, and the rotational velocity of galaxies. The time delay of laser beams is used to determine our distance from the moon. If even an infinitesimal non-linearity were present as, for example, tiny differences in the homogeneity of space, the speed of light, or the properties of intervening matter; the billions of years in transit time of starlight would amplify them making useless attempts to assemble and compare data obtained by different collection methods or with respect to distinct wavelengths. Although the linearity of electromagnetic radiation is used to perform astronomical measurements at accuracies far beyond our ability to quantify them, it is not used at all at the microscopic level. Methods of renormalization ignore linearity in their interpretation of the behavior of quantum systems as a sum over histories or path lengths, and the same is true for entanglement phenomena which dismiss linearity altogether for wave function collapse. Theories that ignore the linearity of light at the microscopic level are not consistent with macroscopically obtained astronomical measurements and the discrepancy needs to be resolved.

2.2. Gravitational perturbation of clocks

In experimental physics there is always a clear separation between the observed physical system and the measuring apparatus, and the same separation is present in quantum mechanical formalism where very different descriptions are used for the physical system and for measuring apparatuses. The physical system is described by its Hilbert space, where different possible pure states of the system are represented by unit vectors. On the other hand, different measuring devices are described by their corresponding Hermitian operators. Observables are measured by bringing a measuring device into contact with the physical system and different values of the observable are obtained depending on the state of the system. However, in quantum mechanics time measurements are performed without making contact with the observed physical system, a clock. So the time "measured" by clocks is not a quantum mechanical observable. It is just a numerical parameter, one of four coordinates, the same as in classical physics. Clocks are treated as measuring devices, but not as systems; a practice that developed due to the belief that measurements of a quantum system are performed by means of physical intervention and it persisted due to strict interpretation of the uncertainty principle.

It is not possible to use the absolute time of a single clock to perform measurements in non-inertial systems such as occur in gravitational fields. To compare physical systems with differing gravitational potentials we use two separate clocks, one as measuring device and another as system. Let a laboratory clock T_L that is fixed in space serve as measuring device and let a second movable clock T_S be introduced as physical system. The system clock T_S may be subjected to different gravitational potentials and then compared with the laboratory clock T_L to determine how the clock rate changes. Clocks placed in locations of higher gravitational potential speed up with respect to a stationary clock, while clocks in uniform relative motion slow down. Thus, the state of the system T_S is determined by its velocity and its gravitational potential, and measurements of the time coordinate with respect to T_L are performed without making physical contact with the system which is normal procedure for time measurements in both relativity theory and classical theory.

The same property of light that allows astronomers to measure the distance of objects at the edge of the universe can now be used to extrapolate to the very small dimensions of an atomic clock. The linearity of the radiation emitted by an atomic clock allows coordinate differences of an oscillating electron to be easily measured. Consider a well-known test for relativity theory using cesium beam atomic clocks. The clocks are flown around the world first in an eastward and then in a westward direction, and later compared to a laboratory clock fixed on the earth's surface [4]. The experiment demonstrates a slowing of clocks Δt_k that is greatest in the eastward direction of flight due to the earth's rotation and a speeding up of clocks Δt_g due to a decreased gravitational acceleration at higher altitudes. They are relativistic corrections to the time of the system clock T_S in the airplane and when summed they will equal the time on the atomic clock T_L in the laboratory. The corrections are due to the relative velocity and altitude of the airplane, so they occur simultaneously.

$$T_L = T_S - \Delta t_g + \Delta t_k \tag{1}$$

The frequency of the cesium atoms, $\Delta\nu_{Cs}$ = 9,192,631,770 Hz, *does not change* during the approximately one week duration, $\Delta T \approx 6\text{x}10^5$ s, of the flights. If Δt_k is neglected the speeding up of time Δt_g due to an increased gravitational potential causes the system clock T_S to record an elapsed time greater than that of T_L by $1.6 \text{ x } 10^{-7}$ seconds. Thus, the clock T_S ticks a greater number of times over the duration of the flight than the clock T_L.

Due to the equivalence principle gravitational time dilation is identical to time dilation caused by an accelerating frame. The effect of a perturbation of gravitational field on the coordinates of the clock frame may be calculated by comparing the proper time interval of the laboratory clock on the earth's surface with that of the clock in a higher gravitational potential. In the example cited, the clocks are compared at an initial event (X_1,Y_1,Z_1,T_1), and again at a second event when the flights conclude (X_1,Y_1,Z_1,T_2). Neglecting kinematic effects due to clock velocity, the proper time interval between the events may be expressed independently of the coordinates.

$$\Delta T = \int_{T_1}^{T_2} dt = T_2 - T_1$$

The classical interval ∆T, or time of flight of the airplane, may be subdivided into a series of infinitely small, identically constituted clock cycles of period τ that sum linearly.

$$\Delta T = \tau_m + \tau_{m+1} \quad . \quad . \quad \tau_{n-1} + \tau_n \tag{2}$$

The clock periods τ correspond to single ticks of the clock, complete cycles of a transitioning electron between excited and ground states. Each of them includes an infinitesimal correction with respect to the laboratory clock that when summed give the correction factor Δ_g in 1). The maximum correction for each clock cycle is calculated by dividing the correction factor by the approximate number of oscillations.

$$\Delta_g \big/ (\Delta T)(\nu_{C_s})$$

This corresponds to a path length of ct ⩽ 8.6×10^{-11} m a distance that is much smaller than limits set by the uncertainty principle due to the wavelength, $\lambda = 3.26 \times 10^{-2}$ m, which applies to the electron's position on the shell. It could be interpreted as a description of the wave function in physical space, or as the maximum thickness of the electron shell. Although we cannot measure the coordinates of an electron that accurately nevertheless that level of precision is necessary in order to explain time dilation in a gravitational field by applying the equivalence principle. Thus, relativity theory demands a precision in the structure of the cesium atom in terms of its surface, that is at least nine orders of magnitude greater than the uncertainty principle.

2.3. Determination of uncertainty by gravitational perturbation

An improved measurement was made of clock rate differences between optical atomic clocks separated by a difference in height of 0.33 m [5]. After 40,000 seconds of data the authors found that due to the difference in gravitational potential the clocks exhibited a "fractional frequency shift" of 4.1×10^{-17} cycles/second. The frequency shift corresponds to the difference in gravitational potential between electron shells. The atomic clock has a characteristic frequency of 1.121×10^{12} cycles/second so the fractional change in frequency for a single clock cycle is calculated as follows:

$$\frac{\Delta f}{f} = 3.6 \times 10^{-29}$$

This corresponds to a fractional shift in wavelength $\Delta\lambda$.

$$\Delta\lambda = \frac{\Delta f}{f} \times \lambda = 3.6 \times 10^{-29}(2.68 \times 10^{-2}\ m) = 9.6 \times 10^{-31}\ m$$

The fractional shift in wavelength represents an improved measurement of the minimum accuracy that atomic coordinates must have in order to reflect a difference in height of .33m. This is more than 29 orders of magnitude smaller than the uncertainty relation allows, since minimum uncertainty in position is given by the wavelength of the light.

Heisenberg defined uncertainty with respect to the size of an electron shell, its radius; whereas uncertainty calculated by gravitational perturbation refers to the maximum "thickness" of the shell. *Causality, which is denied by the uncertainty principle for singularities, is now restored for surfaces.* In other words, the surface of an electron shell is "blurred" an arbitrarily small amount even though its precise location within the atom is indeterminate by direct observation. The coordinate difference between electron shells in atomic clocks located at different gravitational potentials is immeasurably small for experiments performed on earth, and vanishes completely for inertial systems, but the coordinates themselves are an *intrinsic* feature of atomic structure that is called for by the linearity of light and is essential to an understanding of atomic structure.

3. Lagrangian quantum mechanics

3.1. Electron oscillation

The equivalence principle states that no observable distinction can be made between inertial motion and motion under the influence of a gravitational force. Experimental proof is provided by frequency shifts that occur while light is propagating in the earth's gravitational field that are measured in the laboratory [6]. They show that the laws of special relativity govern the propagation of light in all free-falling frames both microscopic and macroscopic. Therefore, the emission of light by an atomic clock is also subject to the equivalence principle and frequency corrections can be applied to it in terms of a local shift of coordinates in Minkowski space. Each of the periods in the series 2) includes an infinitesimal correction with respect to the laboratory clock. They correspond to electron transitions and sum together over classical intervals to give the amount of time dilation. From equation 1) and due to the linearity of light the electron of the quantum oscillator T_S oscillates at frequency $\Delta\nu_{Cs}$ with relativistic correction to *each cycle* $\Delta t(\dot{x})$ due to angular velocity relative to the center of the earth and correction to *each cycle* due to an acceleration of coordinates $\Delta t(\ddot{x})$ during the time period between ticks of the clock.

A spatially determined correction of electron coordinates is not possible inside an atom because atomic structure is an invariant. To apply the equivalence principle to the electron's path we treat the time and space coordinates equivalently. The necessary *manifestly covariant* equation describing photon emission uses time as a dependent variable and spatial coordinates as parameters. The correction factors for the classical interval ΔT in 1) can be extrapolated to the level of the quantum oscillator to obtain a differential equation for the variation of time with respect to space for *each cycle*.

$$f[t(x)] = \Delta t(\ddot{x}) - \Delta t(\dot{x}) \tag{3}$$

Where $\Delta t(\dot{x})$ represents a kinematical time dilation and $\Delta t(\ddot{x})$ represents a speeding up of time due to acceleration.

Hamilton's principle states that the differential equations of motion for *any* physical system can be reformulated as an equivalent integral equation. To obtain an integral equation from 3) we introduce the action integral S[**q**(t)], a functional, which takes a function of the velocities (the summed velocity of earth and airplane) and coordinates (gravitational potential) as input and returns a scalar.

$$S[q(t)] = \int_{t_1}^{t_2} L(\dot{q}(t), q(t), t)\, dt \quad = h \tag{4}$$

We interpret 4) in flat space-time as the evolution **q**(*t*) of a quantum system between the times of a complete cycle t_1 and t_2, where **q** represents the generalized coordinates. The generalized coordinates describe the electron in a configuration space consisting of three coordinates that define the origin, or nucleus, and three coordinates that define the manifold on which the electron is constrained to move in three-dimensional space (the electron shells). In other words, the quantum oscillator is described in configuration space as having six parameters, three for the nucleus and three for the electron shells, a total of six degrees of freedom.

We have an equation that accurately describes the behavior of an atomic oscillator with the coordinates of the electron during transition determined by the principle of equivalence. The electron's proper time interval varies with respect to its discrete initial and final events at t_1 and t_2, and its continuous motion between events as well. The endpoint of an oscillation is an event on an electron shell which also designates a tick of the clock. The time integral of the Lagrangian describes the dynamics of the atomic system, its action. By treating time symmetrically with the space coordinates a relativistic theory describing atomic structure is obtained that has both discrete and continuous aspects. The action S[x(t)] takes into account a gravitational potential $x(t)$ due to the electron's acceleration between the events t_2 and t_1, and a kinematic component $\dot{x}(t)$ due to its continuous motion. Two sets of coordinates are needed in the same equation because they occur simultaneously. Thus, atomic structure requires two complete four-dimensional space-times as a result of the equivalence principle; discrete coordinates that are devoted to the electron shells and continuous coordinates for an electron's transition.

The action integral describes the transition of an electron whose proper time interval varies due to gravitational acceleration and whose continuous fields $(\phi_i, \phi_{i,\mu})$ are subject to kinematic time dilation. It is characteristic of clocks in general to function continuously between discrete "ticks" when measuring time, so the equation 4) describes clock function at all levels, also classical. Solving for the action we obtain an equation describing single cycles of a quantum oscillator, which are the individual ticks of an ideal clock.

$$E\tau = h \tag{5}$$

3.2. *Field quantization*

We can also express the equations of motion derived in 3.1 as a quantization of field energy. Feynman expanded upon Dirac's suggestion to formulate quantum mechanics with a Lagrangian and used the path integral method to sum the contributions from all possible paths [7]. However, he did not comment on another of Dirac's ideas to describe quantum mechanics by using a Lagrangian density given by the fields and its first derivatives $L(\varphi_i, \varphi_{i,\mu})$ in a space-time region [8]. Nor did either of them apply their quantum mechanical models to an interpretation of a quantum oscillator. We will now pursue a description of energy emission in a field representation, where quantization is given by the action integral of a Lagrangian density.

Equation 4) shows that energy is not absorbed by atoms in discrete energy packets. Instead the atom quantizes energy by erecting field boundaries in response to a continuous superposition of fields. Emission follows with an electron located at the space-like potential $V_2(x_i)$ at time t_2 and ends in the ground state with exact potential $V_1(x_i)$ at time t_1. It is meaningless to speak of the "position of an electron" when describing atomic structure since there are an infinite number of possible departure and arrival points which specify a space-like locus of points. The equipotential space-like surfaces representing the locus of points of all possible electron positions in an excited state and a ground state are the electron shells, which we denote by R_2 and R_1. Ideally the surfaces would be spherically shaped, but they are unobservable in principle since the observation of surfaces demands simultaneous detections, which due to special relativity theory are not allowable. As noted, three degrees of freedom are necessary to locate an electron on the surfaces of the electron shells and three to describe its path through the intervening space. The wave function is inadequate because it has only three degrees of freedom to describe both the electron shell and motion between the shells.

We can use the surfaces R_2 and R_1 as integration limits to describe emission from an excited to a ground state as an action integral of the Lagrangian density between field boundaries, where the action $S[\phi_i(t)]$ is a functional. That is, it is a function of the values of the coordinates on the *discrete* boundaries of the space-time surfaces which are in turn a function of the *continuous* space-time variables of the fields within the surfaces. Space-time symmetry requires the discrete space-like coordinates and the time of emission to be exact yielding the following relativistic formulation of energy emission, a manifestly covariant transformation of fields that is the same for all observers.

$$S[\phi_i(t)] = \int_{R_2}^{R_1} \int_{t_2}^{t_1} L\left(\phi_i, \phi_{i,\mu}\right) d^3x\, dt = h \tag{6}$$

The end points of the electron's path are located on equipotential surfaces and the action minimum is not zero as in classical theory but h. Any trajectory is possible so long as it is consistent with these restraints. The unbounded transverse field energy from a laser is absorbed by a lattice of atoms, localized within four-dimensional field boundaries, and then emitted to produce a single clock cycle. Solving for the action we obtain the same result, $E\tau=h$, as in section 3.1. Thus, when energy is absorbed by an atom it is localized between two space-like equipotential surfaces and is subsequently released as a photon. The emission equation 6) gives both the discrete and continuous aspects of time, an important difference with the equations of nonrelativistic quantum mechanics where the wave function is defined continuously in time.

In the relativistic equations 4) and 6) the excitation energy is quantized during absorption, but *before* emission. It means that a physical separation exists between the matter and energy of an excited state. An electron does not receive, or absorb energy when it is excited, rather excitation causes field boundaries to be erected that localize energy within the atom and create a "bound" photon. In fact, the existence of locally autonomous photons within an atom has been demonstrated in experiments referred to as "the phenomena of slow or stopped light" [9]. The storage and retrieval of light are achieved for up to one minute in a rare earth element by converting light coherence in free space to atomic coherence in an excited state and back again. The atom establishes discrete field boundaries that localize energy, while the transverse fields contained within them vary independently and are continuous in time. Nonrelativistic quantum mechanics describes this process by the time independent Schrödinger equation,

$$E\Psi = \hat{H}\Psi$$

where $\hat{H}$ is the Hamiltonian operator and E is the energy of the state. Although it is true that the wave function Ψ contains "all the information that can be known about a system", the reason why is only made apparent by taking into account the experimentally observed phenomenon of "stopped light". Photons, momentarily captured in excited states, are hidden from the view of observers since field boundaries prevent fields from being detected until after the photon is released, so even though the wave and particle properties of a photon cannot be simultaneously observed in free space, both are present in localized states.

4. Transformation of gravitational field energy

Existing attempts to unify the gravitational and electromagnetic fields seek to derive equations to determine the behavior of test particles in a combined field with the conjugate variables position and momentum. Yet we know that real unification already exists in nature as embodied in the structure of electrons and other particles, which exhibit both fields. Rather than address the issue of unification from the view of particle properties we seek equations that use the conjugate variables energy and time. They are physically equivalent descriptions and may be used in place of position and momentum to obtain an alternative view of the emission and absorption of radiation. The time evolution of electromagnetic fields is classical with fields that begin in free space as linear potentials and spontaneously transform into a field source, the photon, with distinct field geometry. We are motivated to adopt the same method as a way of describing the time evolution of gravitational potentials in free space by hypothesizing that the laws of energy apply equivalently. Fundamental to the arguments is the assumption that the laws of energy in nature are universal.

4.1. General relativistic time

We wish to describe gravitational fields classically as a time evolution of fields that begin in free space as linear potentials. Time evolution has different meanings as it is used in quantum mechanics and general relativity theory. The time variable is given by the ticks of a clock in the former by using atomic clocks and the linearity of light as measurement standards, while the latter gives the proper time independently of clocks. Clocks are undefined in general relativity theory because Einstein believed that "measuring rods and clocks would have to be represented as solutions of the basic equations" [10]. Although he was unable to extend the equations to incorporate clocks or measuring rods we can see how differences between theory and practice originate by looking at the Einstein equation defining the local curvature of space-time.

$$G_{\mu\nu} = \kappa T_{\mu\nu} \tag{7}$$

Time and clocks are treated in a fundamentally different way by this equation. Time is continuous on the left side in the form of proper time, with clocks and measuring rods present as ideal test bodies. If clocks, or matter of any type is present in significant amounts it must be placed on the right side due to contributions of mass and energy. Thus, continuous time exists throughout all of space-time whether or not clocks are present, while clocks are functionally distinct because they are described by the discrete ticks of a clock. The equation lacks symmetry because there can be ideal clocks on either side, but real clocks are only allowable on the right.

4.2. Universal properties of energy

In classical theory we treat energy as a simple physical variable or property of matter and it is possible to use the same unit of measurement, joules, to measure all of its forms. Since only quantitative comparisons are possible in the measurement of joules the universal properties of energy are under appreciated or ignored. This is understandable in the case of classical interactions since systems are not precisely defined. Nevertheless, we see the same practice in quantum mechanics where energy is described as an observable in the Schrödinger time independent wave equation. Because each of the myriad forms of energy is conceived of separately with its own independent properties, we cannot compare them with each other. This is true despite the fact that universal properties of energy do exist. Energy conservation and energy equipartition, for example, have never been known to fail at any level of analysis whether microscopic or macroscopic. As noted in in the study of atomic clock experiments it is possible to isolate a quantum system from the environment when describing the transformation of electromagnetic field energy into matter. Gravitational systems in the form of galaxies are centers of energy emission and absorption naturally isolated from the environment and it should therefore be possible to compare the way they transform energy with that of a quantum system despite their vast physical differences. *It is thereby postulated that the properties of energy, when described four-dimensionally with time, are independent of the material system which supports them.*

4.3. The transformation of gravitational field energy

The four-dimensional evolution of gravitational fields may be demonstrated by constructing a model for a gravitating body that has slowly changing mass-energy density. We begin with a uniform distribution of hydrogen atoms, a simple form of clock, in free space distant from each other. Both proper time and clock time are determined in Minkowski space-time and the gravitational field intensity of the system at infinity is found by simply summing particle masses. Now let the attractive force of their mutual gravitational field cause them to slowly coalesce into a spherical body such that particle momenta remain small. Due to the equivalence of mass and energy gravitational field intensity is determined by summing particle masses and binding energy, the energy required to remove particles to infinity. The period of clocks slows and Minkowski space-time is replaced by a Riemannian metric that is described by the Einstein tensor $G_{\mu\upsilon}$. An attempt to use space-time curvature to describe material structure would be unacceptable because it would place the continuous time of curvature on a more fundamental basis than the ticks of a clock, a quantum mechanical phenomenon. A continuous background space cannot be used to replace a discrete phenomenon.

Accumulating atoms will cause an increasing gravitational pressure that generates heat and the emission of black body radiation, early signs of star formation. Eventually the Coulomb repulsion of the atoms is overcome by gravitational attraction in the form of a pressure gradient, protons are attracted to each other due to the strong force, and fusion initiates spontaneously in the star's core. The left side of 7) interprets the star formation process as a continuous change in metric from Minkowski space to a Riemannian manifold with constant proper time; but on the right side there is a slowing of clocks and a corresponding dilation of proper time. After accumulating matter over a time period of several billion years proper time slows to zero on a spherical surface, the event horizon, and a black hole forms with discrete time ($\Delta t=0$). We may refer to the event horizon therefore as a boundary condition with a space-like surface and singular clock time.

4.4. Gravitational emission equation

In equation 6) we described the localization of electromagnetic field energy and photon creation four-dimensionally, using space-like field boundaries and discrete times. The localization of gravitational field energy is also characterized by the formation of a space-like field boundary, the horizon, with discrete time. The similarity between the energy flow of photon creation and the energy flow of black hole formation can be extended to show a formal relationship. The Tully-Fisher relation correlates the luminosity and rotation velocity of galaxies [11]. If the luminosity of a complete revolution is calculated together with a galaxy's period of rotation τ then the Tully-Fisher relation may be compared to the quantization of electromagnetic fields, $E\tau=h$. The assumption that the laws of energy apply universally in nature allows an equivalent equation, $E\tau=H$, to be formulated for the transformation of gravitational field energy, where H is the gravitational equivalent of Planck's constant. Thus, an increased galactic emission energy, or energy flow will correspond to a higher rotational velocity and a lower period of rotation.

It is a short step from postulating that the Tully-Fisher correlation represents the solutions of an emission equation to obtaining the equation. The action integral $S[\Phi_i(t)]$ of a galaxy is a functional. That is, it is a function of the values of the space-like coordinates on an event horizon R which are in turn a function of the continuous space-time variables of the matter within the surface, where integration is performed over all space.

$$S[\Phi_i(t)] = \int_R^{\infty} \int_0^{\tau} L\left(\Phi_i, \Phi_{i,\mu}\right) d^3x \ \ dt = \mathbb{H} \tag{8}$$

The existence of an emission equation governing galaxy energy flow suggests that galaxy structure is the manifestation of a field emanating from a supermassive black hole that consists of a radial component Φ_i due to baryonic mass causing gravitational attraction and transverse components $\Phi_{i,\mu}$ of as yet undetermined origin within the event horizon causing rotational acceleration. The forces are mapped on a flat background space in a reference system whose origin resides at the center of the black hole. The equations 8) and 6) are equivalent with respect to energy-time conjugate variables since both include radial and transverse components. The fact that the emission equations are mathematically equivalent demonstrates a symmetry that is absent from theories that postulate the existence of an unobserved form of “dark” matter.

The interdependent nature of the conjugate variables should now be clear. We use the position and momentum variables of test particles to map local configurations of the electric, magnetic, and gravitational fields. The energy and time variables, on the other hand, are used to describe *non-local, globally determined* coordinates both in space, as manifested by the space-like surfaces of electron shells and black holes, and in time by the formation of galactic structure over time periods that potentially span the life of the universe. Descriptions by the conjugate variables energy and time are complementary to those of position and momentum since neither one excludes the other; and in fact, both are necessary for a complete understanding of the natural laws.

5. Conclusion

The gravitomagnetic field when coupled with mass-energy equivalence has great heuristic value for interpreting the physical significance of energy flow in non-inertial frames such as occur in celestial bodies where direct measurement is not possible. Equations formulated with a time variable that is *symmetrical with space* allows the absorption and emission of radiation to be described relativistically as a continuous flow, rather than using diagonalized energy states with time as an independent background through which states evolve. Additional symmetry of the physical model is realized because the manifestly covariant action integrals 4) and 6) are formulated with the conjugate variables position-momentum (p,x) and energy-time (E,t) respectively. This allows both the axially aligned relativistic jets of galaxies and their transverse rotational accelerations to be interpreted with the gravitomagnetic model that uses continuous translations of coordinates according to the equivalence principle. The fact that rotational acceleration in spiral galaxies has been observed to be directly proportional to intensity supports that hypothesis [12].

Quantum mechanics as presently formulated is *incompatible* with the continuous transformation of coordinates required by the equivalence principle and gravitomagnetic phenomena. It is only applicable in celestial mechanics at locations where it is possible to approximate an inertial frame, such as at the event horizon of a black hole.

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