

# Diffusion Gravity: An Heuristic Model

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## I. Abstract

The evidence from quantum vacuum research suggests that virtual particles may play a much larger role in gravity than previously attributed. Far from being an empty “stage” or blank slate, the vacuum is an active agent in the transmission of energy (photons), and therefore should also serve as the active medium through which gravity works. The model presented here integrates key concepts of an active quantum vacuum and the fundamental physical process of mass diffusion to provide a prime motivator of gravity as well as the key mechanism for the gravitational force.

## 2. Introduction

Fundamental forces of nature work from *differences* and the tendency of nature to level those differences. The most studied of these is heat and thermodynamics, for the obvious reason of employing and extracting useful work from those differences (Laws of Thermodynamics) to power modern society. Entropy, i.e. the second law, can even be construed as a *force*, as proposed by Erik Verlinde, for motivating his alternative theory of *emergent* gravity [1]. In a similar way, laws of mechanics employ another fundamental “leveling” *force* of nature: Mass Diffusion. The laws governing this force are attributed to Fick [2][3], who developed the formalism as to how concentration or mass differences can drive processes to do useful work. Some previous research on gravity as it might integrate with diffusion models was published by Britten [4][5] in “A Gravitational Diffusion Model without Dark Matter “ (1997), however, that model proposed coefficients of diffusion primarily for long range as an alternative to dark matter at galactic scale.

Retracing to Newton’s Laws, the prime mover for gravity is mass, but there is no mechanism to explain the forces described. As he originally formulated those laws, Newton admitted that he had “no hypothesis” as to the causality or how the aether might mediate the force. Einstein subsequently in special relativity explicitly denied that the vacuum was anything other than a void with his famous statement “The introduction of a ‘luminiferous ether’ will prove to be superfluous” [6]. But research and experiment have since shown that the vacuum is an active medium and that quantum fluctuations and Virtual Particles (VP’s) are the processes and players within it. More recently, advanced research [7] about the light propagation mechanisms has postulated that virtual particles, i.e., virtual fermions, can in fact be the transmitting *agents* of photons, i.e., a mechanism for transmission of electromagnetic energy through the vacuum. This work suggests that the quantum vacuum and virtual particles are nature’s completely efficient means of transmitting energy and could likewise be the most efficient means of transmitting gravity. The model proposed herein employs this concept, i.e., that virtual particles can be the transmitting *agents* of gravity through the vacuum, without themselves transmitting any matter or consuming any energy. The difference is important; the medium of the vacuum and virtual particles can act as carriers of the *direction and density* of the source mass object, which are the essential *information* for gravity to affect a destination mass object. Diffusion from the source mass through the vacuum provides the motive power to propel the virtual particles, with their corresponding information, toward the destination or affected mass, where the virtual particle flux from the source mass interacts with the destination virtual particle flux, to generate a resultant of net diffusion of direction and density, which manifests as a gravitational force between the source and destination.

Schematic concept of Diffusion Gravity

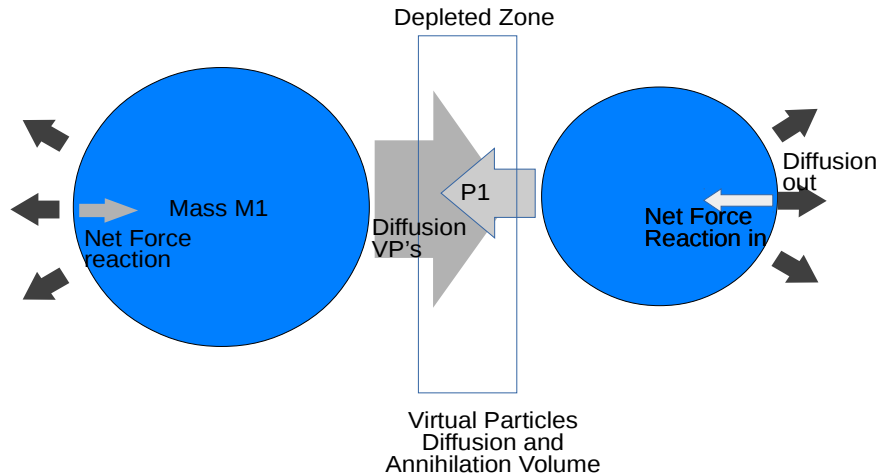


Figure 1 Schematic Model for Diffusion Gravity

The critical mechanism of this model explains where, when and how the diffusion process delivers the gravitational information via virtual particles, and how this leads to the interaction force between two mass objects. Mass diffusion processes in general occur at an interface between two different concentrations (i.e. density gradients) of materials that provide useful work or desired outcomes. For gravity to work, the diffusion process from both masses occurs between the objects at and around the balance point P1, where VP's mix and annihilate with the VP's of opposite directions and densities. This “depleted” VP volume at the interface creates a difference in virtual particle concentrations between the near face and the far face of each mass object; diffusion has thus created an imbalance between the flux of the near sides and far sides of the masses, which results in a reactive inward force on the outer sides of the masses, due to the larger relative outward VP diffusion on the far faces of the affected masses. The net result is the force of attraction between the two masses. See schematic diagram Figure 1.

The model of diffusion gravity presented here offers a straightforward approach by applying Fick's law for diffusion and equating the diffusion flux to Gauss' law flux for gravity, to arrive at an equivalent expression for diffusion gravity “flux” of virtual particles. The sections that follow will develop this concept into the heuristic model of diffusion gravity, and then discuss possible verification experiments. VP's as carriers of the gravitational *information* relieves physics of the “action at a distance” conundrum, and provides an actual physical process of diffusion that implements the attractive force without transmission of actual matter or energy.

Assumptions must be made prerequisite to this Diffusion Gravity model. This mitigates ambiguities in terminology or about details of the background physics.

(1) Virtual particles are well known and accepted mediators of processes and are necessarily required for the physics of quantum electrodynamics as well as quantum field theory.

(2) Diffusion is a fundamental physical process that operates on *virtual* as well as *real* particles, and follows the known laws of diffusion from classical physics.

(3) All matter is surrounded by its own gravitational potential field of virtual particles, in proportion to its mass. This is equivalent to the gravitational potential  $V$  of the Newtonian model.

(4) Virtual particles themselves supposedly do not gravitate like ordinary matter, see Rafelski in [8][9][10], but in this diffusion gravity model, they gravitate in a *time-averaged collective* sense, as limited by the Uncertainty Principle and known quantum mechanical probabilistic behaviors. The model assumes the instantaneous sum of all VP's within the gravitational potential field of an object will equal one half the mass of the object (the average  $\hbar / 2 = \Delta p \Delta x$ ).

To be clear on the Diffusion Gravity mechanism model, it is useful to contrast standard physical theories which require propagation of matter and energy of electrons and photons, in their true material sense, to this concept of **information transfer** which modifies the quantum vacuum around matter. The distinction between the roles of real particles and virtual particles in gravity is the critically unique idea of the Diffusion Gravity Model.

### 3. Diffusion Gravity Model Description and Explanation

The proof of virtual particles' existence, and more importantly the dependence of modern physics on the existence of VP's has been firmly established over many decades. A current discussion of the reality of virtual particles is provided in Jaeger [11] and more generally in Genz [12]. Quantum Electrodynamics (QED) and Feynman diagrams are the foundational framework and instantiation of virtual particles as developed by Feynman in 1949 [13]. Along with the discovery of Casimir Effect [14], as experimental confirmation, the existence of virtual particles is now indisputable, as well as indispensable to modern physics, whose explanations depend on the mechanisms of virtual particle dynamics. Some current theoretical examples are referenced, such as light-by-light scattering [15] and other quantum phenomena which depend on Dirac positron-electron pair production from photons. Cosmology as well as modern quantum physics regularly invoke and require virtual particles as inherent components of theory and experiment, for which examples are referenced [16][17].

#### a. Virtual Particles Background and Vacuum Behavior, production and diffusion of VP's

A mass object emits virtual particles continuously, with a flux proportional to its mass (Figure 2). The flux of virtual particles for an object surface is given by Gauss' law of gravitation:

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

where  $\mathbf{g}$  is the gravitational acceleration. This equation expresses the fact that the Gaussian flux through an enclosed surface is proportional to the gravitational constant  $G$  and the density  $\rho$  out of the surface regardless of its shape. A primary assumption in the formulation of this model is that the flux of the gravitational field out of the surface is equal or proportional to the virtual particle flux out of the surface. Setting the virtual particle flux  $J$  equal to the flux of diffusion according to Fick's Law, in which density and density gradient are the prime movers,

$$\nabla \cdot \mathbf{g} = J = -D \frac{d\rho}{dx} \quad (2)$$

where  $D$  is the diffusion coefficient and  $d\rho/dx$  is the density gradient, or concentration gradient within the diffusing material. The flux-diffusion equation of virtual particles then becomes

$$J = -4\pi G\rho = -D \frac{d\rho}{dx} \quad (3)$$

Combining terms, the flux to mass ratio  $J_{FM}$  becomes

$$J_{FM} = - \frac{D}{4\pi G\rho} \frac{d\phi}{dx} = \kappa \frac{d\phi}{dx} \quad (4)$$

where the critical parameters are the gradient  $d\phi/dx$  and the density  $\rho$  of the VP flow out of the mass. The coefficient of diffusion  $D$  is included with the gravitational constant  $G$  in this overall coefficient  $\kappa$ , but these may in fact need to be normalized with units of measurement and time.

The vacuum functionality as a *light* transmission medium consisting of virtual particles has been presented by M. Urban et al. in reference [7] and also has important linkage to classical electromagnetism as shown in [18]. The findings of that research are closely related to the concepts of this gravity model, since Urban's theory leverages the characteristics and behavior of the *transmissive* quantum vacuum, and postulates how ephemeral VP's can convey *photon energy* across the vacuum in a cascade, or relay fashion.

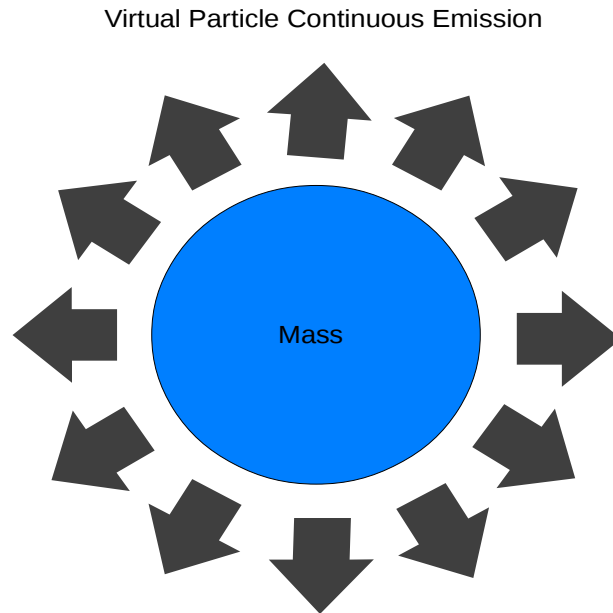


Figure 2: Virtual Particles are continuously emitted by masses in proportion to their mass

### **b. Inertia and the Virtual Particle vacuum: Motion and Diffusion**

The Diffusion Gravity model postulates that the vacuum around an object also plays an active role in the inertia of the object. For constant velocity, the forward motion diffusion of VP's is equal to the trailing diffusion of VP's. Inertia follows from this concept, with the diffusion zones (front volume and trailing volume) storing the energy and momentum of motion. Figure 3 illustrates the principle of inertial constant velocity within the diffusion gravity model. The large arrows indicate the diffusion of the ambient virtual particles from the environment into the emitted virtual particles from the mass

object. The volumes of mixing are the diffusion volumes, characterized by their gradients from high concentration of virtual particles to the ambient levels of virtual particles. This manifests normally as the gravitational potential of the object at any point in space around it, and conforms with the standard Newtonian model of gravitational potential

$$V = \frac{Gm}{r} \quad (5)$$

If a mass is moving with constant velocity, the continuous flow of VP's from the moving mass diffuses into ambient VP's of the background. The diffusion is uniform and symmetrical, so the inertia of the moving mass then is a result of the diffusion of VP's from the object, which interact with the background to form a foreshortened envelope of VP's on the forward side, and a depleted or elongated envelope of VP's on the trailing side. The schematic for this is provided in Figure 3. This inertia model for diffusion preserves the Newtonian Third Law, as it applies for constantly moving, or stationary objects. VP Diffusion for constant velocity completely "balances out" in the vacuum reactive space around the moving mass.

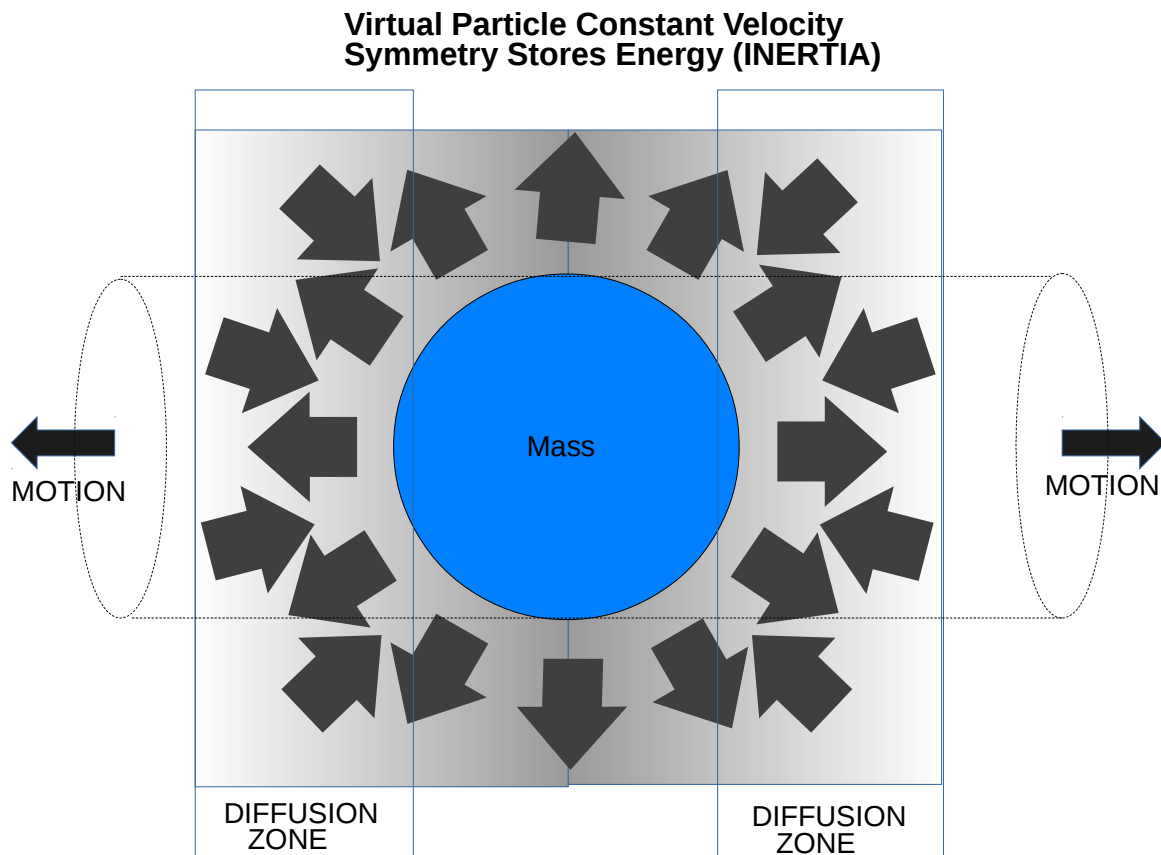


Figure 3 Diffusion Virtual Particles for Constant Velocity

In the forward and rear diffusion zones, equation (4) becomes, upon integration over forward and trailing cylindrical volumes  $V_f$  and  $V_t$

$$\int_{V_f} J_{FM} dV = \int dA \int J_{FM} dx = \pi \kappa R^2 \int d\phi$$

$$\int_{V_t} J_{FM} dV = \int dA \int J_{FM} dx = -\pi \kappa R^2 \int d\phi$$

where  $R$  is the radius of the spherical mass. Hence the sum of the forward and trailing contributions is

$$\int_{V_f} J_{FM} dV + \int_{V_t} J_{FM} dV = 0 \quad (6)$$

The diffusion with balanced forward motion to trailing motion can also be expressed with the Laplace equation for the moving object and the enclosed total potential field around it:

$$\nabla^2 \phi = 0 \quad (7)$$

Thus the diffusion gravity model completely explains **constant velocity**; moreover, it accounts for the inability to shield gravity, as investigated by Majorana [19]. Any mass placed in a diffusion gravity field will allow the field to pass through unmodified by virtue of the above equation (6) for constant velocity, or for zero velocity.

### c. Acceleration and the Virtual Particle Vacuum: Acceleration and Diffusion

Building on the previous model concepts, the paradigm can now be extended to acceleration and gravity. The essential mechanism of diffusion for constant velocity relies on symmetry of the forward and trailing zones of diffusion of the virtual particles from the ambient VP background to the VP field of the mass under consideration. Acceleration differs from constant velocity, in that the diffusion zones in the forward and trailing volumes are *NOT* symmetrical, i.e., the forward volume of diffusing VP's is compressed while the trailing volume is elongated, producing a net difference. This important net difference provides the motive power to the mass object, with the force on the object quantifiable by the asymmetry of the diffusion between front and trailing volumes. The propulsion force is a reaction force out of the trailing side of the mass object by virtual particles emitting from the mass object, expressed by the usual Newtonian second law  $F = ma$  in an unbalanced flow between diffusion of the forward volume and the trailing volumes. A pictorial representation of this concept is provided in Figure 4. The acceleration  $a_{net}$  is the net diffusion volume difference between the trailing and forward diffusion zone volumes,  $V_t$  and  $V_f$  respectively, and is given by

$$a_{net} \propto \int_{V_f} J_{FM} dV + \int_{V_t} J_{FM} dV \neq 0 \quad (8)$$

This volumetric difference is the resultant of vectoral summation of the source and ambient virtual particles, which carry the information about the mass and direction of the object through the vacuum environment of ambient virtual particles.

$$\Delta Vol \propto a_{net}$$

$$a_{net} = K_{diffusion} \Delta Vol \tag{9}$$

where  $K_{diffusion}$  is an undetermined constant relating net diffusion to acceleration. Essentially the net acceleration expressed in this model is the “storage” of energy during acceleration, by the ambient vacuum and VP agents within that volume. Acceleration, then, in this diffusion gravity model is a product of both the mass and the net VP flux that infuses the vacuum around it. The net acceleration flux for the net VP volume is given by Poisson’s equation for sources,

$$J_a = \nabla^2 \phi \tag{10}$$

where  $\phi$  is the gradient density function within the net acceleration volume. The quantity  $J_a$  is also equal to the gravitational flux  $-4\pi G\rho$  for the net acceleration volume, and

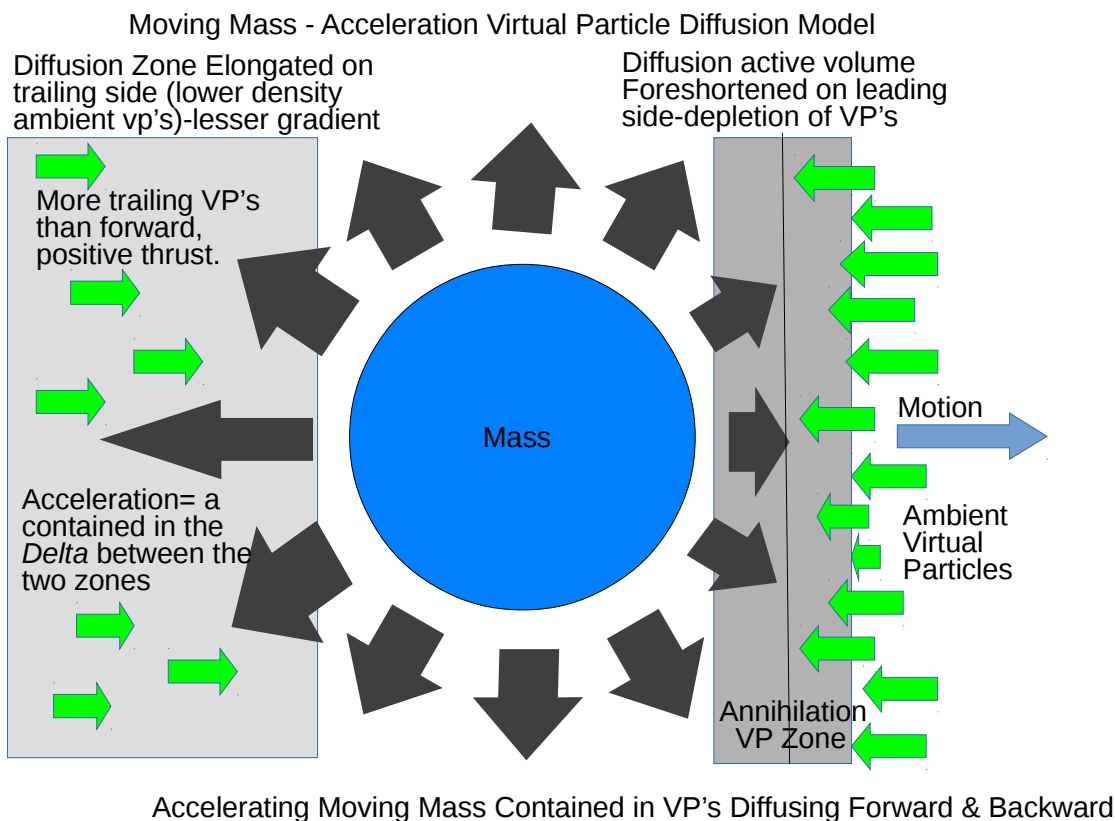


Figure 4 Diffusion Gravity Acceleration Mechanism

$$\nabla \cdot \mathbf{a}_{net} = -4\pi K\rho dV \quad (11)$$

This basic concept of a virtual particle diffusion *differential* from a mass object as the cause of acceleration is the consequence of the sum of virtual particle density gradients in the forward and trailing volumes or diffusion zones around the mass. VP Diffusion is powered by and caused by gradients of virtual particles within a particular volume. No other energy from the mass object is contained beyond the gradient of the concentrations of the virtual particles. Compressed gradient in the forward volume of diffusion amplifies the diffusion, and quickens the cancellation of the virtual particles between the mass object and the ambient vacuum virtual particles, while the elongated trailing volume gradient reduces the diffusion force between ambient VP's and the VP's emitted from the mass, and therefore results in *greater* relative emission flow from the trailing surface.

**d. Gravity from Mass and the Virtual Particle Vacuum**

The models presented in the previous sections can now be combined to show that the acceleration provided by virtual particle diffusion can be, and in fact *is* gravity. The same mechanism works in the sense of a gravitational field as it does for an accelerating mass object. This is readily illustrated in Figure 5, showing acceleration as it applies to any motion, e.g., falling body in a gravitational field.

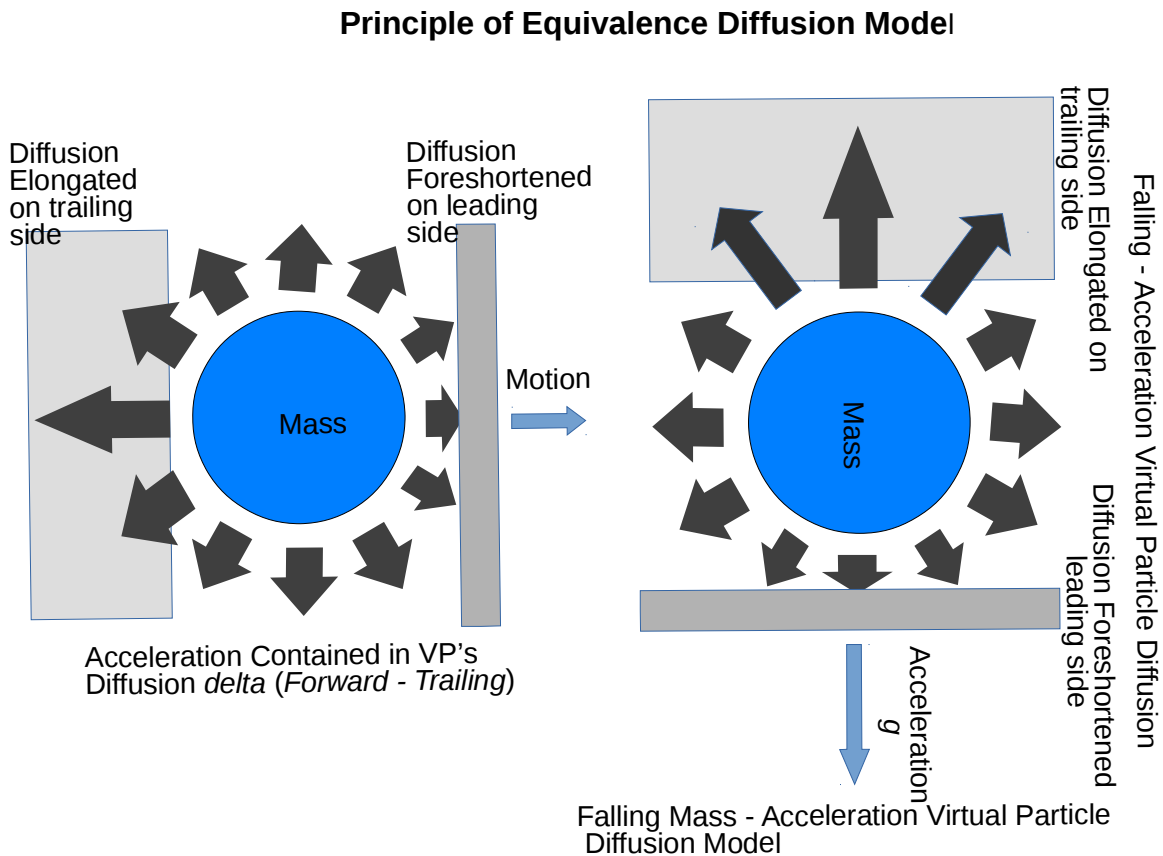


Figure 5 Principle of Equivalence Diffusion Model



This model presents the equivalence principle as a clear consequence of the Diffusion Gravity acceleration mechanism, in the context of the quantum vacuum and VP's, which are the agents of the Equivalence Principle originated by Planck and Einstein [20, Chapter V]. This model then logically leads to the principle of gravity, and gravitational acceleration. As far as the Diffusion mechanism shown applies to acceleration, no difference would be manifest between the sources of acceleration, whether from earth's gravitational potential gradient or any other propulsion source.

#### **e. Diffusion Gradient and the Force-Acceleration Relation**

The principle mechanism for acceleration in this model is diffusion of virtual particles. The gradient, which is the prime mover of diffusion, equals the gravitational gradient of potential. Both of these are differential concepts and signify or embody the essential natural phenomenon of entropy – that nature is constantly “acting” to equalize differences. The obvious similarity to the thermodynamic laws is applicable to gravitational acceleration and to any mass acceleration. The Diffusion Gravity model presented herein could lead to approaches toward greater control of gravity through the diffusion mechanism. The proof of concept experiment might place some diffusion interruption or enhancing device or object at the Lagrange point L1 or opposite side of the small mass at L2, such that gravity is perturbed enough to create a measurable effect at those points.

#### **4. Experimental history and Future Investigation**

Past experimental results provide a starting point for further research. The Casimir Effect demonstrates the reality of the virtual particle vacuum, as it produces macroscopically measurable effects in the laboratory. Other research in the early 20<sup>th</sup> century by experimental physicists such as Majorana [19] included extensive experimentation searching for the mechanism that drives gravity, but they were not able to progress without the knowledge or proof of virtual particles, although they suspected something of that nature, hypothesizing “fluxes out of masses” concepts. One valuable contribution was the discovery that gravity cannot be “shielded”, which shows that the vacuum and virtual particles cascade through and around intervening objects to transmit the gravitational information without attenuation, as shown in section 3b above. In defense of those earlier efforts, the Casimir Effect and behavior of VP's were unknown at that time (around 1920). The development of quantum mechanics and “microphysics” provided the insight into the quantum mechanics and the mechanisms of virtual particles as active mediators in the vacuum.

The discovery of the Casimir Effect in 1948 was an important contribution to quantum vacuum research that supported much of quantum mechanical theory and quantum electrodynamics. Exhaustive research has been conducted since then by many efforts and experiments; some notable efforts include Peter Milonni (LANL)[21] and Steven Lamoreaux (Yale Wright Lab)[22]. Highly accurate measurements and detailed studies have refined the understanding of the Casimir Effect, and empirically confirmed the existence of virtual particles. Alternative explanations for the Casimir Effect by Daniele Sasso show how gravity may account [23] for the effect, i.e., that the diffusion gravity model may also apply to that phenomenon, instead of the accepted electromagnetic wave/particle depletion between plates explanation. Experiments employing the Casimir effect could quantify the ambient VP levels, and whether they vary diurnally or lunar phase-wise. Such an experiment would enhance the understanding and discrimination of purely diffusion gravity effects from the unique Casimir attraction.

Related gravitational experiments and research on gravity effects, such as the Allais Effect [24] and the controversy of whether pendula are affected during an eclipse, have been inconclusive. Diffusion gravity by virtual particles might be the active agent affecting pendula during an eclipse event, such as a full solar eclipse when the virtual particle stream from the sun is briefly disturbed; however, the question is whether a pendulum, no matter how carefully conditioned, is sensitive enough with nearly constant velocity and small acceleration and deceleration, to detect any diffusion gravity VP's changes.

A more precise Casimir plate experiment may be needed to discern the fine diffusion changes that would be of *second order* within the volume enclosed by the plates:

$$\Delta J = -D \frac{d^2 \phi}{dx^2} \quad (12)$$

Another experimental direction for diffusion gravity is the characterization of the quantum vacuum at and around a gravitational Lagrange point L1. The experiment would use the Casimir Effect or sensitive gravimeters to measure the depletion of VP's at or near the L1, where the continuous streams of VP's from masses diffuse and annihilate. In a related experiment, measurement on opposite sides of earth (diurnal variation) could detect the VP flux differences according to the model presented herein. This would be a measurement of the VP ambient levels in earth's surrounding vacuum, to see if the levels change at night, or with the phases of the moon. Saxl did extensive experimentation in the 1950's after Allais, and reported some repeated diurnal and other variances in his pendulum experiments [24], resulting from meridian transits of moon and sun.

In summary, previous experiments have focused on the gravitational perturbations of pendula, and on refinement of Casimir effect measurements, but without the perspective of diffusion as an integral mechanism for gravity. Further sensitive measurement of perturbations of gravity during eclipse events with sufficiently sensitive instrumentation will clarify the existence of diffusion gravity. On a larger scale, diffusion gravity flows from the galactic center and the sun would presumably be large enough for variations in the local vacuum environment to be measured.

## 5. Diffusion Gravity Implications for General Relativity and Physics

The diffusion gravity model proposes alternative explanations via *information agent* virtual particles together with the diffusion laws to further the understanding of gravity. Diffusion may be controllable or modifiable in the vacuum. Diffusion gravity and its instantiation of an integrated *virtual* and *real* medium has implications for revisiting the operational concept of the aether. This simple model also implies possibilities for explanations of other physical phenomena that have been heretofore mysteriously accounted for by space-time, extra dimensions, dark matter, and other theoretical constructs that are unverifiable at the microscopic level. For instance, V.P. outflows from masses causing gravitational potential which drives the physical manifestation of gravity could augment, explain, or even obviate GR metric theory as the underlying physical origin of gravity. The impact of virtual particle diffusion as the underlying physical cause can completely change the perspective from large scale universal gravitation to a more local solar system phenomenon of gravity. The vacuum may vary across the galaxy and at larger scales, thus producing different gravitational and light transmission effects.

Implications for GR as a model for the greater cosmos could be even more important than those for the local quantum vacuum. Extensions of the diffusion model may provide answers for the great questions of our time, such as dark matter and dark energy. Further research on these and corresponding model proposals will follow in subsequent research papers and reports.

## 6. Conclusions

The Diffusion Gravity model presented here provides a mechanism for gravity without invoking theoretical "gravitons" as force mediator bosons. Instead the *information* about the mass or masses is "virtually" carried through the vacuum by virtual particles, conveying the density and direction of the gravitating masses by the process of diffusion. These VP agents are generally virtual fermions as the most common particles of matter, but may include other virtual particles as well. The virtual particle summation, and corresponding cancellation point of the gravity fields is thus established between the

objects. This model depends on a continuous stream of virtual particles emerging out of the mass objects, to cause gravitational potential, as shown in Figure 2,. Diffusion of these virtual particle streams produces the gradient which manifests as the *gravitational force*. Continuous streams of VP's from massive objects do not transfer momentum or energy — only *information*, but these virtual diffusion flows of information *do* result in the gravitational forces between masses. All the model concepts presented herein have been developed through research and investigation into the realm of the quantum vacuum and virtual particles as the underlying mechanisms of natural phenomena.

This model presentation is intended as an entry point for further experiments and elaboration of the mathematical model and details thereof. There is an heuristic opportunity to understand gravity more thoroughly, and even further to address the larger cosmic picture of the universe. The objective is to revise the current models of physics, so we can progress from the currently becalmed state in which physics finds itself. Despite the trillions of dollars spent on science research, the world has scant results to show for all this resource expenditure toward understanding the fundamental phenomenon of gravity.

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