# Two-Scale Three-Phase Regular and Irregular Shape Charged Particles (Electrons, Photons) Movement in MHL Electromagnetic Fields in a Vacuum0 (Aether)

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**Abstract:**

This publication is devoted to a topic that is a venerable and at the same time has been a great arena for research for many decades. That actually means that the governing equations even for a relatively homogeneous range of particles characteristics and physics involved has not been created yet to the extension allowing for lecturing the field to undergraduate students.

We are delivering here the techniques, some fundamentals of theories, and methods applied for the two-scale description of the sub-atomic particle (real particles - not point-like) arrays dynamics in electromagnetic fields. That topic is intriguing in a way that it describes the used physical mechanisms for the field force acting on particles. The much known and advanced in many sciences force field method, formula by Lorentz is known for many insufficiencies.

Nevertheless, as an example and as the very known and applied Lorentz EM force field formula is used for creation of the governing two-scale dynamic equations (adding, of course, the electrodynamics involved, in this case of the Maxwell-Heaviside-Lorentz electrodynamics) for a volumetric charged particle(s) aiming this development first of all for the subatomic particles movement application. One more feature in this work is that the action-at-a-distance is not allowed without the medium as the second phase being present in the volume. For that medium is used the aether while its properties have been at serious physical studies for more than a century, at least.

Key words: *Polyscale physics; Electron; Electrons in Vacuum; Photons; CMBR; Aether; Heterogeneous media; Averaging theories; HSP-VAT; Multiscale; Polyscale modeling; Collective interaction; Electrodynamics; Heterogeneous electrodynamics; Sub-Atomic modeling; Particles model; Elementary particles dynamics; Gauss-Ostrogradsky theorem; WSAM theorem; Scaleportation.*

## 1. **Introduction**

We would like, for many reasons, to keep referring to the medium that infiltrate all the materials' forms around, in environment, and known to exists and to be believed by physicists in old times as an aether.

For the strictness of exposition of known and coherently explained and modeled within the paradigm of simultaneous  Polyscale-Polyphase-Polyphysics (3P) physical entities and modeling them as a set of related concepts, 3P theories has been suggested as the needed one the concept of intermediate medium - an aether. The long range interaction can not be provided, executed via the real emptiness, real nothing.

That is known for centuries that physicists always considered the presence of some intermediate substance and called it an aether. That is a partial explanation, also because at the beginning of XX century there was no understanding and no of physics and mathematics polyphase, heterogeneous methods. So, physicists couldn't even approach that kind of problems. The vision for heterogeneous media physics need had appeared later in the time of WWII for the tasks related to nuclear weaponry and nuclear power.

Returning back to the many centuries fundamental acceptance of aether existence immediately stands the question that physicists of XX century couldn't approach and solve: Any medium with the aether recognized is being meant having at least of two "phase" medium - one is the aether itself and another is what is put in the problem at the beginning of study (at least one medium for even homogeneous medium).

Meanwhile, since the 80th of XX the two-phase problem began started formulation and solution as the two scale two phase statements - that is the real sense of the two-phase physics [ 1-18].

Most of these improvements can be referred to the proper, stricter treatment of collective, interactive phenomena while taking heterogeneous matter for study. To this kind of phenomena/changes we can relate almost any action or process more complicated than collision of "mathematical" ball onto the "mathematical" wall, or movement and collisions of two "mathematical" balls, meaning particles, atoms or molecules in MD.

In all other nature prescribed cases the physical matters are of scaled or multiscale character by existence.

***There is no substance of physical content in our known universe that is not a heterogeneous one.***

***Also, in physics there is no action or process that we can name a local one, unless we want to. Otherwise, we have to look into the point and what it means more strictly.*** Obviously, many actions or processes can be separated from their less important, at the moment or case, surroundings or/and forces. But that is always more or less an artificial choice.

In this paper we assured to be concerned to the multiscale, heterogeneous, nonlocal and nonlinear properties mostly of the atomic and sub-atomic scales group ~ $(10^{-17} \div 10^{-9})$ m.

For these ~9 orders of decimal magnitude the conventional homogeneous one scale physical theories provide mostly for the approximate or even ad-hoc adjusting mechanisms for the two-scale Bottom-Up scale communication, and that mode is to be re-entered in the current paper from the Bottom-Up and Top-Down interscale transport (communications) point of view. That says the connections of the scale inherited fields are of great significance/importance. We previously studied thoroughly in many sciences (fields) the contemporary homogeneous physics theories for heterogeneous matter and these reviews are referred below.

The strictest definition for the different scale related fields communication - transformation we suggested in 2004 as the ***Scaleportation***.

Scaleportation is the means and procedures of the direct and strict "transformation" of data and processes at one scale to the data and processes of the neighboring Upper or Lower Scale. These interscale communications, scale transformations of data are performed mostly not by formulae using the coefficients as this is customary in homogeneous physics, but via using the interscale governing equations for the phenomena.

Scaleportation has being performed over the all our two-scale solved the HSP problems mentioned in this text and in the website - http://www.travkin-hspt.com, as soon as the simulation methods that have been based on the algorithms of analytical (exact) or numerical methods created for the direct Bottom-Up (BU) or Top-Down (TD) two-scale solutions.

It might help with the understanding of our approach to the more strict physically and mathematically description of many subjects of Heterogeneous, Scaled, and Hierarchical nature, made by nature itself from the atomic, molecular scale that the some knowledge of HSP-VAT (Hierarchical Scaled Physics - Volume Averaging Theory) can be of assistance.

## 2. Fundamentals of the HSP-VAT Theory in Application to Particle Physics

Some principal provisions, conceptual definitions, concepts of scaling matter related to the subject of Particle Physics collective interaction of the arrays of Sub-atomic particles and modeling of Heterogeneous particulate media of the two, at least, phase (components) as scaled media we have been placed in a few manuscripts and publications - one is the easiest to reach is at [19-27].

### 2.1 Introductory to Polyphase Description in Particle Physics and Related Technologies

*2.1.1 Hierarchical Scaled Volume Averaging Theory (HSVAT) introductory mathematical notions and theorems*

The basic idea of hierarchical medium description and modeling is to recognize that the physical phenomena, mathematical presentation of those phenomena, and their models can be very different at even neighboring scales. In most of situations those are different even if phenomena themselves are similar or looking as identical, but the scales are different and the lower scale features should be transported to the upper level of description (or Top-Down). With that action, the useful information from the lower scale physics would be added to the characteristics on the upper scale level.

The following definitions were used in 1980-2010s in heterogeneous media theories as well as at the earlier times for other sciences dealing with the scaled heterogeneous problems.

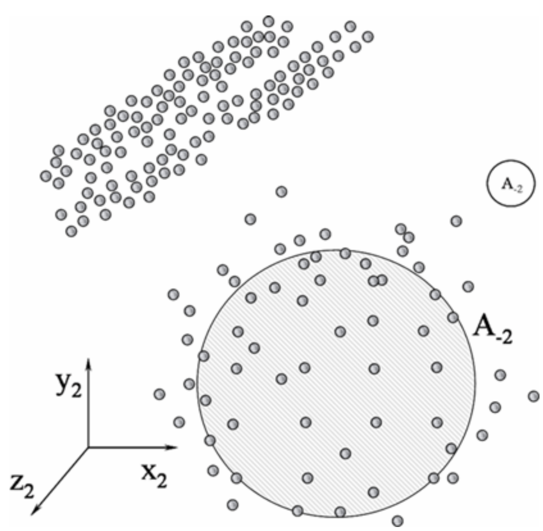


**Figure 1.** Representative Elementary Volume (REV) REV in space (heterogeneous medium) with the continuum particles and the aether as intermedium. The shape (volumetric form) of the REVs can be not only of spherical one. Mathematical modeling and simulation are supposed to be performed on both scale spaces with the mathematical statements that complicate formulation and numerical (analytical) calculation of the physical field distributions.

The volume average value of one phase in a two phase medium $\langle s \; (\mathbf{x}) \rangle$ in the REV and its fluctuations in various directions, its main physical and mathematical needs, definitions are determined, for example, in [2-10] at first looking simple

$$s_1(\vec{x}) = \left\langle s_1(\vec{x}) \right\rangle + \hat{s}_1(\vec{x}), \qquad \langle s_1 \rangle = \frac{\Delta\Omega_1}{\Delta\Omega}.$$

The three types of two-phase medium averaging over the REV (Figure 1) function $f$ are defined by the following averaging operators arranged in the order of seniority

$$\langle f \rangle = \langle f \rangle_1 + \langle f \rangle_2 = \langle s_1 \rangle \tilde{f}_1 + (1 - \langle s_1 \rangle) \tilde{f}_2,$$

where the phase averages are given by

$$\langle f \rangle_1 = \langle s_1 \rangle \frac{1}{\Delta\Omega_1} \int_{\Delta\Omega_1} f\left(t, \vec{x}\right) d\omega = \langle s_1 \rangle \tilde{f}_1,$$

$$\langle f \rangle_2 = \langle s_2 \rangle \frac{1}{\Delta\Omega_2} \int_{\Delta\Omega_2} f\left(t, \vec{x}\right) d\omega = \langle s_2 \rangle \tilde{f}_2,$$

and the two internal phase averaged functions are given by

$$\{f\}_1 = \tilde{f}_1 = \frac{1}{\Delta\Omega_1} \int_{\Delta\Omega_1} f\left(t, \vec{x}\right) d\omega,$$

$$\{f\}_2 = \tilde{f}_2 = \frac{1}{\Delta\Omega_2} \int_{\Delta\Omega_2} f\left(t, \vec{x}\right) d\omega,$$

where $\tilde{f}_1$ is an average over the space of phase one $\Delta\Omega_1$ in the REV, $\tilde{f}_2$ is an average over the second phase volume $\Delta\Omega_2 = \Delta\Omega - \Delta\Omega_1$, and <f> is an average over the whole REV. There are also important averaging theorems for averaging of the spatial operator - heterogeneous analogs of Gauss-Ostrogradsky theorem. Those are plenty of already since 70-80s [1-10,16-18,21-27]. The first few of them are needed to average the field equations are the WSAM theorem (after Whitaker-Slattery-Anderson-Marle) and the one is for the intraphase $\nabla$ averaging. The differentiation theorem for the intraphase averaged function reads

$$\{\nabla f\}_1 = \nabla \tilde{f} + \frac{1}{\Delta\Omega_1} \int_{\partial S_w} \hat{f} \, \vec{ds}_1 \ ,$$

$$\hat{f} = f - \tilde{f}, \quad f \,\forall\, \Delta\Omega_1,$$

where $\partial S_w$ is the inner surface in the REV, $\vec{ds}_1$ is the second-phase, inward-directed differential area in the REV ( $\vec{ds}_1 = \vec{n}_1 dS$).

The WSAM theorem sets the averaged operator $\nabla$ in accordance with

$$\langle \nabla f \rangle_1 = \nabla \langle f \rangle_1 + \frac{1}{\Delta\Omega} \int_{\partial S_{12}} f \, \vec{ds}_1 \ .$$

It can be shown that for the invariable morphology (<m>=const) of the medium the operator $\{\nabla f\}_1$ can be presented also as

$$\{\nabla f\}_1 = \nabla\{f\}_1 + \frac{1}{\Delta\Omega_1}\int_{\partial S_w} f\,\overrightarrow{ds}_1,$$

when <m>=const. Meanwhile, the foundation for averaging made, for example, by Nemat-Nasser and Hori [28] (and many other authors) is based on conventional homogeneous Gauss-Ostrogradsky theorem (see pp.59-60 in [28]), not of its heterogeneous analogs as the WSAM theorem.

The following averaging theorem has been found for the **rot** operator

$$\langle\nabla\times\mathbf{f}\rangle_1 = \nabla\times\langle\mathbf{f}\rangle_1 + \frac{1}{\Delta\Omega}\int_{\partial S_{12}} \vec{ds}_1\times\mathbf{f},$$

and as a consequence, the theorem for the intraphase average of ($\nabla\times\mathbf{f}$) is found to be

$$\{\nabla\times\mathbf{f}\}_1 = \nabla\times\{\mathbf{f}\}_1 + \frac{1}{\Delta\Omega_1}\int_{\partial S_{12}} \vec{ds}_1\times\widehat{\mathbf{f}}.$$

The averaged time derivative according to transport theorem forms in the heterogeneous medium the following mathematical equation for a phase one, for example, is

$$\left\langle\frac{\partial f}{\partial t}\right\rangle_1 = \frac{\partial}{\partial t}\langle f\rangle_1 - \frac{1}{\Delta\Omega}\int_{\partial S_{12}} (\mathbf{V}_s f)\cdot\vec{ds}_1,$$

where vector $\mathbf{V}_s$ is the velocity of the interface surface $\partial S_{12}$.

At present, the models of transport phenomena in heterogeneous media when using the HSP-VAT allow to treat media with the following features: 1) multi-scaled media; 2) media with non-linear physical characteristics; 3) polydisperse morphologies; 4) materials with phase anisotropy; 5) media with non-constant or field dependent phase properties; 6) transient problems; 7) presence of imperfect interface surfaces; 8) presence of internal (mostly at the interface) physical-chemical phenomena, etc.

*2.3.2 Hierarchical Scaled Volume Averaging Theory (HSVAT) Operating Lemmas*

When the interface is fixed in space the averaged functions for the first and second phase (as liquid *f* and solid *s*, for example, or two-phase solid) within the REV and over the entire REV fulfill the following conditions, namely

$$\{f+g\}_f = \{f\}_f + \{g\}_f, \qquad \{a\}_f = a,$$

for the conditions of steady state phases

$$\left\{\frac{\partial f}{\partial t}\right\}_f = \frac{\partial\{f\}_f}{\partial t}, \qquad \left\{\tilde{f}\,g\right\}_f = \tilde{f}_f\,\tilde{g}_f,$$

where $a$ - a constant, except for the differentiation condition $\left\{\nabla f\right\}_1$ and $\left\langle\nabla f\right\rangle_1$, that is as written above in the two forms.

There is an important difference in the definitions of averaged and fluctuation values in regards of their meaning and values in the REV comparing to definitions supported by Whitaker and co-authors see, for example, in [6,9-16,29-31]. The treatment and interpretation of the averaged values inside of the REV are supported in the classical interpretation when a value, considered as an averaged inside of the Lower scale REV volume, is still the constant value within the same initial ground scale REV the assigned representation point $\mathbf{x}^u$ for the Upper scale description space. The more detail on that problem are given in [6,9-11]. These methods are supported and verified by the exact two--scale solutions that have been able for performing because of that.

Some clearance to this difficult issue brings the concepts and formulation of the scaled problems in the two or more scales.

The **intrinsic type** of averaging $\left\{f\right\}_f$ fulfill all **four** of the above conditions as well as the following **four consequences**

$$\left\{\tilde{f}\right\}_f = \tilde{f},\quad \left\{\hat{f}\right\}_f = \left\{f-\tilde{f}\right\}_f = 0,$$
$$\left\{\tilde{f}\,\tilde{g}\right\}_f = \tilde{f}_f\,\tilde{g}_f,\quad \left\{\tilde{f}\,\hat{g}\right\}_f = \tilde{f}_f\,\tilde{\hat{g}}_f = 0.$$

At the same time, $\left\langle f\right\rangle_f$ and $\left\langle f\right\rangle$ do not fulfill neither the second of the averaging conditions for $\left\{f\right\}_f$, with equalities

$$\langle f+g\rangle_f = \langle f\rangle_f + \langle g\rangle_f,\qquad \langle a\rangle_f \neq a,\quad \langle a\rangle_f = \langle m\rangle a,$$

while for the stationary morphology spatial volumes

$$\left\langle \frac{\partial f}{\partial t}\right\rangle_f = \frac{\partial\langle f\rangle_f}{\partial t},\qquad \left\langle \tilde{f}\,g\right\rangle_f = \tilde{f}_f\,\langle g\rangle_f,$$

nor the consequences of the other averaging conditions

$$\left\langle\tilde{f}\right\rangle_f = \langle m\rangle\tilde{f},\Rightarrow \left\langle\tilde{f}\right\rangle_f \neq \tilde{f},\quad \left\langle\hat{f}\right\rangle_f = \left\langle f-\tilde{f}\right\rangle_f = 0,$$
$$\left\langle\tilde{f}\,\tilde{g}\right\rangle_f = \langle m\rangle\tilde{f}_f\,\tilde{g}_f,\Rightarrow \left\langle\tilde{f}\,\tilde{g}\right\rangle_f \neq \tilde{f}_f\,\tilde{g}_f,$$
$$\left\langle\tilde{f}\,\hat{g}\right\rangle_f = \tilde{f}_f\,\langle\hat{g}\rangle_f = 0.$$

More detail on the non-local VAT procedures and governing equations for different physical problems modeled in homogeneous media by linear mathematical physics equations can be found in publications [16-18,26-27,29-31] and many other. Meanwhile, features depicting closure, nonlinear theory, polyphysics applications, polyscale developments, exact solutions, etc.

can be found only in the works like [6,9-18,19-27,32] and in the website http://www.travkin-hspt.com.

## 3. Particle Physics and Sub-Atomic Scales Electrodynamics

### 3.1 The Aether Phase in the Sub-Atomic Scales Electrodynamics

We would like, for many reasons, to keep referring to the medium that infiltrate all the materials' forms around, in environment, and known to exists and to be believed by physicists in old times as an aether.

For the strictness of exposition of known and coherently explained and modeled within the paradigm of simultaneous Polyscale-Polyphase-Polyphysics (3P) physical entities and modeling them as a set of related concepts, 3P theories has been suggested as the needed one concept that includes an intermediate medium - an aether. The long range interaction can not be provided, executed via the real emptiness, real nothing.

That is known for centuries that physicists always considered the presence of some intermediate substance and called it an aether.

Many, if not any researcher on aether conclude that the aether has a structure and that it has to be with - "one feature of the aether, one overlooked by Clerk Maxwell and all those who did pursue their 19th century models of aether. The aether conveys electromagnetic waves. Those waves have a lateral oscillation, meaning that they wriggle sideways in their forward progress as does a snake." (Insisted by Aspden, in his "The Heresy of the Aether" [33]).

Meanwhile, what is not known to any devoted educated and even highly qualified researcher of aether is that the structure features of aether demanding the recognition that aether is the Heterogeneous medium, and as such needs to have rather different treatment as a physical medium than that these researchers are able to employ for the purpose at the current moment.

The pretty important is the fact that electromagnetic "waves" is actually rather mathematical, but not physical characteristic of electrodynamics in any medium. Electromagnetism is the feature and quality belonging to electromagnetic particles and a medium in which those particles are distributed and/or moving through. There is no so called "electromagnetic" field without charges and a media. Media itself cannot create the "electromagnetic" field.

That means when researchers are saying or treating the "electromagnetic" field - they treat the mathematical implementations of charges that are moving within the media [34-42]. What kind of charges and how they create the "electromagnetic" field, we will discuss below in the text of this manuscript.

Some researchers of aether, for example [43], think that aether is the viscous, compressible fluid-like medium. Nevertheless, other worker [44] does not agree with this and considers that

"....Ether is presented as an all-pervading medium consisting of particles of two equal but opposite in sign, species. Ether has a certain electromagnetic density and elasticity."

"Established facts and phenomena suggest that the ether is a specific medium, fundamentally different from the liquid and solid media." "One of the most remarkable properties of ether is that it has no resistance to a uniform movement."

In the studies [45,46] profoundly shown inconsistencies in electrical engineering (conventional MHL electrodynamics) without existence of aether. That is, even in practical usage of conventional electrical engineering when experimentally verified rules (laws) - it is obvious the need of an aether as intermediating medium.

We are studying the possible characteristics of aether on the basis of Heterogeneous structure of aether itself. We rest in this development on the unspecified mechanical structure of aether and take it as a still medium with electromagnetic and some of continuum mechanics known properties. Also, we do not support the simplistic definition of electron, other sub-atomic particles as the swirls of aether itself. We don't have evidences of that; otherwise it's just one of frivolous convenient conjectures.

## 3.2 Electron and Photon as Volumetric particles

There are many, not only of Conventional Orthodox Homogeneous Physics (COHP) authorship, theories of sub-atomic particles. In this text we are first of all interested in theories where the sub-atomic "elementary" particles are treated as the volumetric objects with the substantiated properties, with their models where the established in physics doubtless features are present in the volumetric particle models.

We found those also. Among them we mostly are interested in theories that have some connection to faultless other areas of physics. For example, when person develops the volumetric theory for an electron and at the same time talking about QM and/or QFT or QED - it is the clear sign that this person is of not enough qualifications in physics, because he supports obsolete or simply approximate or wrong theories in COHP.

We will add here some text and basics for including that in models for electron and photon specifically into the details of particle physics. Nucleus is not to be engaged in this section into the specifics of particle physics or nuclear one. We just want to have ability to simulate our most unusual terms in governing equations on the Upper scale where the continuum electrodynamics is being formulated.

The great reason for seeking the volumetric models of sub-atomic particles is that in this way the tight connection of sub-atomic electrodynamics with the dynamics of particles themselves and with the overall collective Bottom-Up and Top-Down scaleportation of some properties, may be the substantial part of all characteristics is clearly on the table.

The problem with the dynamics of sub-atomic particle is that their momentum equations are insufficient in COHP even at the lower scale governing equations with the short-handed Lorentz force model that is working for more than a century and brought in during this period many problems in particle and general physics. At the same time, the COH physics itself can not average any equation of the sub-atomic phenomena by its own internal inability.

We would start in the current theory with the theory of structured electron and photon mostly following the developments by Ph.M. Kanarev in particle and atomic physics those we have found as the most advanced at this time in physics see, for example [34-42].

Then we proceed to physics of electron arrays and photon arrays based on the HSP-VAT methods for Maxwell-Heaviside-Lorentz and Galilean electrodynamics where the electron arrays dynamics (not the molecular dynamics (MD) of homogeneous physics) ***can be explored with a mathematical rigor***, while we accept the ideas and vision of the nature of one and numerous electrons (photons, atoms) in the determined volume. Those issues are different than in COHP explained hydrogen physics, for example, phenomena, while the hierarchical scaled approach allows contemplating the known phenomena at present at each scale of considered physics, homogeneous and/or heterogeneous.

For example, if in scaled physics the electron arrays should be and can be undoubtedly considered as the number of electrons, not a cloud of mathematical mass-points, in the aether, in the medium, not in the vacuum that has, nevertheless, the electrodynamics properties? If a medium is empty - means nothing inside of a volume, it should not have any properties by the logical and philosophical definitions. How the nothing can have internal properties?

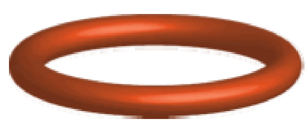

**Figure 2**. Electron in 3D - shown without the surficial movements and magnetic momentum and a spin, that is following

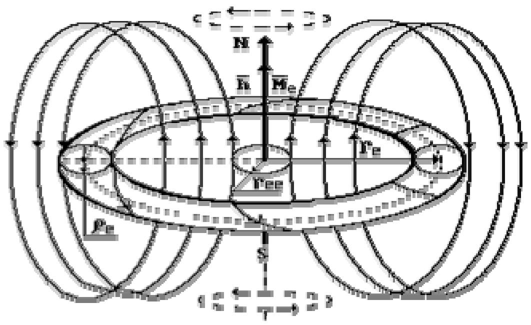


**Figure 3**. Electron in an aether - Kanarev, Ph.M. [37,40,41]

Then, we are concerned to the never correctly considered problem (well, it was considered either simplistically or bluntly incorrect regarding the mathematics and physics statement), of what are the properties of such an array if it is still or moving in space (aether) while particles (electrons, protons) explicitly have dynamics or due to initial impulse or due to external electromagnetic fields (while this definition of electromagnetic field needs to be specified additionally to get to more strictly and openly stated meanings), when even the governing equations are written incorrectly, with unrecognizable simplifications.

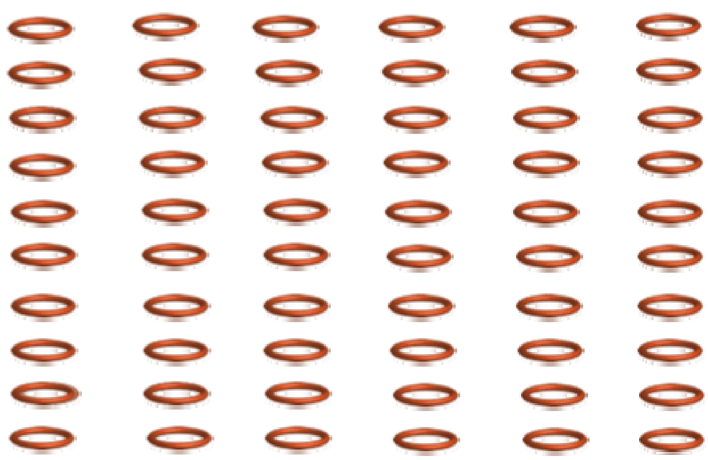

**Figure 4**. An array of ordered electrons in space.

To theorize and model this array the COHP methods are artificial, so the modeling of particles swarm in particle accelerators, for example, is pretty simplified because can not be Upscale averaged, while the dynamics equations are incorrect themselves.

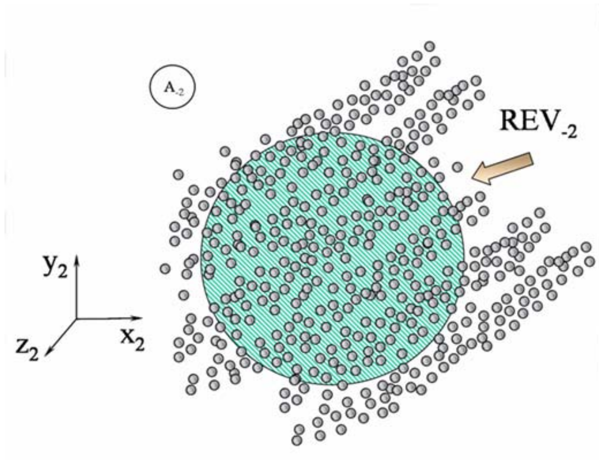


**Figure 5**. An array of photons in space dynamics - two-scale modeling reveals the wave character of some dynamics regimes.

### 3.3 Lower Sub-Atomic Scale Maxwell-Heaviside-Lorentz (MHL) GE in SI

Now we provide the set of Maxwell-Heaviside-Lorentz (MHL) GE in SI with the current $\mathbf{j} \neq 0$, and charge distribution $\rho \neq 0$ for a vacuum (aether) and moving charge point-like particles as for the homogenized mixture with sources (electrons, for example) as it is described in GOHP textbooks when $\mathbf{j} \neq 0, \rho \neq 0$:

in the (**e-b**) pair before averaging (real) for the upper scale governing EM equations

$$\nabla \cdot (\mathbf{e}) = \frac{\rho_{ch}}{\varepsilon_0}, \ \nabla \cdot \mathbf{b} = 0,$$

$$\nabla \times \mathbf{b} = \mu_0 \varepsilon_0 \frac{\partial \mathbf{e}}{\partial t} + \mu_0 \mathbf{j}, \quad \mathbf{j} = (\rho_{free} \mathbf{v}_{free} + \rho_{bound} \mathbf{v}_{bound}),$$

$$\mu_0 \varepsilon_0 = \frac{1}{c_0^2}, \quad \mathbf{b} = \mu_0 (\mathbf{h} + \mathbf{m}), \ with \quad \mathbf{m} = \mathbf{0},$$

$$\nabla \times (\mathbf{e}) = -\frac{\partial}{\partial t}(\mathbf{b}),$$

These might be also compared to the pure vacuum0 MHL equations in (**e-b**)

$$\nabla \cdot \mathbf{e} = 0, \qquad \nabla \cdot \mathbf{b} = 0,$$

$$\nabla \times \mathbf{b} = \left(\frac{1}{c_0^2}\right) \frac{\partial}{\partial t}(\mathbf{e}), \quad \nabla \times \mathbf{e} = -\frac{\partial}{\partial t}(\mathbf{b}).$$

### 3.4 Averaging of the MHL Governing equations at the Sub-Atomic Scale in SI

The common view pseudo-averaged matter in an aether (vacuum0) linear Maxwell-Heaviside-Lorentz (MHL) Homogeneous Electrodynamics Governing Equations are:

the Gauss's law equation

$$\nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0},$$

the Faraday's law of induction equation

$$\mathrm{rot}\mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t},$$

the conservation of magnetic induction B equation

$$\nabla \cdot \mathbf{B} = 0,$$

and the Ampere-Maxwell law equation

$$\mathrm{rot}\mathbf{B} = \frac{1}{c_0^2}\left[\frac{\mathbf{j}}{\varepsilon_0} + \frac{\partial \mathbf{E}}{\partial t}\right], \quad c_0^2 = \frac{1}{\mu_0 \varepsilon_0},$$

then we can write that

$$\nabla \times \mathbf{B} = \mu_0 \mathbf{j} + \frac{1}{c_0^2}\frac{\partial \mathbf{E}}{\partial t}.$$

As soon as conventional homogeneous physics states that this set of equations is the most accurate we can use it for writing the 3-phase MHL equations for aether-electrons-photons in a volume - as the MHL EM sub-atomic media (Lower scale) GEs in SI:

where in the aether phase EM MHL GE (Lorentz style) in the (**e-b**) pair

$$\nabla \cdot (\varepsilon_0 \mathbf{e}_0) = 0, \quad \nabla \cdot (\mathbf{b}_0) = 0,$$

$$\nabla \times (\mathbf{b}_0) = \frac{1}{c_0^2}\frac{\partial}{\partial t}(\mathbf{e}_0),$$

$$\nabla \times (\mathbf{e}_0) = -\frac{\partial}{\partial t}(\mathbf{b}_0),$$

$$\mu_0 \varepsilon_0 = \frac{1}{c_0^2}, \quad \mathbf{b}_0 = \mu_0(\mathbf{h} + \mathbf{m}), \text{ with } \mathbf{m} = \mathbf{0},$$

plus the electrons phase - for a one electron the MHL similar GEs ( the coefficients are taken just by analogy - no real physics at present time can be provided regarding the internal properties and function of electron, apart of some surface of electron properties and some sizes)

$$\nabla \cdot [\varepsilon_1 \mathbf{e}_1] = \langle \rho \rangle_1 = e,$$

$$\nabla \cdot (\mathbf{b}_1) = 0,$$

$$\nabla \times (\mathbf{b}_1) = \frac{1}{c_1^2}\frac{\partial}{\partial t}(\mathbf{e}_1),$$

$$\nabla \times (\mathbf{e}_1) = -\frac{\partial}{\partial t}(\mathbf{b}_1),$$

plus the photons phase, the great number of photons with their local scale ($10^{-15} \div 10^{-10}$) m fields ( the coefficients are taken just by analogy - no confirmed real physics now can be provided about the internal properties of photons, but physical models by Kanarev [38,40-42], Klushin [47-49], some other personalities, apart of some surface of photon properties (hypothetical and some sizes) advanced by Kanarev [38,40-42]

$$\nabla \cdot [\varepsilon_2 \mathbf{e}_2] = 0, \quad \nabla \cdot (\mathbf{b}_2) = 0,$$

$$\nabla \times (\mathbf{b}_2) = \frac{1}{c_2^2}\frac{\partial}{\partial t}(\mathbf{e}_2),$$

$$\nabla \times (\mathbf{e}_2) = -\frac{\partial}{\partial t}(\mathbf{b}_2).$$

These equations according to COHP are the best for the description of sub-atomic scales electrodynamics, but not for the interior of electrons and photons that considered in COHP as the point-like particles - so, no volume for "phase" equations. Meanwhile, many characteristics of electron and photon's "exterior" surfaces are actually assessed and known even at current moment [39.40].

Notes, that the whole litany regarding the "speculative" like formulation of electrodynamics for the phases of electron and photon is not worthwhile the piece of paper for its placement - because it is still of much better justification then numerous artificial constructions of QM and QF theories. As of, for example, particle is the wave - wave-particle famous "duality." That is not of physical reality. That is of experiments wrong interpretation. Interpretation that is based on the point-like volumeless nature of particles and other forced imaginable features, while methods of HSP-VAT allows to have the data reduction on the two-scale base - that is the essence of most experiments.

Pretty important is that the equations of particles momentum should be assessed and taken into the whole set of governing equations.

Averaged equations of aether, electrons and photons combined electrical fields

$$\nabla \cdot [\varepsilon_0 \langle m_0 \rangle \widetilde{\mathbf{e}}_0] + \nabla \cdot [\langle s_1 \rangle \varepsilon_1 \widetilde{\mathbf{e}}_1] + \nabla \cdot [\langle s_2 \rangle \varepsilon_2 \widetilde{\mathbf{e}}_2] +$$
$$+\varepsilon_0 \frac{1}{\Delta\Omega} \int\limits_{\partial S_{0p}} (\mathbf{e}_0) \cdot d\vec{s}_0 + \varepsilon_1 \frac{1}{\Delta\Omega} \int\limits_{\partial S_{p1}} (\mathbf{e}_1) \cdot d\vec{s}_1 + \varepsilon_2 \frac{1}{\Delta\Omega} \int\limits_{\partial S_{p2}} (\mathbf{e}_2) \cdot d\vec{s}_2 = \langle s_1 \rangle ne,$$

when

$$\langle \mathbf{E} \rangle = [\langle m_0 \rangle \varepsilon_0 \widetilde{\mathbf{e}}_0 + \langle s_1 \rangle \varepsilon_1 \widetilde{\mathbf{e}}_1 + \langle s_2 \rangle \varepsilon_2 \widetilde{\mathbf{e}}_2], \mathbf{E} = (\varepsilon_0 \mathbf{e}_0 + \varepsilon_1 \mathbf{e}_1 + \varepsilon_2 \mathbf{e}_2),$$

where $n$ is the mean assessed quantity of electrons in the $\Delta\Omega$

Finally

$$\nabla \cdot (\langle \mathbf{E} \rangle) + \frac{1}{\Delta\Omega} \int\limits_{\partial S_w} (\mathbf{E}) \cdot d\vec{s} = \langle s_1 \rangle ne = \langle \rho \rangle_1.$$

Further the averaged magnetic induction equation combined when

$$\langle \mathbf{B} \rangle = \left[ \langle m_0 \rangle (c_0 \varepsilon_0) \widetilde{\mathbf{b}}_0 + (c_1 \varepsilon_1) \langle s_1 \rangle \widetilde{\mathbf{b}}_1 + (c_2 \varepsilon_2) \langle s_2 \rangle \widetilde{\mathbf{b}}_2 \right],$$
$$\mathbf{B} = ((c_0 \varepsilon_0) \mathbf{b}_0 + (c_1 \varepsilon_1) \mathbf{b}_1 + (c_2 \varepsilon_2) \mathbf{b}_2),$$

then finally (symbolically)

$$\nabla \cdot (\langle \mathbf{B} \rangle) + \frac{1}{\Delta\Omega} \int\limits_{\partial S_w} (\mathbf{B}) \cdot d\vec{s} = 0.$$

Further is the averaging of other two ($\nabla \times$ ) Lower sub-atomic scale homogeneous MHL equations.

After some mathematics finally the Upper scale charged particles plus aether combined Ampere-Maxwell equation looks as

$$\nabla \times \langle \mathbf{B} \rangle + \frac{1}{\Delta\Omega} \int_{\partial S_w} \vec{ds} \times \mathbf{B} = \frac{\partial}{\partial t} \langle \mathbf{E}_{K3} \rangle - \frac{1}{\Delta\Omega} \int_{\partial S_w} (\mathbf{V}_s \mathbf{E}_{K3}) \cdot \vec{ds},$$

if averaged

$$\langle \mathbf{B} \rangle = \left[ \langle m_0 \rangle (c_0 \varepsilon_0) \widetilde{\mathbf{b}}_0 + (c_1 \varepsilon_1) \langle s_1 \rangle \widetilde{\mathbf{b}}_1 + (c_2 \varepsilon_2) \langle s_2 \rangle \widetilde{\mathbf{b}}_2 \right]$$

$$\mathbf{B} = ((c_0 \varepsilon_0) \mathbf{b}_0 + (c_1 \varepsilon_1) \mathbf{b}_1 + (c_2 \varepsilon_2) \mathbf{b}_2), \; (c_0 \varepsilon_0) = \sqrt{\frac{\varepsilon_0}{\mu_0}},$$

and where

$$\langle \mathbf{E}_{K3} \rangle = [\langle m_0 \rangle \widetilde{\mathbf{e}}_0 + \langle s_1 \rangle \widetilde{\mathbf{e}}_1 + \langle s_2 \rangle \widetilde{\mathbf{e}}_2], \quad \mathbf{E}_{K3} = (\mathbf{e}_0 + \mathbf{e}_1 + \mathbf{e}_2).$$

The last Upper scale charged particles plus aether Faraday induction combined equation for the three-phase medium mean (averaged) fields finally appears as this

$$\nabla \times \langle \mathbf{E}_{K3} \rangle + \frac{1}{\Delta\Omega} \int_{\partial S_w} \vec{ds} \times \mathbf{E}_{K3} = -\frac{\partial}{\partial t} \langle \mathbf{B}_{K2} \rangle + \frac{1}{\Delta\Omega} \int_{\partial S_w} (\mathbf{V}_s \mathbf{B}_{K2}) \cdot \vec{ds},$$

where

$$\frac{1}{\Delta\Omega} \int_{\partial S_w} (\mathbf{V}_s \mathbf{B}_{K2}) \cdot \vec{ds} = \frac{1}{\Delta\Omega} \int_{\partial S_{0p}} (\mathbf{V}_{sp}(\mathbf{b}_0)) \cdot \vec{ds}_0 +$$

$$+ \frac{1}{\Delta\Omega} \int_{\partial S_{p1}} (\mathbf{V}_{sp}(\mathbf{b}_1)) \cdot \vec{ds}_1 + \frac{1}{\Delta\Omega} \int_{\partial S_{p2}} (\mathbf{V}_{sp}(\mathbf{b}_2)) \cdot \vec{ds}_2.$$

if for this taken that

$$\langle \mathbf{B}_{K2} \rangle = \left[ \langle m_0 \rangle \widetilde{\mathbf{b}}_0 + \langle s_1 \rangle \widetilde{\mathbf{b}}_1 + \langle s_2 \rangle \widetilde{\mathbf{b}}_2 \right], \quad \mathbf{B}_{K2} = (\mathbf{b}_0 + \mathbf{b}_1 + \mathbf{b}_2).$$

The nature and characteristics of additional surficial terms are the important isues that will be studied with methods of HSP-VAT.

## 3.5 Particles Momentum Equations in the Aether (vacuum0)

Now - when the charged and magnetic moment particles (photons, electrons, nuclei, ions, atoms) are moving in an aether (vacuum0) and one might be using the Lorentz force formula developed for two, but used anyway for more charged particles where the fields $\mathbf{e}_2$, $\mathbf{b}_2$ are symbolizing (affecting) the force onto the charged test particle $q_1$

$$\mathbf{F}_{21} = q_1(\mathbf{e}_2 + \mathbf{w}_1 \times \mathbf{b}_2), \tag{3.1}$$

where both particles are the moving charges. Note, the issue of charge $q_1$ effecting the moving another charge $q_2$ even does not sound for Lorentz force formula. We guess that it is because at that time Lorentz did not know - How to do this?

The equation of motion of particle with mass $m_1$ in the present "inviscid" framework" of aether while the second particle having the fields $\mathbf{e}_2$, $\mathbf{b}_2$ is

$$m_1 \dot{\mathbf{w}}_1 = m_1 \frac{d\mathbf{w}_1}{dt} = \mathbf{F}_{21} = q_1(\mathbf{e}_2 + \mathbf{w}_1 \times \mathbf{b}_2), \tag{3.2}$$

or commonly in the general fields "averaged" **E** and **B** the Lorentz force formula in the equation looks as

$$m_1 \frac{d\mathbf{w}_1(\mathbf{r}_1,t)}{dt} = \mathbf{F}_{int}(\mathbf{r}_1,t) = q_1(\mathbf{r}_1,t)(\mathbf{E}(\mathbf{r}_1,t) + \mathbf{w}_1(\mathbf{r}_1,t) \times \mathbf{B}(\mathbf{r}_1,t)),$$

where **E** and **B** should be here taken or known as "averaged" already field variables? Or assigned or known "averaged" functions.

### *3.5.1 Averaging of the Force formulae Equations in the REV*

Then we should phase average $< >_p$ this equation with the Lorentz's (Heaviside) force field formula over the phase of particles ($p$) as

$$\left\langle m_1 \frac{d\mathbf{w}_1(\mathbf{r}_1,t)}{dt} \right\rangle_p = \langle \mathbf{F}_{int}(\mathbf{r}_1,t)\rangle_p = \langle q_1(\mathbf{r}_1,t)(\mathbf{E}(\mathbf{r}_1,t) + \mathbf{w}_1(\mathbf{r}_1,t) \times \mathbf{B}(\mathbf{r}_1,t))\rangle_p,$$

where we get the averaged equation of momentum of collective array (field) of interacting particles - particle phase, electrons, for example, as (with the simplified for start electron mass $m_1 = m_e$ =const), while the total time derivative

$$\frac{d\mathbf{w}_1(\mathbf{r}_1,t)}{dt} = \frac{\partial \mathbf{w}_1(\mathbf{r}_1,t)}{\partial t} + (\mathbf{w}_1 \cdot \nabla \mathbf{w}_1),$$

the averaged particle phase 1 (electrons) equation will be

$$m_e \left[ \langle s_1 \rangle \frac{\partial(\widetilde{\mathbf{w}}_e)}{\partial t} - \frac{1}{\Delta\Omega} \int_{\partial S_{p1}} (\mathbf{V}_{sp}(\mathbf{w}_e)) \cdot d\vec{s}_1 \right] + m_e \langle s_1 \rangle \widetilde{\mathbf{w}}_e \cdot \nabla(\widetilde{\mathbf{w}}_e) +$$
$$+ m_e \widetilde{\mathbf{w}}_e \cdot \left( \frac{1}{\Delta\Omega} \int_{\partial S_{p1}} \mathbf{w}_e \, d\vec{s}_1 \right) + m_e < \widehat{\mathbf{w}}_e \cdot \nabla(\widehat{\mathbf{w}}_e) >_{p1} = < \mathbf{F}_e >_{p1} . \quad (3.3)$$

This Upper scale governing equation COHP is not even able to obtain, to derive. The methods of COHP don't allow doing this. Here we observe the 3 unknown in COHP terms included in this equation.

Comparing this upper scale momentum equation for the particulate phase (medium) with the COHP standard scaleless momentum equation with the Lorentz force formula

$$m_e \frac{d\mathbf{w}_e(\mathbf{r}_e,t)}{dt} = \mathbf{F}_{int}(\mathbf{r}_e,t) = e(\mathbf{r}_e,t)(\mathbf{E}(\mathbf{r}_e,t) + \mathbf{w}_e(\mathbf{r}_e,t) \times \mathbf{B}(\mathbf{r}_e,t)),$$

used, for example, in [50] (in chapter 6 and in other use of electron's momentum) and in million of such textbooks on COHP electrodynamics (and other disciplines) further as already the well done momentum equation for "generalized" electrons field (by the way, the focus in textbooks of COHP is shifted at once from the velocity field to other functions), everyone can observe a striking difference in mathematics and physics therein.

Well, this kind of mathematics-physics used in COHP everywhere. Because conventional physics professionals in COHP cannot do the averaging of this even simple kind of governing equation.

The force field should be averaged as over the phase of particles (remember, the particles are the volumetric objects with our some knowledge about their properties), so the field of external influence on the particle when using the Lorentz force **F**(**r**,t) can be seen as

$$< \mathbf{F}_{int}(\mathbf{r},t) >_p = < q_p(\mathbf{r},t)(\mathbf{E}(\mathbf{r},t) + \mathbf{w}_p(\mathbf{r},t) \times \mathbf{B}(\mathbf{r},t)) >_p =$$
$$= < q_p(\mathbf{r},t)\mathbf{E}(\mathbf{r},t) >_p + < q_p(\mathbf{r},t)(\mathbf{w}_p(\mathbf{r},t) \times \mathbf{B}(\mathbf{r},t)) >_p ,$$

but **E**(**r**,t) and **B**(**r**,t) are supposed to be already averaged external functions in the problem, in the space. Those could be and External Fields also, but now we are talking about only internal collective fields as a result of numerous dynamic charges that are present in the space.

While taking the charge at first as the constant value $q(\mathbf{r},t) = e = const$ for a separate electron and for a photon; we can write this averaged equation as, for example, for electrons force field

$$< \mathbf{F}_{int}(\mathbf{r},t) >_1 \; =< q_1(t)\mathbf{E}(\mathbf{r},t) >_1 \; + q_1(t) < (\mathbf{w}_1(\mathbf{r},t)\times\mathbf{B}(\mathbf{r},t)) >_1 \; =$$
$$= \langle s_1\rangle n q_1(t)\{\mathbf{E}(\mathbf{r},t)\}_1 + n q_1(t)\langle s_1\rangle\left[\widetilde{W}_{1i}\times\widetilde{B}_i + \left\{\widehat{w}_{1i}\times\widehat{B}_i\right\}_1\right],$$
$$\mathbf{w}_1(\mathbf{r},t) = w_{1i}(\mathbf{r},t), \quad \mathbf{B}(\mathbf{r},t) = B_i(\mathbf{r},t).$$

We should point out here that in homogeneous physics for more than 100 years COHP physicists just do the substitution in this formula as in [50] and not only, we described this with interest in [24,25]

$$\mathbf{F} = \iiint d\mathbf{r}(\rho\mathbf{E} + \tfrac{1}{c}\mathbf{J}\times\mathbf{B}),$$

while they cannot average (integrate mathematically correct) this kind of equations and processes. Physicists in conventional physics also use the equation (6.1) of motion for charge particle as in [50] in p. 63

$$m_1\frac{d\mathbf{w}_1}{dt} = \mathbf{F}_{21} = q_1(\mathbf{e}_2 + \mathbf{w}_1\times\mathbf{b}_2) = e_e(\mathbf{E} + \mathbf{w}_1\times\mathbf{B}), \qquad (6.1)$$

where used the already "pseudo-averaged" fields **E** and **B**, while they should be averaged along the whole equation of motion and MHL set of equations. Professionals in COHP - they do not make the averaging of the right hand side, they cannot do this.

At the left hand side we have the one particle velocity term, while at the right we have the already averaged fields $<\mathbf{e}_2> = \mathbf{E}$ and $<\mathbf{b}_2> = \mathbf{B}$ ?

These kinds of tricks one can often find in the homogeneous one-scale atomic, particle physics.

At last we need to do

$$< \mathbf{F}_{int}(\mathbf{r},t) >_1 \; +< \mathbf{F}_{int}(\mathbf{r},t) >_0 \; =< \mathbf{F}_{int}(\mathbf{r},t) >_1 \; =$$
$$= \langle s_1\rangle n q_1(t)\{\mathbf{E}(\mathbf{r},t)\}_1 + n q_1(t)\langle s_1\rangle\left[\widetilde{W}_{1i}\times\widetilde{B}_i + \left\{\widehat{w}_{1i}\times\widehat{b}_i\right\}_1\right],$$

as soon as for the aether (vacuum0) $<\mathbf{F}_{int}(\mathbf{r},t)>_0=0$. At least for a weak exchange with the aether.

The next is the Upper scale averaged Lorentz force fields equation for distributed in space arrays of charges. If the charged particles are not constant fields (with their mass and charge), and mostly they are not, then the averaged right hand part of the Lorentz force will be as

$$< \mathbf{F}_{int}(\mathbf{r},t) >_1 \; =< q_1(\mathbf{r},t)\mathbf{e}(\mathbf{r},t) >_1 \; +< q_1(\mathbf{r},t)(\mathbf{w}_1(\mathbf{r},t)\times\mathbf{b}(\mathbf{r},t)) >_1 \; =$$
$$= \langle s_1\rangle\left[\widetilde{q}_{1i}\widetilde{e}_i + \{\widehat{q}_{1i}\,\widehat{e}_i\}_1\right] +$$
$$+\langle s_1\rangle < \left[(\widetilde{q}_1(\mathbf{r},t) + \widehat{q}_1(\mathbf{r},t))\left(\left(\widetilde{\mathbf{f}}_2 + \widehat{\mathbf{f}}_2\right)\times\left(\widetilde{\mathbf{f}}_3 + \widehat{\mathbf{f}}_3\right)\right)\right] >_1 , \qquad (3.4)$$
$$\mathbf{f}_2 = \mathbf{w}_1(\mathbf{r},t), \quad \mathbf{f}_3 = \mathbf{b}(\mathbf{r},t).$$

Summarizing, we can write the dynamics equations for the two-scale commonly with the general fields "averaged" **E** and **B** in the Lorentz force formula in the dynamic equation on the lower scale

$$m_1 \frac{d\mathbf{w}_1(\mathbf{r}_1,t)}{dt} = \mathbf{F}_{int}(\mathbf{r}_1,t) = q_1(\mathbf{r}_1,t)(\mathbf{E}(\mathbf{r}_1,t) + \mathbf{w}_1(\mathbf{r}_1,t) \times \mathbf{B}(\mathbf{r}_1,t)),$$

and the upper scale dynamic equation for electrons is as (3.3) with the r.h.s. force field mathematics using (3.4).

### 3.6. Discussion

We develop and demonstrate the polyscale consideration of the sub-atomic physical problems - only dynamics and electromagnetism of 3-phase medium - aether and electrons and photons in the unspecified volume. In this large volume every time can be selected and outlined the specific volume REV (Representative Elementary Volume) in which the upper collective, averaged medium and its properties are sought.

Because the dynamics of our particles are following the accepted electrodynamics theory we have chosen for simplicity the MHL electrodynamics for the lower scale sub-atomic dynamics statements in spite its numerous insufficiencies. This is done for better familiarity of students with the scaled physics, which is not taught in the universities. Meanwhile, the MHL electrodynamics is given in any technical specialty basics.

As long as the 3-phase sub-atomic medium description is following in many parts to the more advanced HSP-VAT techniques for nanoscale and higher spatial scales polyphase physics, that can be used to draw the similarity features, questions. One of them is the formulating for the interior of final size (small, but not negligible) particles the physical and mathematical statements for possible electrodynamics phenomena. We know that any of these particles may display some electromagnetic properties. Formulation of the interior space electrodynamic medium features does not contradict to the exterior electromagnetic features demonstration by these particles. Contrary, the formulation of the interior medium as having some electrodynamics properties should help to reveal some of these properties using the scaled polyphase HSP-VAT analysis and some simulation.

Thus, we can observe in the above governing two-scale equations the additional terms that communicate between both media of particles arrays. These terms are fortunately directly interacting in a way to outline the exterior dynamics and electrodynamics of the media to the interior formulated possible properties of the media.

The two-scale dynamics of three-phase interacting via aether particles gives the opportunity to find out the exact values for interacting terms in the governing equations. And this is achievable for the first time in particle physics.

## 4. Conclusions

We have shown in this paper for the first time the obtained in 2001-2009 the full path to derivation of the two-scale (local-nonlocal) mathematical formulation for the sub-atomic scale particulate dynamics phenomena when the particles are the volumetric objects, but not the fictitious point-like particles of conventional particle physics. Students are never told the real meaning of this kind presentation for sub-atomic particles. The kind of volumetric particulate polyphase medium portrayal was not achieved throughout the previous 100 something years.

There was the lack of needed directly applicable concepts, methods and mathematics in the past ~100 years. They started to appear only after 1970s.

Now, at the beginning of XXI there is appeared the understanding that the fictitious point-like sub-atomic particles are not the physical object, but mathematical simplification which opened a way for numerous discussion s on the topics like - "how many devils can occupy the needle tip?".

Which is the metaphysical question, but not of physics.

Now it is understood the reasons that century ago physicists could not go in a real particle characteristics chapter study. There were not enough methods, tools in physics and primarily in mathematics - that was and is the primary tool for physics modeling.

One of the great fatal choices was to abandon the aether as an intermediate medium. That was the way to open a "Pandora pithos" in physics; so many things should have been treated in an artificial and wrong ways.

The sufficient numbers of advancements were accumulated enough for new polyphase, polyscale particles treatment only during and after 1970-80s.

That are the treatment of particles as of volumetric particles with their internal and surficial properties; the dynamics of particles according to their electromagnetic properties with an individual and collective dynamics equations; the more correct and mathematically fundamental electrodynamic governing equations - GEK equations; the inclusion in all dynamics of sub-atomic particles the inter-medium of the aether; and methods for considering the particles dynamics in a unitary way as well as at the same time and of collective Upper scale Polyphase-Polyscale-Polyphysics (3P) physical processes.

Now the 3P tools and methods of HSP-VAT particle physics are available for adequately educated students and exploratory scientists.

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