Encyclopedia of Fundamentals

This wiki has the aim to give an overview of fundamental physics as approached from the sub-microscopic concept of real space.

Fundamental physics as it is currently being developed by most scientists is based on abstract concepts such as general relativity, quantum fields, symmetries and supersymmetries, loops, strings, etc. However, by continuing to use these abstract constructions, which are resting on speculations of so-called 'physical mathematics', physics is running into difficulties explaining phenomena happening at a sub-microscopic scale: the scale very much smaller than the size of the atom.

In order to understand such phenomena, fundamental physics has been approached by developing a model of real space at the Planck scale (10^{-35} m) from which subsequently an attempt has made to describe known phenomena at the microscopic scale. This sub-microscopic approach has resulted in a theory: inerton theory.

It has been found that inerton theory can and does support classical theories: Newton's theory, general relativity, quantum theory, the Schrödinger and Dirac formalisms, the Maxwell equations, and much more.

But inerton theory has also shown that a deeper insight in the fundamentals is possible. This deeper insight translates into the understanding of phenomena hitherto not understood. And indeed, this insight also allows for thinking on novel technological applications.

Although inerton theory seems consistent with general relativity and quantum theory, inerton theory is still in its infancy. A lot of further research will be needed to understand the finer details of the submicroscopic world and its implications for mankind.

Anybody interested in taking part in this exciting journey is invited to contact us: info@inerton.org

These wiki pages discuss the different aspects of inerton theory as developed from the concept of real space as it stand today. It will be updated regularly as the insights become deeper.
A pdf version of these pages can be downloaded by clicking here: Encyclopedia of Fundamentals (3.2 MB download).

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Ether

**Ether** (Greek: αἰθήρ) means the air. An idea of an aether (later also ether), as a light substance that forms the universe, was introduced into antique European thought by Democritus (460-370 B.C.). Democritus determined ether as a universal substance thinking that it is light due to its pervasive property in contrast to the heavy substance of the Earth.

According to Democritus, among components of the ether there are atoms (those that cannot be divided) and amers (those that cannot be measured because of their tiny size). These components, especially amers, are eternal; they are never created nor do they die. Democritus' amers and atoms possess various geometric forms; their shapes can be very different and they can have concavities and convexities.

It is known that Democritus traveled a lot; especially he visited Egypt, Iran and India. He did not ascribe the knowledge on atoms, amers and the ether to himself. It is known that among his teachers there were Magies – wise men living in India and Iran.

The knowledge of Democritus is indeed very close to that presented in Vedic physics. Democritus’ views were accepted by Epicurus (341-270 B.C.). Manuscripts from the 4th century say that Epicurus’ knowledge was further accepted by Titus Lucretius Carus who stated these views in his well-known book *De rerum nature* ("On the Nature of Things"). Only in the 17th century European researchers returned to the ether as a preliminary physical substance. Up to the beginning of the 20th century the ether dominated in physics, as a primary substance, in which also matter exists (points of singularity in the ether), and in which light, radio waves and electrical and gravitational interactions spread far away from objects that generate these fields, up to infinity.

It is interesting to note that the concept of deterministic submicroscopic physics presented on this web site, especially the theory of real physical space, exactly coincides with both ideas on the ether as stated by Democritus and as described in the Vedic physics. Such ether is also in line with de Broglie's requirements needed to construct his double solution theory. Submicroscopic physics as presented here builds on the notions of ether and space as developed at the beginning of the 20th century by Henri Poincaré.
Quantum mechanics and de Broglie's concept

Quantum mechanics is a probabilistic theory that has been developed in an abstract phase space on the scale of the atom size $\sim 10^{-10}$ m. The formalism of quantum mechanics is based on the Schrödinger and Dirac equations. Quantum mechanics can predict/calculate stable energy levels for such quantum systems, as atoms or free electrons, in the presence of applied electric and magnetic fields, etc.

In 1952 after the publication of works by David Bohm [1], which repeated de Broglie's ideas from 1927 on the particle as a pilot-wave, Louis de Broglie came back to his earlier consideration of quantum mechanics and during the next more than 30 years he worked on a double solution theory [2] for the Schrödinger equation. De Broglie strongly believed that the prevailing quantum mechanical formalism should be replaced by a more fundamental theory. In such a theory Schrödinger's wave function $\psi$ should have a strong physical meaning instead of Max Born's interpretation that the module $|\psi(\vec{r})|$ prescribes a probability for the particle to occupy a position in a point $\vec{r}$. Many scientists including high-level scholars turned their back on Louis de Broglie, considering him crazy. Nevertheless, some eager researchers still tried to follow-up on de Broglie's and Bohm's thoughts, developing ideas that are based on so-called hidden variables. Among new interesting results, which were obtained by de Broglie in the 1960s, we can refer to works [3] where he showed that the motion of a particle should be accompanied by a variation in its mass.

Conventional quantum mechanics is not lacking conceptual difficulties; they are discussed by de Broglie [4] (see also comments by G. Lochak in the book). Some principal difficulties of quantum mechanics, such as long-range action, etc., have been discussed in papers [5,6,7].

Thus, de Broglie relationships $E = h\nu$ and $\lambda = h/p$, which allow the derivation [4] of the Schrödinger wave equation, de Broglie's concept on the motion of a particle guided by a real wave that spreads in a sub quantum medium and de Broglie's idea on a particle that moves with a variation in mass, allow us to suggest a submicroscopic mechanics for quantum particles. In addition to de Broglie's ideas, submicroscopic mechanics includes: 1) notions and peculiarities of solid state physics and 2) a rigorous mathematical background for the structure of our ordinary physical space in which all quantum mechanical phenomena occur.
Bibliography


Physical space

The term space is used somewhat differently in different fields of study. In physics space is defined via measurement and the standard space interval, called a standard meter or simply meter, is defined as the distance traveled by light in a vacuum per a specific period of time and in this determination the velocity of light \(c\) is treated as constant.

In classical physics, space is a three-dimensional Euclidean space where any position can be described using three coordinates. In relativistic physics researchers operate with the notion space-time in which matter is able to influence space (the old idea of Riemann [1]: he stated that the question of the geometry of physical space does not make sense independently of physical phenomena, i.e., that space has no geometrical structure until we take into account the physical properties of matter in it, and that this structure can be determined only by measurement. In his opinion the physical matter determined the geometrical structure of space.)

In astronomy, space refers collectively to the relatively empty parts of the universe; any area outside of a celestial object can be considered as space.

In microscopic physics, or quantum physics, the notion of space is associated with an "arena of actions" in which all physical processes and phenomena take place. And this arena of actions we feel subjectively as a "receptacle for subjects". The measurement of physical space has long been important. The International System of Units (SI) is today the most common system of units used in the measuring of space, and is almost universally used within physics.

However, let us critically look at the determination of physical space as an “arena of actions”. In such a determination there exists, first, subjectivity and, second, objects themselves that play in processes that can not be examined at all (for instance, size, shape and the inner dynamics of the electron; what is a photon?; what are the particle’s de Broglie wavelength \(\lambda\) and Compton wavelength \(\lambda_{\text{Com}}\)?; how to understand the notion/phenomenon “wave-particle”; what is spin?; what is the mechanism that forms Newton’s gravitational potential \(Gm/r\) around an object with mass \(m\); what does the notion ‘mass’ mean exactly?, etc.).

Especially interesting are three next examples of the motion “on the arena of action, as a reservoir for objects”:
1. When a vehicle suddenly jams on the brakes, an experienced physicist sitting in the vehicle will feel that something pushes him forward;

2. Our experienced physicist comes to a playground and decided to go on the merry-go-round. The physicist raises the marry-go-round to a high speed and jumps onto it. However, holding hands tightly over the merry-go-round, he suddenly feels that something unseen grabs his legs pulling them out of the merry-go-round;

3. The experienced physicist wished to have fun with a gyroscope and taking it in his hands, when the gyroscope’s rotor reached the speed of about 20 thousand revolutions per minute, he feels that this quietly functioning plaything for some reasons goes out of hand, which injures his muscles and tendons of his arms.

These three examples clearly give evidence of the existence of otherworldly forces at the scene of action among normal subjects.

However, this “arena of actions” can be completely formalised, such that those mystical forces (veiled under the force of inertia and the centrifugal force) will unravel explicitly, because fundamental physical notions and interactions are to be derived from pure mathematical constructions.

It is interesting to read Professor Vernadsky's work who back in 1920-1930s introduced the notion of noosphere [2] (from Greek nous — mind and sphaira — ball): a sphere of the arena of interaction between people and nature. In particular, he mentioned that Helmholtz probably was the first who noted that geometric space did not embrace all of empirically studied space—what Helmholtz called physical space; Helmholtz distinguished physical space from geometric space, as possessing its own properties, such as right-handedness and left-handedness; besides, Poincaré observed that geometry could not have been developed without solids. Further Vernadsky notes: "In discussing the state of space, I will be dealing with the state of empirical or physical space, which has only in part been assimilated by geometry. Grasping it geometrically is a task for the future". Vernadsky introduced such notion as the state of space, which in his opinion has to be closely connected with the concept of a physical field, which plays such an important role in contemporary theoretical physics.

All this means that physical space is a peculiar substrate that is subject to certain laws, which as has been seen below are purely mathematical. Such a view allows us to completely remove any subjectivity and all the figurants of fundamental physical processes will be hundred percent defined. The present article is dedicated to an elucidation of those somethings that form a primordial physical substrate and the determination of its mathematical properties.
Starting point for a deeper understanding

A real physical space – is the term that stands behind such vague undetermined notions as Newton’s space (according to Newton, space was densely filled with solid balls), as a physical vacuum or ether, or ‘energofluid’. This last one is becoming more and more popular among high-energy physicists who have started to determine mass through the notion of energy, \[ m^2 = E^2/c^4 - p^2/c^2 \], rejecting such fundamental things as the rest mass and the dependence of mass on velocity. This is due to the specificity of quantum chromodynamics in which quarks are massless particles, although protons, neutrons and so on are objects with concrete masses.

However, this viewpoint completely rejects such disciplines as gravity and, in particular, Newton’s gravitational law. Abstract methods of modern quantum theories do not allow one to resolve the problem of the structure of physical vacuum. High-energy physics operates with notions experimentally obtained at the scale around the size of the atom \[ 10^{-10} \] m, but then tries to extrapolate them up to \[ 10^{-30} \] m where all kinds of fundamental interactions have to coincide. At the same time no less fundamental interactions – microscopic quantum mechanical and macroscopic gravitational – have already been lost somewhere when we approach the scale of the size of the atom. So it is clear that extrapolation does not help us to resolve the problem of the structure of physical space.

Moreover, the high-energy physicists focus on interactions between particles, but the study of quantum objects that generate these interactions, i.e. canonical particles and their interaction with space remain outside the attention of researchers. Below we explain the reasons why the interaction of quantum objects with space needs to be taken into account.

Structure of mathematical space

So far in mathematics, a space is treated as a set with some particular properties and usually some additional structure. It is not a formally defined concept as such but a generic name for a number of similar concepts, most of which generalize some abstract properties of the physical concept of space. Distance measurement is abstracted as the concept of metric space and volume measurement leads to the concept of measured space.
Generalisation of the concept of space can be done [3,4,5,6] through set theory, topology and fractal geometry, which will allow us to look at the problem of the constitution of physical space from the most fundamental standpoint.

The fundamental metrics of our ordinary space-time is a convolution product in which the embedded part $U_4$ looks as follows:

\[ U_4 = \int \left\{ \int [d\vec{x} \cdot d\vec{y} \cdot d\vec{z}] \ast d\Psi(w) \right\} \]

where $dS$ is the element of space-time, $d\Psi(w)$ is the function that accounts for the expansion of 3-D coordinates to 4-th dimension through the convolution $\ast$ with the volume of space.

Set theory, topology and fractal geometry allow us to consider the problem of structure of space as follows. According to set theory only an empty set $\emptyset$ can represent nothing. Following von Neumann, Bounias considered an ordered set,

\[ \{\emptyset, \{\emptyset\}\}, \{\emptyset, \emptyset, \{\emptyset\}\}, \{\emptyset, \emptyset, \emptyset, \{\emptyset\}\}, \{\emptyset, \emptyset, \emptyset, \emptyset, \{\emptyset\}\} \]

and so on. By examining the set, one can count its members: $\{\emptyset\} = \emptyset$, $\{\emptyset, \{\emptyset\}\} = 1$, $\{\emptyset, \emptyset, \{\emptyset\}\} = 2$, $\{\emptyset, \{\emptyset\}, \{\emptyset\}\} = 3$, ... This is the empty set as long as it consists of empty members and parts. On the other hand, it has the same number of members as the set of natural integers, $N = 0, 1, 2, ..., n$. Although it is proper that reality is not reduced to enumeration, empty sets give rise to mathematical space, which in turn brings about physical space. So, something can emerge from emptiness.

The empty set is contained in itself, hence it is a non-well-founded set, or hyperset, or empty hyperset. Any parts of the empty hyperset are identical, either a large part $(\emptyset)$ or the singleton $\{\emptyset\}$; the union of empty sets is also the same:

\[ \emptyset \cup (\emptyset) \cup \{\emptyset\} \cup \{\emptyset, \emptyset\} \cup \{\emptyset, \{\emptyset\}\} \cup \{\emptyset, \{\emptyset\}, \{\emptyset\}\} \cup ... = \emptyset. \]

This is the major characteristic of a fractal structure, which means the self-similarity at all scales (in physical terms from the elementary sub-atomic level to cosmic sizes). One empty set $\emptyset$ can be subdivided into two others; two empty sets generate something $(\emptyset) \cup (\emptyset)$ that is larger than the initial element. Consequently, the coefficient of similarity is $\rho \in [1/2, 1]$. In other words, $\rho$ realizes fragmentation when it falls within the interval $[1/2, 1]$ and $\rho$ realizes union when it is within the
interval \([0, 1/\varepsilon]\). The coefficient of similarity allows us to estimate the fractal dimension of the empty hyperset, which owing to the interval \([0, 1/\varepsilon]\) becomes a fuzzy dimension.

4-D mathematical spaces have parts in common with 3-D spaces, which yields 3-D closed structures. There are then parts in common with 2-D, 1-D and zero dimension (points). General topology indicates the origin of time, which should be treated as an assembly of sections \(S_i\) of open sets (Poincaré sections).

Due to fuzzy dimensions generated by fractality, the general part of a pair of open sets \(W_q\) and \(W_l\) with different dimensions \(q\) and \(l\) also accumulate points of open space. For instance, it is impossible to put a pot onto a sheet without changing the shape of the 2-D sheet into a 3-D packet. Only a 2-D slice of the pot can be a part of a sheet. Therefore, infinitely many slices, i.e. a new subset of sections with dimensionality from 0 to 3, ensure the raw universe in its timeless form.

Primary topology is a topology of open sets (in particular, the empty set \(\emptyset\) is an open set, but its topological ball is not open). That is why primary topology cannot be a physically measured space. However, the availability of closed intersections (timeless Poincaré sections) of abstract mathematical spaces creates properties typical for a physical space. What happens to these sections \(S_i\) if all belong to an embedding 4-space? A series of sections \(S_i, S_{i+1}, S_{i+2}, \ldots\), etc. resembles the successive images of a movie, and only nothing does not move. Therefore, the difference of distribution of objects within two corresponding sections will mean a detectable increment of time. Hence time will emerge from order relations holding onto these sections. And hence space-time acquires a topological discrete structure.

**Measure, distance, metric and objects [3,4,5,6]**

The concept of measure usually involves such particular features as existence of mappings and the indexation of collections of subsets on natural integers. Classically, a measure is a comparison of the measured object with some unit taken as a standard. The “unit used as a standard” is the part played by a gauge \(J\). A measure involves respective mappings on spaces, which must be provided with the rules \(\cup, \cap\) and \(C\).

Any space can be subdivided in two major classes: objects and distances. In spaces of the \(\mathbb{R}^n\) type, tessellation by balls is involved, which again requires a distance to be available for measurement of
diameters of intervals. Intervals can be replaced by topological balls, and therefore evaluation of their diameter still needs an appropriate general definition of a distance.

In physics, a ruler is called a metric. As a rule, mathematical spaces including topological spaces have been treated as not endowed with a metric, and properties of metric spaces have not been the same as those of non-metric spaces. However, Michel Bounias [3,4] showed that all topological spaces are metric. In fact, union and intersection allow the introduction of the symmetric difference between two sets \( A_i \) and \( A_j \)

\[
\Delta(A_i)_{i \in \mathbb{N}} = \bigcup_{i \neq j} (A_i \cap A_j),
\]

i.e. we have the complementary of the intersection of these sets in their union. Symmetric difference satisfies the following properties:

\[
\Delta(A_i, A_j) = 0 \quad \text{if} \quad A_i = A_j, \quad \Delta(A_i, A_j) = \Delta(A_j, A_i) \quad \text{and} \quad \Delta(A_i, A_k) \quad \text{is contained in union of} \quad \Delta(A_i, A_j) \quad \text{and} \quad \Delta(A_j, A_k). \]

This means it is a true distance and can also be extended to the distance of three, four and so on, sets in one.

The complementary \( \bigcup_{i \neq j} (A_i \cap A_j) \) is closed in a closed space; it is also closed even when it includes open components with non-equal dimensions. In this system the characteristic was called “instant” by Bounias, because it is responsible for the state of objects in a timeless Poincaré section. Since distances \( \Delta \) are complements to the objects, the system looks like a manifold of open and closed parts. The mapping of these manifolds from one to the other section, which preserve the topology, corresponds to a frame of reference in which topology will describe significant changes in the configuration of some components. If morphism takes place, we can compare the state of the section with the state of mapping of this section and these changes can be interpreted as a phenomenon similar to motion.

Since the definition of a topology implies the definition of the mentioned set distance, every topological space is endowed with this set metric. The norm of the set metric is \( ||A|| = \Delta(\emptyset, A) \). Therefore, all topological spaces are metric spaces, \( \Delta \)-metric spaces, and they are measurable.

Now we can explore the intersection of sets. If we have sets of non-equal dimensions, then their intersection will be closed – the intersection of closed space is also closed, \( \bigcup_{i \neq j} (A_i, A_j) \), which means the availability
of physical objects. Since distances $\Delta$ are complements to the objects, the whole system becomes a manifold of open and closed subparts. Such a procedure subdivides a universe to two parts: distances and objects.

**Tessel-lattice and the generation of matter [4,5,6,7]**

Providing the empty set $(\mathcal{O})$ with mathematical operations $\in$ and $\subset$, as combination rules, and also the ability of complementary $(\mathcal{C})$ we obtain a magma (i.e. fusion) of empty sets: Magma is a union of elements $(\mathcal{O})$, which act as the initiator polygon, and complementary $(\mathcal{C})$, which acts as the rule of construction; i.e., the magma is the generator of the final structure. This allowed Bounias to formulate the following theorem:

*The magma $\mathcal{O}^\mathcal{O} = \{\mathcal{O}, \mathcal{C}\}$ constructed with the empty hyperset and the axiom of availability is a fractal lattice.*

Writing $(\mathcal{O}^\mathcal{O})$ denotes the magma, and reflects the set of all self-mappings of $\mathcal{O}$. The space, constructed with the empty set cells of the magma $\mathcal{O}^\mathcal{O}$, is a Boolean lattice, and this lattice $S(\mathcal{O})$ is provided with a topology of discrete space. A lattice of tessellation balls has been called a tessel-lattice [4], and hence the magma of empty hyperset becomes a fractal tessel-lattice.

Introduction of the lattice of empty sets ensures the existence of a physical-like space. In fact, the consequence of spaces $(W_m, W_n)$, ... formed as parts of the empty set $\mathcal{O}$ shows that the intersections have non-equal dimensions, which gives rise to spaces containing all their accumulating points forming closed sets. If morphisms are observed then this enables the interpretation as a motion-like phenomenon, when one compares the state of a section with the state of a mapped section. A space-time-like sequence of Poincaré sections is a non-linear convolution of morphisms. Our space-time then becomes one of the mathematically optimal morphisms and time is an emergent parameter indexed on non-linear topological structures guaranteed by discrete sets. This means that the foundation of the concept of time is the existence of orderly relations in the sets of functions available in intersect sections.

Time is thus not a primary parameter and the physical universe has no beginning: time is just related to ordered existence, not to existence itself. The topological space does not require any fundamental difference between reversible and steady-state phenomena, nor between reversible and irreversible process. Rather relations simply apply to non-linearly distributed topologies and from rough to finest topologies.
So real physical space can be presented in the form of a mathematical lattice: the tessel-lattice is regularly ordered such that the packing has no gaps between two or more empty topological balls. This is guaranteed by a set \( \mathcal{G} \), which does not have members and parts. Such tessel-lattice accounts for the existence of relativistic space and the quantum void (vacuum), as: 1) the conception of distance and the conception of time are defined and 2) such space includes a quantum void, because the mosaic space introduces a discrete topology with quantum scales and, moreover, it does not have “solid objects” that would appear as real matter. The tessel-lattice with these characters has properties of a degenerate physical space. The sequence of mappings from one structural state to the other of an elementary cell of the tessel-lattice generates an oscillation of the cell’s volume along the arrow of physical time. However, there is also an option of transformation of a cell under the influence of some iteration similarity that overcomes conservation of homeomorphism. For \( N \) similar figures with the ratio of similarity \( 1/\rho \) the Bouligand exponent \( (e) \) is given by expression

\[
N \cdot (1/\rho)^e = 1
\]

and the cell of an image changes its dimension from \( D \) to

\[
D' = \ln N / \ln \rho = e \quad \text{where} \quad e > 1.\] A change of the dimension means an acquisition of properties of “solid” objects, i.e. the creation of matter.
Figure 1: The continuity of homeomorphic mappings of structures is broken once a deformation involves an iterated transformation with internal self-similarity, which involves a change in the dimension of the mapped structure. Here the first 2 or 3 steps of the iteration are sketched, with basically the new figure jumping from (D) to approximately (D + 1:45). The mediator of transformations is provided in all cases by empty set units.

The universe can be treated as a tessel-lattice composed of a huge number of cells or topological balls. The measure includes such notions as length, surface and volume. Because of that a loop distance $l$ of the universe (i.e. the perimeter that would be measured by means of a ruler in principle) can be related to parameters of $N$ balls.

Indeed, let $\mu$ be a measure of balls (their length, surface or volume with the corresponding dimensions $\delta = 1$-D, 2-D or 3-D). In the middle part of the universe with the dimension $D$ we have $N$ times $\mu^D$, which equals approximately $l^D$, so that we estimate the dimension of this part of the universe:

\begin{equation}
D \sim (\delta \cdot \log \mu + \log N) / \log l.
\end{equation}

Thus, from expression (4) we can see that at least a part of the universe having different dimension $D$ can be distinguished from the other universe, which can be perceived as the presence of dark matter there.

If we know the universe’s components, that is if we can describe sizes and shapes of topological balls, we will be able to re-establish an invisible structure of a large size.
The present theory of space predicts the formation of sub-universes, or clusters that embrace $10^x$ cells of the tessel-lattice where the exponent changes from $x = 1$ to $x = 60$. Thus, $x = 1$ (Planck’s scale) corresponds to the size of an elementary cell of the tessel-lattice; a radius that covers $10^{10}$ cells describes the size of a quark; a radius that includes $10^{17}$ cells depicts the atom size; a radius with $10^{21}$ cells is characterized as the molecular size; a radius that includes $10^{28}$ cells represents the humanoid size; a radius that consists of $10^{40}$ cells features the solar system scale; a radius covering $10^{56}$ cells corresponds to a cluster of a cosmic structure. Of course the universe suggests different arrangements of the organisation of matter at each of those scales.

Figure 2: A topological ball is represented as a triangle, figuring 3 dimensions in a metaphorical form. A degenerate ball keeps the same dimension in contrast with a particled ball endowed with a fractal substructure. A complete decomposition into one single ball ($k = 1$) conserves the volume without keeping the fractal dimension. The von Koch-like fractal has been simplified to 3 iterations for clarity.
The organisation of matter at the microscopic (atomic) level has to recreate a sub microscopic spatial ordering. Hence the crystal lattice is also a reflection of the sub microscopic ordering of real physical space that can be associated with the tessel-lattice of tightly packed balls – elementary bricks of the primary substrate of the universe.

In the tessel-lattice balls are found in a degenerate state and their characteristics are such mathematical parameters as length, surface, volume and fractality. Evidently, the removal of degeneracy must result in local phase transitions in the tessel-lattice, which creates “solid” physical matter. So matter (mass, charge and canonical particle) is immediately generated by space and has to be described by the same characteristics as the balls from which matter is formed. The behaviour of a canonical particle obeys submicroscopic mechanics that is determined on the Planck’s scale in the real space and is wholly deterministic by its nature. At the same time, deterministic submicroscopic mechanics is in complete agreement with the results predicted by conventional probabilistic quantum mechanics, which is developed on the atomic scale in an abstract phase space. Moreover, submicroscopic mechanics allows the derivation of Newton's law of universal gravitation and the nuclear forces starting from first sub microscopic principles of the tessellation structure of physical space.

Bibliography


Mass

Mass is a physical quantity, which is treated as one of the basic characteristics of matter and determines its inertial and gravitational properties; mass is usually designated by the letter \( m \). — *This is a conventional definition of mass as used in manuals and encyclopedias.*

In physics the majority of scientists still put in the forefront the theorem of everything, i.e. they try to formulate a theory that would unify all forces observed in physics. Today only three of the six forces have been successfully unified: the electromagnetic, the weak and the strong forces. The efforts to include the nuclear forces, the quantum mechanical forces and the gravitational forces in the unification are still ongoing. In the unification efforts, the fundamental basis of physics remains completely unclear: there is no successful examination of the determination or derivation of initial physical notions such as mass, charge, particle, de Broglie wavelength, spin, photon, etc. General relativity, as a phenomenological abstract theory, is also unable to clarify the situation: it is based on separate notions of mass and space, or space-time, which exist independently from each other (even though mass may influence space).

On the other hand, the physical notion of mass directly stems from a mathematical theory of the constitution of physical space. Set theory, topology and fractal geometry allow us to construct the real physical space as a mathematical lattice of topological balls, which was called \([1,2]\) the tessel-lattice and which possesses fractal properties. In this approach to the fundamentals, the theorem of something occupies the first place, i.e. a peculiar object becomes primary, which is typical for set theory. Then, having a definition of the primary 'something', we can study its behaviour in the tessel-lattice, i.e. space mosaically composed of primary bricks or topological balls.

In the tessel-lattice a local deformation can appear in the form of a volumetric fractal deformation of a topological ball. The creation of such local deformation in the mathematical lattice - the tessel-lattice - can be associated with the physical notion of mass. A surface fractal deformation of a topological ball defines the electric state of the ball (see electric charge). Thus a mass of a canonical particle has to be considered as a ratio of the initial volume \( V_0 \) of the degenerate ball in the tessel-lattice to a volume \( V_{\text{def}} \) of a ball that has undergone a fractal volumetric deformation, i.e.

\[
m = \text{const} \frac{V_0}{V_{\text{def}}};
\]
here \( \text{const} \) is a dimension constant and the ratio \( \frac{V_0}{V_{\text{def}}} > 1 \).

In this way the mass of a canonical particle can be determined. This particle (its kernel) is characterised by a local deformation described by expression (1). During the motion the kernel experiences a fractal decomposition: owing to the interaction with adjacent cells of the tessel-lattice, which forms the real space, the whole deformation (1) of the kernel gets scattered such that the particle becomes surrounded by elementary excitations that carry fragments of the particle deformation, i.e. particle's mass. The dynamics of the canonical particle is the subject of submicroscopic mechanics.

A particle surrounded by these mass excitations has a reflection in orthodox quantum mechanics: this is the well-known particle's \( \psi \)-wave function. These elementary excitations, carriers of mass, have been referred to as inertons. As a result, the \( \psi \)-wave function gains a real physical meaning as the field of inertia of the particle.

**Bibliography**


Charge

The physical notion of elementary electric charge follows from a mathematical theory of the constitution of real physical space. Set theory, topology and fractal geometry allow us to construct space, as a mathematical lattice of topological balls - the tessel-lattice, which possesses fractal properties.

A fractal volumetric deformation of a topological ball is associated with the notion of mass. A fractal surface deformation of a topological ball is associated with notion of elementary electric charge. In the degenerate tessel-lattice one can distinguish a middle radius of cells such that amplitudes of oscillations of the cells' surfaces (surface wavelets) cross the surface both out and in. Then the quant of surface deformation, when all amplitudes, i.e. needles, of the surface oscillations are directed outward of the cell can be associated with a positive electric charge. When all surface amplitudes, i.e. needles, are directed inward of the cell, the form can be called a negative electric charge.

![Figure 1: Completely free topological ball outside of the tessel-lattice (left figure); topological ball as part of the tessel-lattice, which can be referred to here as a superparticle (central figure); the formation of particles from the topological ball (right figures).](image)

How many such amplitudes, or needles, cover the surface of a topological ball in the tessel-lattice? Obviously as many as the number of harmonics in the tessel-lattice. This number \( N \) is defined by the quantity of balls that forms the tessel-lattice. If the middle size of a cell of the tessel-lattice equals the Planck's fundamental length

\[
R_{\text{cell}} \sim l_f = \sqrt{\hbar G/c^3} \approx 10^{-35} \text{ m}
\]

and the radius of the visible universe

\[
R_{\text{univ}} \approx 10^{26}
\]

we can easily estimate the number of needles that cover an elementary electric charge:

\[
N \sim \frac{R_{\text{univ}}^3}{r_{\text{cell}}^3} = 10^{183}
\]
In the macroscopic world the most descriptive analogy of the positive charge is a chestnut; ramified roots of plants are also look like a positive charge. Hence the negative charge must be an inverse spatial topological structure such as the stomachs of animals.

The motion of a charged particle in the tessel-lattice can be described by means of the appropriate Lagrangian [1]

\[
\mathcal{L}_n = C \left\{ \frac{1}{2} \dot{\Phi}_n^2 + \frac{1}{2} \dot{A}_n^2 + \frac{1}{2} \dot{\phi}_n^2 + \frac{1}{2} \dot{\alpha}_n^2 - \nu_0 \left( \Phi_n \nabla \dot{\alpha}_n + \phi_n \nabla \dot{A}_n \right) - \nu_0^2 \left( \nabla \times A_n \right) \right\}
\]

Here, \( \Phi \) and \( A \) are scalar and vector fields determined on the surface of the particle; \( \phi \) and \( \alpha \) are the appropriate scalar and vector fields located on the particle's inertons; in other words, these polarized inertons represent a cloud of photons around the charged particle. \( \nu_0 \) is the velocity of the particle.

The equations of motion, i.e. the Euler-Lagrange equations derived on the basis of the Lagrangian (1) result in the Maxwell equations written in the d'Alambert form. The motion of the charge is associated with the ejection and reabsorption of photons, which are electromagnetically polarized inertons - because photons represent the same inertons whos surface is additionally covered with fractal polarization. Running each odd section \( \lambda/2 \) of the charge's path, where \( \lambda \) is the de Broglie wavelength of the corresponding particle, step-by-step, the charge on
the surface transforms its electric state to the magnetic state, i.e. the state of a magnetic monopole.

The magnetic state, or magnetic charge, looks like a combed electric charge, i.e. all needles are stowed, or bended to the surface of the particulate ball. Then emitted photons (or rather 'inerton-photon' cloud) gradually comes back to the particle in even sections $\lambda/2$ and restores the particle's initial pure electric surface state.

Bibliography

Inerton

**Inerton** is a quasi-particle, i.e. an excitation of the *physical space*, which carries a fragment of a local volumetric fractal deformation of the spatial tessel-lattice. The size of an elementary cell of the tessel-lattice can be compared with the Planck's fundamental length

\[ l_T = \sqrt{\frac{\hbar G}{c^3}} \sim 10^{-35} \text{ m}. \]

Under a local deformation of the tessel-lattice we understand a deformation of a cell. In physical language an inerton is an elementary excitation of space which transfers a fragment of mass, because a local volumetric deformation of the mathematical tessel-lattice (that consists of topological balls and represents the constitution of real space) has to be identified with the physical notion of mass. An inerton migrates through the tessel-lattice, carrying the state of local fractal volumetric deformation from cell to cell.

When a **canonical particle** moves through the cells of the tessel-lattice it interacts constantly with surrounding cells. As a result of such collisions spatial excitations must appear; they are referred to as inertons \([1,2]\). The mass (i.e. local deformation) of a canonical particle is scattered due to the interaction with the surrounding space, such that around the particle a cloud of **inertons** is created which thus constantly accompanies the particle. It is interesting to note that this way of motion of a particle in the world ether was considered by Henri Poincaré far before the beginning of 20th century: a particle was treated as a singularity in the ether and moved through the ether surrounded by the ether's excitations \([3]\). Later, Louis de Broglie in his thesis of 1924 considered the motion of a particle that was guided by a real wave that spread in a sub quantum space \([4]\); in our modern approach we can say that de Broglie treated the motion of a particle surrounded by the ether excitations as produced by the particle and these excitations were structured in a wave.

In has been shown that a cloud of inertons appears around the particle moving in the real space and the inerton cloud has an expansion \( \lambda/2 \) (where the section \( \lambda \) of the particle's path is identical to the de Broglie wavelength of the particle studied) and in transferal directions the inerton cloud covers the area \( \pi \Lambda^2 \) (where \( \Lambda = \lambda c/u \) is the amplitude of the inerton cloud and \( u \) and \( c \) are velocities of the particle and light respectively).

The behaviour of inertons in the inerton cloud is as follows: The particle arriving at odd sections \( \lambda/2 \) of its path emits inertons that are scattered to the surroundings reaching the distance \( \Lambda \) in transferal directions. The particle looses its velocity and mass stops.
Inertons, rejecting from the space at the distance $\Lambda$ from the particle, come back to it such that in each next even section $\lambda/2$ of the particle's path inertons return the velocity and mass to the particle. At the distance $\Lambda$ from the particle a local deformation of the kernel cell of the canonical particle, i.e. particle's mass $m$ (Figure 1: a) is transformed to another type of distortion, namely a tension of the tessel-lattice (Figure 1: b); in other words, in this place the cell is not deformed volumetrically but shifted from its equilibrium position. It is this shift of cells in the tessel-lattice that generates the returning force in the elastic tessel-lattice, which replaces cells back into their original equilibrium positions. Coming back to the particle, inertons experience a gradual transformation from the tension to the local deformation: the tension decreases $\xi \rightarrow 0$ but the mass increases $0 \rightarrow m$. Thus from fragment to fragment inertons pass mass back to the particle (this is the subject of study of the theory of gravity) and return the velocity to the particle (this is the subject of study of submicroscopic mechanics).

If we only talk about the behaviour of the particle's mass we can say that the location of the mass periodically becomes point-like for a short moment until the inertons spread out again. But it is important to note that the whole cloud represents the particle.

The inerton cloud experiences periodic oscillations of its density that is periodically transformed to the tension of space. This pattern is similar to the behaviour of photons, or the electromagnetic field in general, because during the motion of the photon a periodical transformation of its polarization from the pure electric to pure magnetic state takes place (and similarly the electric charge behaves as a motion too).

The velocity of motion of these bound inertons (i.e. the cloud's inertons) can be compared with the speed of light $c$. Harsh collisions, sharp stops and accelerations of a particle cause the ejection of free inertons from the inerton cloud. Under such conditions their velocity may exceed the speed of light up to two orders [5]. A free inerton migrates in the tessel-lattice similarly to an excitation migrating in a molecular crystal, i.e. the inerton hops from cell to cell through a relay mechanism. The path of an inerton can be subdivided by sections of the length $\lambda/2$. In odd sections
a local deformation (i.e. mass $\mu$ of the inerton) gradually drops to zero, but the tension $\xi$ increases (i.e. the size of each next cell increases to the size that exceeds that of a degenerate cell of the tessel-lattice). In even sections $\frac{\lambda}{2}$ the tension progressively decreases to zero but the mass $\mu$ is restored again.

So the motion of a free inerton features the wavelength $\lambda$ and is accompanied by the oscillation of its mass $\mu$ and the tension $\xi$ (compared with oscillations of parameters of the photon).

Figure 2: Motion of the free inerton along its path $l$; the volume of the appropriate cells changes, which means periodical oscillation of the value of its mass from $\mu$ in the point $l = 0$ to zero in the point $l = \frac{\lambda}{2}$ and so on.

Inertons carry not only mass; they are carriers also of fractal deformations of quantum systems because the tessel-lattice is endowed with certain fractal properties itself.

For the theoretical background of the concept of inertons see papers [1,2,6].

In conventional quantum mechanics, which is constructed in an abstract phase space, the inerton cloud manifests itself as the particle's wave function. Hence, an overlapping of wave functions of neutral particles (neutrons, atoms, etc.) is characterised by the exchange of inertons.

Inertons are also carriers of gravity, i.e. the gravitational attraction between particles/objects, because they form a deformation field (i.e. a potential mass field) around bodies and due to the overlapping of these fields the exchange of inertons between the bodies has to occur instantly [7,8]. Inertons are also carriers of the so-called nuclear forces, which appear at short distances $\sim 10^{-15}$ m between nucleons [9].

The existence of inertons has been shown in many different experiments.
Bibliography


Photon

A theory of real physical space that is treated as the tessel-lattice of densely packed topological balls and notions of mass and charge, which are respectively the manifestations of volumetric and surface fractal deformations of a cell of the tessel-lattice, allow us to introduce the notion of the photon as follows [1,2]. An elementary canonical particle, for instance the electron, is exemplified by a mass and charge. The mass and the charge in their turn deform the surrounding tessel-lattice, such that a deformation coat is formed around the particulate cell (the same as it is the case of a polaron coat round the electron in a polar crystal or a solvate shell round an ion in a liquid).

The motion of a particle in the tessel-lattice obeys submicroscopic mechanics; a moving particle generates elementary excitations that migrate together with the particle. In the case of a charged particle such excitations are endowed both with volumetric and surface fractal deformations. The excitations migrate by a relay mechanism hopping from cell to cell. A volumetric deformation of a cell is associated with a (fragment) of mass and the surface deformation is associated with a fragment of the electricity, i.e. polarization. Hence the moving charged particle is surrounded by a cloud of excitations that carry elements of mass and electricity. The availability of electric polarization on these excitations enable us to identify them with photons. Hence, the photon is the same inerton but which has a polarised surface.

The motion of a charged canonical particle can be stable only when the particle and its photon cloud periodically change (due to the interaction with the tessel-lattice) both their volumetric and surface states: the volumetric state oscillates between a local deformation and the tension and the surface state oscillates between pure needles and the surface tension (when needles are bended to the surface). Therefore one type of deformation is periodically transformed to the other type. Since all this occurs in real space we can clearly draw the appropriate picture: the mass (local deformation) of the photon oscillates periodically transforming to the state that can be described as the tension of the cell. The geometry of the surface of the photon oscillates between the state of normal needles (electric polarization) and the state of combed needles (magnetic polarization).

Owing to certain non-adiabatic processes free photons are released from the photon cloud that surrounds the charged particle. A free photon migrates in the tessel-lattice by hopping from cell to cell. During such a motion the state of its surface periodically changes between the state of normal needles (electric polarization) and the state of combed needles.
(magnetic polarization). The photon in each odd section $\frac{\lambda}{2}$ of its path looses the electric polarization which is going to zero and acquires the magnetic polarization; in even sections $\frac{\lambda}{2}$ of the photon's path it looses the magnetic polarization but restores its electric polarization. Thus the wavelength $\lambda$ of the photon represents a spatial period in which the polarization of the photon is transformed from pure electric to pure magnetic. Having $\lambda$ and knowing the velocity $c$ of a free photon we can calculate the photon frequency, which features the frequency of transformation of magnetic and electric polarizations: $\nu = \frac{c}{\lambda}$.

**The size of the photon.** Since we compare the size of an elementary cell of the tessel-lattice with the Planck's fundamental length

$$l_f = \sqrt{\frac{\hbar G}{c^3}} \sim 10^{-35}$$ m, we shall recognize this scale as an actual size of the photon. However, high energy physics extrapolates the unification of three types of interactions (electromagnetic, weak and strong) on the scale $10^{-30}$ m. This would mean that although the core of the photon occupies only one cell, a certain fluctuation in the tessel-lattice may reach up to the scale $10^{-30}$ m.

An instantaneous **photo of the photon:** it is a cell of the tessel-lattice whose upper part of the surface is covered by needles that stick out of the cell and the lower part of the surface is covered by needles that stick inside of the cell.

Polarization of the photon. Needles are periodically combed which physically means the appearance of the magnetic field in the present point. If needles are combed towards the direction of motion of the photon, the photon can be called right-polarised. If needles are combed in the reverse direction of the motion of the photon, the photon can be called left-polarised.

**Bibliography**

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A canonical particle is a particle that can be described in the framework of quantum mechanical formalism. Elementary particles can be viewed as canonical particles (electron, positron, proton, neutron, etc.) but isolated atoms would also fall under this definition. A canonical particle has such quantum characteristics as the de Broglie’s wavelength, the $\psi$-wave function, spin, etc. Its energy, momentum and the moment of momentum are determined through the Schrödinger and Dirac quantum equations. In quantum mechanics a canonical particle is a wave-particle and its characteristics are bound by de Broglie relationships: $E = h\nu$ and $\lambda = h/p$.

It is known from experiments on the scattering of light by these particles that canonical particles possess a radius of some hardness, which has been referred to as the Compton wavelength, $\lambda_{\text{Com}} = h/(mc)$, where $m$ is the particle’s mass and $c$ is the velocity of light.

Why we speak about some radius of hardness? Because this directly follows from the theoretical consideration of collisions of quanta of light with electrons (see, e.g. the description of the experiment in the well-known remarkable book by Born [1]).

Indeed, the equation characterising the energy conservation law and two appropriate equations for the momentum conservation law have the form

1. $h\nu + m_0c^2 = h\nu' + mc^2$,
2. $\frac{h\nu}{c} = \frac{h\nu'}{c} \cos \phi + mv \cos \alpha$,
3. $0 = \frac{h\nu'}{c} \sin \phi - mv \sin \alpha$.

Here, $\nu$ is the frequency of quantum of light, $m_0$ and $m = m_0/\sqrt{1 - v^2/c^2}$ are the electron’s rest mass and the total mass, respectively; $\phi$ is the angle of deviation of the quantum of light after the scattering with the electron and $\alpha$ is the angle of deviation of the electron after collision with the quantum of light.
The final expression, Compton's formula for the change of the wavelength of the quantum of light due to the collision with the electron, can easily be derived from equations (1)-(3):

\[
\Delta \lambda = \lambda' - \lambda = c \left( \frac{1}{\nu'} - \frac{1}{\nu} \right) = \left( 1 - \cos \phi \right) \frac{h}{m_0 c},
\]

where \( \frac{h}{m_0 c} = \lambda_{\text{Com}} \) is the Compton wavelength of the electron. This length, \( \lambda_{\text{Com}} \), is not formal. We can rewrite equations (1)-(3) in the form, which explicitly shows how spatial intervals characterising the scattering objects behave,

\[
\frac{1}{\lambda} + \frac{1}{\lambda_{\text{Com}}} = \frac{1}{\lambda'} + \frac{1}{\lambda_{\text{Com}}} \frac{1}{\sqrt{1 - v'^2/c^2}},
\]

\[
\frac{1}{\lambda} = \frac{1}{\lambda'} \cos \phi + \frac{1}{\lambda_{\text{Com}}} \frac{v}{c} \cos \alpha,
\]

\[
0 = \frac{1}{\lambda'} \sin \phi - \frac{1}{\lambda_{\text{Com}}} \frac{v}{c} \sin \alpha.
\]

Equations (5)-(7) show that the quantum of light, which is described by the wavelength \( \lambda \), is scattered by an object that has the characteristic length, Compton's wavelength \( \lambda_{\text{Com}} \); and then the length \( \lambda_{\text{Com}} \) influences the \( \lambda \) such, the latter is changed. Hence, the object's wavelength \( \lambda_{\text{Com}} \) is much more rigid, than wavelength \( \lambda \) of the running quantum of light. Eqs. (5) to (7) result in the same Compton's expression (4).
Thus, canonical particles possess an actual radius of hardness, which is determined by the Compton's expression \( \lambda_{\text{Com}} = \frac{h}{(m_0c)} \).

Notwithstanding this, in orthodox quantum mechanics the size of a canonical particle does not play a part in the theory. In high energy physics a particle is regarded as pointlike.

At the same time in submicroscopic mechanics, which starts from the size of an elementary cell of physical space, i.e. the tessel-lattice, the real size of a canonical particle plays an important role. Since the size of cell in the tessel-lattice is identified with the Planck fundamental length \( l_f = \sqrt{\frac{\hbar G}{c^3}} \sim 10^{-35} \text{ m} \), it is quite reasonable to suggest this scale to be the size of the kernel of an elementary particle (recall that in agreement with the theory of real physical space an elementary particle appears directly from a cell of the tessel-lattice owing to fractal changes in its volume and surface).

It is known from solid state physics that the emergence in the crystal lattice of a foreign particle or an ion/atom leads to a deformation of the crystal lattice in the vicinity of the particle, which is called a deformation coat.

Because of that, in the tessel-lattice, a deformation coat is also formed around a created elementary particle [2,3]. Hence it is logical to assume that the created particle distorts the tessel-lattice up to the radius \( \lambda_{\text{Com}} \), which manifests itself in experiments on the scattering of light [1]. For instance, for the electron \( \lambda_{\text{Com}, \text{e}} \sim 10^{-12} \text{ m} \) and for the proton \( \lambda_{\text{Com}, \text{p}} \sim 10^{-15} \text{ m} \). In the deformation coat, cells of the tessel-lattice are shifted from their equilibrium position to the particulate cell (i.e. the kernel of the particle); the importance of this deformation gradually decreases as the boundary of the coat is reached. Behind the deformation coat an unmovable particle does not express itself; here the tessel-lattice remains in the degenerate state. Clearly in line with the conservation law, the deformation of the particulate ball has to be compensated by the surrounding distortion of the tessel-lattice (i.e. the deformation coat). Hence the initial volume of a spatial locality which includes the particle with its deformation coat, remains the same as that of the degenerate tessel-lattice.
Figure 2: the particle - moving to the right - pulls its deformation coat with it and emits a cloud of inertons

A moving particulate cell also pulls its deformation coat with it. The state of the coat migrates together with the particle through a relay mechanism: in each point of the particle's path it induces the deformation coat onto the surrounding cells. At the backside of the particle the tessel-lattice restores its degenerate state.

The tessel-lattice has its dynamics that makes itself evident in the trajectory of motion of the particle. In particular, the particle's original characteristic is the value of the appropriate deformation, i.e. the mass $m$; the deformation coat's original characteristic is the value of shift of cells from their equilibrium positions, i.e. the tension of cells $\xi$. Consequently, in a dynamic system we should anticipate the oscillation between mass and tension, between the parameters $m$ and $\xi$. The motion of an inerton, an elementary excitation of the tessel-lattice, induces the periodical transformation of the parameters $m$ and $\xi$. The behaviour of a moving particle that emits and reabsorbs its inertons and the interaction of the moving particle with its deformation coat is the subject of study of submicroscopic mechanics.

**Bibliography**


Submicroscopic Mechanics

Submicroscopic mechanics \([1,2,3,4,5,6]\) describes the behaviour of the canonical particle in the real physical space constructed as the tessel-lattice of primary topological balls. The size of a cell in such mathematical lattice is identified with Planck's fundamental length \(l_f = \sqrt{\hbar G/c^3} \sim 10^{-35}\) m. The motion in the tessel-lattice is only deterministic, because a particle coming between the tessel-lattice's cells must interact with them and hence its path is traced. And at the same time we can calculate the particle's parameters (the kinetic energy, velocity, momentum, etc.) at any point of the particle's trajectory. The notion of the particle is exactly defined: it appears from an ordinary cell of the tessel-lattice when dimensional changes locally occur. In other words, the cell experiences fractal volumetric and surface deformations, which represent its mass and charge respectively.

A canonical particle is accompanied by its deformation coat in which oscillations of cells take place. The deformation coat can be simulated by a crystallite with the same radius \(\lambda_{\text{com}} = \hbar/(mc)\), i.e. the crystallite whose nodes are occupied by the same massive particles. The total mass of all these model particles is equal to the mass of the central particulate cell, \(m_0\); these particles are found in a vibratory state, such that they can be described by the Lagrangian \([3]\)

\[
L = \frac{1}{2} \sum_{\vec{n},\beta} \mu_{\vec{n}} \dot{\zeta}_{\vec{n},\beta}^2 - \frac{1}{2} \sum_{\vec{n},\beta,\beta'} \gamma_{\beta\beta'} (\zeta_{\vec{n},\beta} - \zeta_{\vec{n},\beta'} - \vec{a})^2
\]

where \(\mu_{\vec{n}}\) is the mass of a particle located in the point \(\vec{n}\) of the crystallite, \(\zeta_{\vec{n},\beta}\) are three components of the shift of the particle from its equilibrium position \(\vec{n}\), \(\vec{a}\) and \(\gamma_{\beta\beta'}\) are the crystallite constant and the crystallite's force constant, respectively. The crystallite exists only in one excited state such that its unique mode is characterised by the vibrational energy \(\hbar \omega_0 = m_0 c^2\). In this mode all particles vibrate in directions transferal to the vector of motion of the particle (along this vector vibrations are impossible owing to the migration of the crystallite as a whole along the mentioned vector).

The motion of a particulate cell accompanied by its deformation coat looks as follows: at each next movement, the particulate cell moves on the crystallite constant \(\vec{a}\), which is practically identical with the size of cell of the tessel-lattice (i.e. the Planck's fundamental length \(l_f\)), the crystallite mode \(\hbar \omega\) attacks the particle, knocking a fragment of its deformation out of it, or in physical terms, a fragment of mass \(\delta m\).
The direction and the velocity of this elementary excitation called **inerton** poses the crystallite mode whose speed is identified with the velocity of light \( c \); if \( v \) is the velocity of the particle, then the direction and value of the \( i \) -inerton is found from the vector sum of velocities, such that the inerton velocity is \( c_{\text{inert}} = \sqrt{c^2 + v_i^2} \). Ejected inertons must turn back to the particle, because otherwise the particle would lose its velocity (and also mass) will eventually stop. The number \( N_{\text{inertons}} \) of ejected inertons can be associated with a number of collisions of the particle with adjoining cells, which takes place in the section \( \lambda / 2 \) where the velocity of the particle drops from the value \( v \) to zero. For instance, in the case of an electron in the hydrogen atom \( N_{\text{inertons}} \approx \lambda / (2t_1) \approx 10^{25} \). Inertons ejected from the particle come back to it reflecting from the tessel-lattice. Returned inertons bring the velocity and mass back to the particle and, hence, they guide it in the next section \( \lambda / 2 \) of the particle path. Such periodical motion can be described by equation

\[
\mu d^2 r / dt^2 = -\gamma r.
\]

The maximal distance which the particle's inertons reach, the amplitude of the inerton cloud, is \( r_{\text{max}} = \Lambda \).

Thus inertons periodically project out of the particle and then return. The motion of the particle and the inerton cloud enclosing it can be described by the Lagrangian (here it is simplified)

\[
L = \frac{1}{2} m \dot{x}^2 + \frac{1}{2} \mu \dot{\chi}^2 - \frac{\pi}{T} \sqrt{m \mu} \dot{x} \chi
\]

where \( T \) is the free run time of the particle between its collisions with the inerton cloud; then \( 1 / T \) is the frequency of collisions.

The solutions for the particle

\[
\dot{x} = v_0 \cdot (1 - |\sin(\pi t / T)|); \tag{4}
\]

\[
x(t) = v_0 t + \lambda \cdot \{(1 - [t / T]) \cos(\pi t / T) - (1 + 2[t / T])\} \tag{5}
\]

show oscillations of the particle's parameters: the velocity periodically changes from \( v \) to zero, \( v_0 \rightarrow 0 \rightarrow v_0 \) in each section \( \lambda \) of the particle's path. Therefore, the section \( \lambda \) is the spatial amplitude of the particle.
Analogously for the particle's inertons:

\[ \chi = \frac{\Lambda}{\pi} |\sin(\pi t/T)|; \]

\[ \dot{\chi} = c(-1)^{[t/T]} \cos(\pi t/T), \]

that is, the inerton cloud periodically leaves the particle and comes back and the parameter \( \Lambda \) appears as the amplitude of oscillations of the inerton cloud.

The following relationships hold:

\[ \frac{1}{T} = \frac{v_0}{\lambda} = \frac{c}{\Lambda}. \]

**Figures:** Motion of the particle is associated with the ejection and reabsorption of its inerton cloud and shows an oscillation of its parameters; in particular, the velocity of the particle gradually decreases from the initial value \( v_0 \) to zero and then increases again to \( v_0 \) in each section \( \Delta \) of the particle's path.

With the use of the transformation

\[ \]
\[ \dot{\kappa} = \dot{\chi} - \pi \sqrt{m/\mu} \frac{x}{T} \]

we can obtain the Hamiltonian that describes the motion of a particle as to the centre of inertia of the system 'particle-inerton cloud':

\[ (10) \]

\[ H = \frac{1}{2} \frac{p^2}{M} + \frac{1}{2} M \left( \frac{2\pi}{2T} \right)^2 x^2. \]

However, this is the Hamiltonian of harmonic oscillator and hence such motion of the particle can be written in the form of the Hamilton-Jakobi equation for the shortened action \( S_1 \)

\[ (11) \]

\[ \frac{1}{2m} \left( \frac{\partial S_1}{\partial x} \right)^2 + \frac{1}{2} m \left( \frac{2\pi}{2T} \right)^2 x^2 = E \]

where \( E \) is the energy of the moving particle. Introducing variables action-angle we obtain an increment of the action per cycle \( T \):

\[ (12) \]

\[ \delta S_1 = \int p dX = E \cdot 2T. \]

This equation can be rewritten though the frequency \( \nu = 1/2T \). At the same time \( 1/T \) is the collision frequency of the particle with its inerton cloud. Taking into account that \( E = mv^2/2 \) we also can write (below \( p_0 = mv_0 \) is the initial momentum)

\[ (13) \]

\[ \delta S_1 = mv_0 \cdot v_0 T = p_0 \lambda. \]

Identifying two left hand sides of equations (12) and (13), i.e. the increment of the action \( \delta S_1 \) per the period \( T \), with Planck's constant \( h \), we get two basic relationships of quantum mechanics

\[ (14) \]

\[ E = h\nu \quad \text{and} \quad \lambda = h/p_0. \]

These two de Broglie's relationships enable us to derive the Schrödinger equation (see de Broglie [7]). Thus the spatial amplitude \( \lambda \), which has been introduced above, can be set equal to the de Broglie wavelength of a particle.
The availability of correlations $\Lambda = \frac{\lambda}{v_0}$ and the de Broglie wavelength $\lambda = \frac{h}{mc}$ allow us to deduce the very interesting relationship:

\begin{equation}
\Lambda = \frac{\lambda_{\text{Com}} c^2}{v_0^2},
\end{equation}

which connects the amplitude of the inerton cloud $\Lambda$ with the size of the deformation coat (crystallite) $\lambda_{\text{Com}}$.

From relationship (15) one can see that in the case of a small velocity of the particle, $v_0^2/c^2 \ll 1$, the amplitude of the inerton cloud is significantly larger than the range of the deformation coat: $\Lambda \gg \lambda_{\text{Com}}$. The inerton cloud carries the kinetic energy of a particle and a detector will record the particle with the energy $E = \frac{mv^2}{2}$. Therefore, in this case for the description of such particle we have to use Schrödinger's formalism.

When the velocity of a particle is close to the velocity of light, $v_0 \sim c$, the amplitude of the inerton cloud comes very close to the range of the deformation coat, $\Lambda \sim \lambda_{\text{Com}}$. But the deformation coat together with the kernel (particulate cell) is specified by the total energy of the canonical particle and the detector will record the particle just with this energy, $E = m_0c^2/\sqrt{1 - v_0^2/c^2}$. Because of that, for the description of the particle in this situation we have to use the Dirac formalism.

The analysis above shows that it is the deformation coat that causes a peculiar phase transition from the Schrödinger formalism to the Dirac formalism when the particle's velocity $v$ approaches the speed of light $c$. Moreover, in addition the particle features also an inner motion (asymmetrical pulsations), which is mapped on the formalism of quantum mechanics as the particle's spin.

The inerton cloud is expanded up to the distance $\lambda/2$ along the particle path and occupies a band width $2\Lambda$ in transversal directions. The formalism of quantum mechanics does not take the reality of the inerton cloud into consideration but fills a range around the particle with an abstract wave $\psi$-function.

The results stated in this article enable us to reveal the true physical interpretation of the wave function $\psi$ as the particle's field of inertia.

Then the expression the "material wave" acquires a real sense, because now behind this term we see not an abstract probability $|\psi(r)|^2$, but the
material field of inertia of the particle and inertons become carriers of this field.

Such an interpretation of the physical nature of the wave $\psi$ -function completely satisfies those conditions that Louis de Broglie laid down, namely: There should be another solution for the Schrödinger equation and the wave function should have a true causal physical meaning and not statistical.

It is interesting to note that this allegedly abstract function $\psi$ was directly observed in experiment [8] (so it is not so abstract!). The researchers put in the title of their paper: "Looking at electronic wave functions...". The inerton field has been detected in our experiments.

Furthermore, submicroscopic mechanics is a starting point for an understanding and the derivation of Newton's law of universal gravitation, the problem of quantum gravity and the nuclear forces.

Bibliography


Spin

Usually physical encyclopedias write the following about spin in quantum mechanics. In quantum mechanics spin is a fundamental property of elementary particles, atomic nuclei and hadrons. Spin direction is treated as an important intrinsic degree of freedom. Spins have important theoretical implications and practical applications. The electron spin is the key to the Pauli exclusion principle and to the understanding of the periodic system of chemical elements. Spin-orbit coupling leads to the fine structure of atomic spectra. Electron spins play an important role in magnetism. The photon spin is associated with the polarization of light. For instance, all the electrons have spin s = 1/2. The photon spin is thought to be 1.

There have been a number of approaches to understanding the phenomenon of spin (see, reviews, i.e. in papers [1,2]).

Submicroscopic mechanics points to the fact that a moving canonical particle periodically changes its characteristics, i.e. its basic parameters, such as velocity \( v \), mass \( m \) and charge \( e \) are not constant but oscillate on the length of the spatial period \( \lambda \), which has been identified with the particle's de Broglie wavelength. These parameters have their maximum value in points \( \lambda \cdot l \) of the particle's path (where \( l = 0, 1, 2, 3, \ldots \) ) and zero in points \( \lambda/2 \cdot l \) of the particle's path (where \( l = 1, 3, 5, 7, \ldots \) ). Parameters which supplement the mass and charge, namely the tension (or the rugosity) of space \( \xi \) and the magnetic charge \( g \) respectively, oscillate in counter-phase: from zero in points \( \lambda \cdot l \) of the particle's path (where \( l = 0, 1, 2, 3, \ldots \) ) to the maximum value in points \( \lambda/2 \cdot l \) of the particle's path (where \( l = 1, 3, 5, 7, \ldots \) ).

In submicroscopic mechanics we can introduce one more parameter, an intrinsic motion of a particle, which can easily be mapped to the notion of spin in quantum mechanics. Namely, a pulsation of the volume of a particulate cell can be associated with the manifestation of spin as used in quantum mechanics [1]. In the real physical space in the section of \( \lambda \) the moving particle changes its shape from the initial strain bean-like shape in points \( \lambda \cdot l \) of the particle's path (where \( l = 0, 1, 2, 3, \ldots \) ) to the non-strain spherical shape in points \( \lambda/2 \cdot l \) (where \( l = 1, 3, 5, 7, \ldots \) ). This intrinsic motion may have the same kinetic energy as the kinetic energy of the particle's translational movement, \( mv^2/2 \).
The mentioned intrinsic motion, pulsation, features the quantum equation

(1)

\[ \left( \frac{\hat{\Pi}_\alpha^2}{2m} - e_\alpha \varepsilon_\alpha \right) \chi_\alpha = 0. \]

Allowing that the induction \( B \) is aligned solely with the \( O^e \) axis, instead of equation (1) we can write

(2)

\[ \left( \frac{\hat{\Pi}_{\alpha_1}^2}{2m} + \frac{\hat{\Pi}_{\alpha_2}^2}{2m} - e_\alpha \varepsilon_\alpha \right) \chi_\alpha = 0. \]

where the operators satisfy the equation

(3)

\[ [\hat{\Pi}_{\alpha_1}, \hat{\Pi}_{\alpha_2}] = i\hbar \mathcal{B}. \]

With allowance for the function \( e_\alpha = \pm 1 \), we can get the solution for the eigenfunction \( \chi_\alpha \) and the expression for the eigenfunctions \( \xi \uparrow(\downarrow) \) in the representation of the so-called operator of the spin projection onto the axis \( Oe^3 \):
where, as is known, the eigenvalues of this operator

\[ \varepsilon_{\uparrow(1)} = \frac{eB}{m} \hat{S}_3, \]

(4)

Correction (4) to the particle energy which is due to the intrinsic degree of freedom, should be inserted into the total particle spectrum renormalising the eigenvalue \( E \) to the value \( E + eBS_{\uparrow(1)3}/m \). The renormalised equation goes into the Pauli equation. They differ only in the mass quantity: in submicroscopic mechanics the relativistic mass of the particle \( m \) enters the Schrödinger equation with the spin component, which includes the interaction of spin with an applied magnetic field. But only the mass at rest \( m_0 \) appears in the conventional Pauli equation. However, if the terms proportional to \( v_0/c \) are accounted for, the Schrödinger equation with the spin component derived in the framework of submicroscopic mechanics and the Pauli equation coincide.

In the submicroscopic approach, the Dirac equation is derived from the Hamiltonian that includes the intrinsic motion of the particle in question (a new term \( c^2 \pi^2 \uparrow(1) \) that has not been taken into account so far), i.e.

\[ H_{\uparrow(1)}^{\text{part.tot}} = \sqrt{c^2 \vec{p}^2 + c^2 \vec{\pi}^2_{\uparrow(1)} + m_0^2 c^4}. \]

(6)

The Hamiltonian (6) includes additional terms associated with two possible projections of intrinsic pulsations of particles. Therefore, if we decompose the square root in expression (6), which has a matrix form, we must obtain the equation in a matrix form too. This is the inner reason why the Dirac equation should possess matrix components associated with the particle spin.

Particles that have an integral spin are particles combined of simple particles with half-integer spin.

Since the photon is not a particle, but a quasi-particle of real physical space, we cannot write down any quantum equation for it in the form similar to equation (1). That is why the notion of spin cannot be applied to this field particle which is an excitation of space. In the case of the photon we should rather use the term "integer-valued polarization" \( \pm 1 \).

Bibliography

Gravitation
Preliminary knowledge

Gravitation is the theory dealing with attraction of massive objects. Gravity is a force; it makes things move toward each other. Physics describes gravitation by using Newton's law of universal gravitation (formulated in 1687) in which the gravitational force of attraction between two objects with masses \( M_1 \) and \( M_2 \) separated by a distance \( r \) has the form

\[
F = -G \frac{M_1 M_2}{r^2}
\]

where \( G = 6.67410^{-11} \) N m\(^2\) kg\(^{-2}\) is the gravitational constant. From expression (1) we can obtain the potential energy of gravitation

\[
V = -G \frac{M_1 M_2}{r}
\]

and the gravitational potential generated by a mass \( M \) in its surrounding

\[
U = -G \frac{M}{r}.
\]

Let us mention here the integral form of Gauss' law for gravity, which states:

\[
\oint_{\partial S} \vec{g} \cdot d\vec{s} = -4\pi GM
\]

where \( \partial S \) is any closed surface, \( d\vec{s} \) is a vector whose magnitude is the area of an infinitesimal piece of the surface \( \partial S \) and whose direction is the outward-pointing surface normal; \( M \) is the total mass enclosed within the surface \( \partial S \). The left-hand side of equation (4) is called the flux of the gravitational field; it is always negative (or zero), and never positive (although for electricity Gauss' law allows fluxes to be either positive or negative, because the charge can be either positive or negative, while mass can only be positive).
The Gauss law (4) is interesting to us, as it introduces the gravitational field $\tilde{g}$, which is a vector field that originates from the central point, i.e. the point of location of mass $M$.

Since 1916 Newton's law has been superseded by Einstein's theory of general relativity. General relativity is only required when there is a need for extreme precision, or when dealing with gravitation for very massive objects. General relativity or the general theory of relativity is the geometric theory of gravitation published by David Gilbert and Albert Einstein in 1916. The theory unifies special relativity and Newton's law of universal gravitation and describes gravity as a property of the geometry of space and time, or space-time. In particular, the curvature of space-time is directly related to the four momenta (mass-energy and linear momentum) of whatever matter and radiation are present. The relation is specified by the Einstein field equations, a system of 10 differential equations.

General relativity became very popular due to the prediction of three phenomena (two of them were very new), which were confirmed experimentally in 1919-1920. Namely, general relativity predicted:

1. The Motion of Mercury's perihelion by an amount
   \[ \Delta \phi = \frac{6\pi GM_{\text{Earth}}}{(Lc^2)} \]
   where $M_{\text{Earth}}$ is the Earth's mass, $L$ is the focal parameter, $c$ is the velocity of light;

2. The Bending of a light ray by the sun, i.e. the following angle deviation of the ray from the direct line was derived:
   \[ \Delta \phi = \frac{4GM_{\text{Sun}}}{(rc^2)} \]
   where $M_{\text{Sun}}$ is the Sun's mass, $c$ is the velocity of light and $r$ is the radial distance from the centre of the Sun to the point where the light ray is bending;

3. The Gravitational red shift of spectral lines
   \[ \Delta \nu = \frac{-GM\nu_0}{(rc^2)} \]
   on the surface of the massive body whose mass is $M$, $r$ is the radius of the body, $\nu_0$ is the frequency of generated light without the presence of gravity.

General relativity predicted also gravitational time dilation and gravitational time delay, which were observed as well. However, unanswered questions remain, the most fundamental one being how general relativity can be reconciled with the laws of quantum physics to produce a complete and self-consistent theory of quantum gravity. Nevertheless, it seems this challenge cannot be resolved in principle because of principal differences in approaches to physical laws by microscopic quantum physics and phenomenological general relativity. Besides, general relativity does not look like a true physical theory but rather like an abstract mathematical theory.
In the case of general relativity, which denied the classical ether and introduced an abstract vague vacuum, we can distinguish five problems, conceptual difficulties, that do not have resolutions in the framework of relativity formalism:

- general relativity is founded on the basic Newtonian term $-\frac{GM}{r}$, but cannot explain its origin;
- a massive object can influence space-time but cannot be derived from it, because the unknown and undetermined parameter mass is entirely separated from the phenomenological notion of space-time;
- the formalism of relativity is failing on a microscopic scale as it does not pay attention to the wave nature of matter. At distances compared to or less than the object’s de Broglie wavelength $\lambda$ the formalism of general relativity has to give way to an approach based on microscopic consideration;
- general relativity does not offer any sorts of particles/quasi-particles, which will be able to realize short-range action in the gravitational attraction of objects and hence it is a theory based on an action-at-a-distance phenomenological approach, the same as the Newtonian theory (and also quantum mechanics whose long-range action also falls within the range of its conceptual difficulties); regarding quasi-particles gravitons we can say that, based on the studies of other researchers [1] as well as experimental results [2], these are abstract mathematical objects absent in real nature;
- light, which plays an exceptionally important role in relativity, has to be massless in theory; however, light carriers, photons, transfer momentum and energy and therefor by the principle of equivalence, photons must have non-zero mass.

Sub-microscopic consideration

1. Derivation of Newton’s gravitational law

The submicroscopic concept based on the constitution of physical space and submicroscopic mechanics allows a detailed theory of gravity to be derived which suggests a radically new approach to the problem of quantum gravity and allows the derivation of Newton’s gravitational law from first subatomic principles. Such approach completely removes all difficulties that concern the action-at-a-distance phenomenology by introducing inertons as carriers of the interaction between massive objects.
Since any motion in the tessel-lattice generates clouds of inertons - mass excitations of the real physical space - may be considered as the actual carriers of the gravitational field as it occurs in Gauss's approach (4) to the problem of gravity.

The cloud of inertons surrounding the particle spreads out to a range \( \Lambda = \lambda c / \nu \) from the particle center where \( \lambda \) is the particle's de Broglie wavelength and \( \nu \) and \( c \) are velocities of the particle and light, respectively. Since inertons transfer fragments of the particle's mass, they also play the role of carriers of gravitational properties of the particle. First of all we should understand how inertons emitted by the particle come back to it, returning fragments of its mass as well as the velocity. The behaviour of the particle's inertons can be studied in the framework of the Lagrangian [3,4]

\[
L = -m_0 c^2 \left\{ \frac{T^2}{2 m_0^2} \dot{m}^2 + \frac{T^2}{2 \Lambda^2} \dot{\xi}^2 - \frac{T}{m_0} \dot{m} \nabla \dot{\xi} \right\}^{1/2}.
\]

Here \( m(r,t) \) is the current mass of the \{particle-inerton cloud\} system; \( \xi(r,t) \) is the variable that describes a local distortion of the tessel-lattice, which can be called the rugosity or tension (see in inerton); \( T \) is the time period of collisions of the particle and its inerton cloud.

The Euler-Lagrange equations for variables \( m \) and \( \xi \) is

\[
\frac{\partial}{\partial t} \frac{\partial L}{\partial \dot{q}} - \frac{\delta L}{\delta q} = 0.
\]

The equations for \( m \) and \( \xi \) become

\[
\frac{\partial^2 m}{\partial t^2} - \frac{m_0}{T} \nabla \dot{\xi} = 0; \quad \frac{\partial^2 \xi}{\partial t^2} - \frac{\Lambda^2}{m_0 T} \nabla \dot{m} = 0.
\]

Taking the initial and boundary conditions as well as the radial symmetry into account, we can obtain the following solutions to equations (7) and (8):
These solutions exhibit the dependence $1/r$, which is typical for standing spherical waves.

The solution for mass $m$ (9) shows that at a distance $r \ll \Lambda$ the time-averaged distribution of mass of inertons along the radial ray which originates from the particle, becomes

$$m(r) \approx l_\xi m_0 r.$$

In this region the rugosity (or tension) of space, as followed from expression (10), is: $\xi \approx 0$.

When the local deformation is distributed in space around the particle, it forms a deformation potential $\propto 1/r$ that spreads up to the distance $r = \Lambda$ from the particle's kernel-cell.

In the range covered by the deformation potential, cells of the tessel-lattice are found in the contraction state and it is this state of space which is responsible for the phenomenon of the gravitational attraction.

In terms of physics, the distribution (11) is replaced with the Newton's gravitational potential

$$U(r) = -G \frac{m_0}{r},$$

where the gravitational constant $G$ plays the role of a dimensional constant.

An object, which consists of many particles (a solid, a planet, or a star), experiences vibrations of its entities (atoms, ions, particles). Entities vibrate in the neighborhood of their equilibrium positions and/or move to new positions. These movements produce inerton clouds around the appropriate particles. Inerton clouds overlap forming a total inerton cloud of the object [5]. The spectrum of inertons is similar to the
spectrum of phonons, as inertons immediately appear when entities move from their initial position, which is discussed in submicroscopic mechanics (we may say that a body of phonons is filled with inerton carriers). For instance, if we have a solid sphere with a radius \( R_{\text{sph}} \), which consists of \( N_{\text{sph}} \) atoms, the spectrum of acoustic waves consists of \( N_{\text{sph}}/2 \) waves with the wavelengths \( \lambda_n = 2an \) where \( a \) is the mid-distance between nearest atoms and \( n = 1, 2, 3, \ldots, N_{\text{sph}}/2 \).

At the same time, inertons that accompany acoustically vibrating atoms produce also their own spectrum and the wavelengths of these collective inertonic vibrations can be estimated by expression

\[
\Lambda_n = 2an \frac{c}{u_{\text{sound}}}.
\]

Also note that the behaviour of these inerton oscillations obeys the law of standing spherical waves, i.e. the dependence of the front of the inerton wave must be proportional to the inverse distance from the source irradiating the wave, \( 1/r \).

For instance, a solid sphere with volume \( 1 \text{ cm}^3 \) includes around \( 10^{22} \) atoms; estimating the velocity of sound \( u_{\text{sound}} \approx 10^3 \text{ m/s} \) (order of magnitude) and the distance between atoms \( a = 0.5 \text{ nm} \), we obtain for the amplitude of the longest inerton wave: \( \Lambda_{N/2} \approx 10^{18} \text{ m} \). Thus, up to this distance the inerton field of the solid sphere is able to propagate in the form of the standing spherical inerton wave.

To the solid sphere studied we may now apply the same consideration which has been done above for the gravity of a particle. In particular, expression (12) is also applicable for the case of an massive object.

Therefore, we were able to derive Newton's potential (12) in terms of short-range action provided by inertons, carriers of mass properties of objects. Being averaged in time, a mass field around the object studied can be considered as a stationary gravitational potential (3).

The availability of the rugosity/tension \( \xi \) around a massive object may be able to shed light on the problem of so-called "dark matter", because in places with a more or less significant value of \( \xi \) the distortion of the tessel-lattice is quite significant. Hence a kind of a repulsion force, which is caused by the local tension of space, can appear at the interaction of masses located in such places.
The theory presented sheds light on the principle of equivalence, which proclaims the equivalence of gravitational and inertial masses: $m_{\text{grav}} = m_{\text{inert}}$. Namely, this equality, which is held in a rest-frame of the particle in question, becomes invalid in a moving reference frame. In the quantum context, this equality should be transformed to the principle of equivalence of the phases of gravitational and inertial waves, $\phi_{\text{grav}} = \phi_{\text{inert}}$. This correlation ties up the gravitational and inertial energies of the particle and also shows that the gravitational mass is completely allocated in the inertial wave that guides the particle. De Haas [6] was the first who came to this conclusion when comparing Mie’s variational principle and de Broglie's harmony of phases of a moving particle. So the matter waves consist of kernel, particle and its inerton cloud, which exchange velocity, mass and hence energy and momentum; this exchange occurs owing to the strong interaction of the particle and its inertons with the tessel-lattice and it is this interaction that causes the induction of the gravitational potential in the range of spreading of the particle's/object's inertons.

2. Correction to Newton's gravitational law [7]

The sub-microscopic approach points out to the fact that the gravitational interaction between objects must consist of two terms: (i) the radial inerton interaction between two masses $M$ and $m$, which results in the classical Newton gravitational law (2), and (ii) the tangential inerton interaction between the masses, which is caused by the tangential component of the motion of the test mass $m$ and which is characterized by the correction:

(13)

$$\delta V = -G \frac{Mm}{r} \frac{r^2 \phi^2}{c^2}.$$

Note that the existence of such a correction is in line with a remark by Poincaré [8] who stated that the expression for the attraction should include two components: one is parallel to the vector that joins positions of both interacting objects and the second one is parallel to the velocity of the attracted object. Thus the velocity of an object must influence the value of its gravitational potential.

By using the total expression for the gravitation

(14)

$$V = -G \frac{Mm}{r} \cdot \left(1 + \frac{r^2 \dot{\phi}^2}{c^2}\right)$$
we can study three problems that were investigated by general relativity, namely: 1) the motion of Mercury’s perihelion; 2) the bending of light by the sun; 3) the gravitational red shift of spectral lines. Expression (14) allows us to examine the three problems in the framework close to that carried out in terms of classical physics, not general relativity. Expression (14) enables the immediate and easy derivation of the same equations of motion that general relativity derived by using complicated geodesic equations. That is why having the same equations describing these three problems, we can use the same solutions pointed out in the above section Preliminary knowledge.

Therefore it does not make sense to use the complicated mathematics of general relativity to solve this or that challenge. The physics of the phenomena studied is hidden in the potential energy (14), which describes the interaction of two attracting objects.

This approach also clarifies the situation with so-called "black holes", which were introduced in physics at the end of the 1960s. The approach described above shows that a point mass $M$ at rest possesses the conventional Minkowski flat-space metric, i.e. is exactly exemplified by Newton’s gravitational potential (12) and hence does not show any singularity. But this metric disturbed by a smaller mass $m$ changes to the Schwarzschild metric (or maybe another metric) in the location of the smaller mass.

In other words, a point mass does not have any peculiarity in its metric, its metric is flat/linear. The sub microscopic consideration of gravity suggests no reasons to hypothesize a "black hole" solution. Only an outside source of the gravitational field is able to disturb the flat metric of a heavy central mass. Thus researchers dealing with the formalism of general relativity must be extremely careful in application of their theoretical results to the description of the surrounding.

**Bibliography**


**Nuclear Forces**

The **nuclear forces** determine the interaction between two or more nucleons in an atomic nucleus. They are responsible for binding of protons and neutrons. The nuclear force is nearly independent of whether the nucleons are neutrons or protons. This property is called charge independence. To a large extent, this force can be understood in terms of the exchange of virtual light mesons, such as the pions. Sometimes the nuclear force is called the residual strong force, in contrast to the strong interactions that are now understood to arise from quantum chromodynamics (QCD). Since nucleons have no colour charge available in the interaction between quarks, the nuclear force does not directly involve the force carriers of QCD, i.e. gluons.

**Difficulties**

At the same time, the understanding of how QCD works remains one of the great puzzles of many-body physics. Indeed, the degrees of freedom observed in low energy phenomenology are totally different from those appearing in the QCD Lagrangian. In the case of many-nucleon systems, the question of the origin of the nuclear energy scale is immediately aroused: the typical energy scale of QCD is in the order of 1 GeV, even though the nuclear binding energy per particle is very small, in the order of 10 MeV. Is there some deeper insight from which this scale naturally arises? Or should the reason be looked for in complicated details of near cancellations of strongly attractive and repulsive terms in the nuclear interaction?

Recent high precision measurements [1] of the deuteron electromagnetic structure functions ($A$, $B$ and $T_{20}$) extracted from high-energy elastic $ed$ scattering and the cross sections and asymmetries extracted from high-energy photodisintegration $\gamma + d \rightarrow n + p$ have been reviewed and compared with theory. The rigorous results [1] demonstrate that QCD and the meson theory seem to disagree. Hence the origin of nuclear forces in an unperturbed nucleus is still unclear.

Regarding a possibility of deriving nuclear forces from the quark-quark interaction, Santilli [2] reasonably remarks that quarks can only be defined in a mathematical unitary space that has no direct connection to an actual physical reality. Then he continues: “It is known by experts that, because of the impossibility of being defined in our space-time, quarks cannot have any scientifically meaningful gravitation, and their masses are pure mathematical parameters in the mathematical space of SU(3) with no known connection to our space-time.” Indeed, quarks cannot be defined through special relativity and its fundamental Poincaré
symmetry. Therefore, this means that mass cannot be introduced as the second order Casimir invariant. However, this is the only necessity for mass to exist in our space-time. In other words, the basic challenge of deducing the gravitational interaction from quarks seems completely unfeasible.

Taking into account the mentioned fundamental difficulties, Santilli, developing hadronic mechanics, started from the hypothesis that in a system of strongly interacting particles the total Hamiltonian cannot be subdivided into kinetic and potential parts. Hadronic mechanics is constructed via a non-unitary transform of orthodox quantum mechanics, namely the unitary character appears only at a distance larger than the radius of nuclear forces $10^{-15}$ m.

Such a transform allows the introduction of a modernized Lie product, Pauli matrices, Dirac equation, etc. So, the conventional Hamiltonian of relativistic quantum mechanics and the appropriate spinors are transformed to new Santilli isomathematical presentations. The mathematics developed enabled the calculation of basic parameters of nuclear systems, which exactly agreed with the experimental data [2].

Unlike conventional quantum mechanics that operates with point particles and their appropriate wave packets, or wave functions, hadronic mechanics deals with the extended particles that feature peculiar shapes in our space-time. Hadronic mechanics predicts a strongly coupled structure for a proton and electron i.e. in hadronic mechanics the neutron is treated as a strongly coupled proton-electron pair. Hence the nuclear forces are associated with the pure Coulomb interaction between protons and neutrons. Thus in hadronic mechanics the origin of nuclear forces is completely plain: this is the usual Coulomb interaction between nucleons.

**Sub-microscopic standpoint**

None of the quantum theories being developed pays any attention to the background of the systems studied, i.e. the structure and peculiarities of the real physical space. The theories are developed in abstract spaces: energy, momentum, phase, Hilbert and so on. Instead of the background space they use such completely undetermined notions as a “physical vacuum” or/and an ether providing them with every possible and imaginary properties. It seems the aforementioned quotation from Santilli regarding quarks as objects that are not determined in the space-time is the apt turn of phrase, which emphasizes the validity of our criticism.
As was hypothesized in paper [3], we can consider the interaction of two nucleons that closely approach each other to start their interaction through their respective deformation coats that touch each other, because any canonical particle in the tessel-lattice is specified by the deformation coat. For nucleons in a nucleus the radius of such coat coincides with their Compton wavelength, i.e.

\[ \lambda_{\text{Com}} = \frac{h}{cM_0} \approx 1.32 \times 10^{-15} \text{ m}, \]

which exactly coincides with the experimentally detected radius of nuclear forces (here we set approximately \( m_{\text{proton}} \approx m_{\text{neutron}} = M_0 \)). The behaviour of the deformation coat can be treated in terms of vibrating particles of a crystallite, see submicroscopic mechanics.

In the crystallite, vibrations of all particles (i.e. superparticles of the tessel-lattice, which have distortions) co-operate and the total energy of superparticles, which is equal to the total energy of the particle, \( M_0 c^2 \), is quantized,

\[ \hbar \omega_k = M_0 c^2 \]

where \( k = \frac{2\pi}{\lambda_{\text{Com}}} \) is the wave number and \( \omega = ck \) is the cyclic frequency of an oscillator in the \( k \)-space (the quantity \( \lambda_{\text{Com}} \) is the amplitude of the oscillator, which is given by the crystallite size, i.e. Compton wavelength. Below we designate radius of the crystallite as \( R_0 \), which in the undisturbed state can be set equal to \( \lambda_{\text{Com}} \).

Vibrating superparticles of one coat begin to interact with those of the other coat. It is a fact that the interaction between two oscillators reduces the total energy of the oscillators.
Since the interaction of nucleons can reduce their energy by 47 MeV (in agreement with the Fermi gas model, see e.g. Ref. [4]), we can write the equality

\[ \frac{1}{1 + \frac{\Delta R}{R_0}} \approx (938.26 - 47) \text{ MeV} \]

that makes it possible to estimate an effective range \( \Delta R \approx 0.053R_0 \) of the overlapping of deformation coats of two nucleons.

Such an overlapping can virtually draw two nucleons together, but only a little. A deeper penetration into the core can be achieved only in the case of weighty nuclei when the collective motion of a great number of nucleons is allowed for.

The total mass of the nucleon and the superparticles in its deformation coat increases too: \( M_0 \rightarrow M_0 + \Delta M \) where \( \Delta M = M_0 \cdot \Delta E/(M_0c^2) \approx (0.037 \text{ to } 0.05) \cdot M_0 \).

Hence the notion of a “potential well” implies that in the range of space covered by the well, spatial blocks, i.e. superparticles, are found in a more contracted state than in the space beyond the potential well.

Thus the consideration above shows that the coupling of nucleons through their deformation coats is a beneficial process.

One more source of nuclear forces is associated with the overlapping of inerton clouds of moving nucleons. Such an approach allows the study of the deuteron problem from a deeper viewpoint. In particular, the study [3] shows that the radius of the deuteron \( R_d = 2.85 \times 10^{-15} \) m, which exceeds the double radius \( R_0 = \lambda_{\text{Com}} = 1.32 \times 10^{-15} \) m. Therefore, in the case of the deuteron the proton-neutron coupling occurs rather through overlapping of their inerton clouds than through the compression of their deformation coats, as is the case for heavy nuclei.

In heavy nuclei nucleons try to gather in clusters such that the number of nucleons \( A \) in a cluster is linked with the elasticity constant \( \gamma \) of the inerton field in this nucleus, the nuclear density \( \rho \) and the elementary charge \( e \) of the proton. \( A \) is inversely proportional to \( \gamma \) : an increase in \( A \) requires a decrease in \( \gamma \) approaching to the critical value of \( \gamma_c \), such that at \( \gamma < \gamma_c \) the inerton field is incapable of holding nucleons in the cluster and hence this particular nucleus has to be unstable.

**Bibliography**

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Vedic Physics

The most interesting interpretation of the Vedic heritage has been done by two physicists: Dr. Subhash Kak [1] and Dr. Raja Ram Mohan Roy [2].

Kak [1] notes that Sayana, Prime-minister of India in the 14th century, could decipher an extract from *The Rigveda* from which followed that the value of the velocity of light was equal to 300,000 km/s. Note that in Europe, Danish astronomer O. Römer could measure the same value of the velocity of light only in 1676, i.e. around 150 year later.

Roy [2] showed that in *The Rigveda* and other ancient Vedic books under names of gods, people and their activity with the participation of domestic animals there was coded the ancient knowledge about the structure of space, cosmology and elementary particles. In particular, he discloses the structure of the real space called in *The Rigveda* loka: loka has a web structure, it consists of indivisible cells; cells are characterised by their interface. Then he derived the notion of the electric charge from a few verses of *The Rigveda*: "The electric charge is kept and plays on the surface of the particle." He identified names of gods with elementary particles: God Varuna = electron; God Mitra = proton; God Aryama = neutron; God Vishnu = universe; God Vritra = surface tension of the universe; God Indra = electric force; God Rudra = radiation; sage Vasistha (rich, a rich man) = atomic nucleus.

Then by Roy [2] the Vedic cosmology says that : 1) the universe had a beginning and it started very cold; 2) mass-energy content was zero at the beginning; 3) mass-energy is created in the form of matter and anti-matter; 4) mass-energy continuously has been created; 5) the universe has a center; 6) the universe has a boundary and all processes of creation of matter take place near the surface of the universe.

Let us read *The Bhagavad-Gita* together with Bhaktivedanta Swami Prabhpada, the great religious scholar. Let us touch Chapter 2, which is a review of the book. It contains the information on the existence of the first cause of matter in the form of an indivisible thing that is usually called "soul". However, Bhaktivedanta Swami Prabhpada noted [3] that soul should also be understood as a subtle particle. Then we can read in the chapter the following: "In spite of the material body being subject to destruction, the subtle particle is eternal" (*Bhg.*: 2.18); "It never takes birth and never dies at any time nor does it come into being again when the material body is created. It is birthless, eternal, imperishable and timeless and is inviolable when the body is destroyed" (*Bhg.*: 2.20); "After some time it is disenthralled by entire annihilation of the material body. Yet it endures the destruction of the material world" (*Bhg.*: 2.22); "It is not fissionable, not burning out, not soluble, and not drying
up" (BhG.: 2.23); "Since it is not visible, its entity does not change, its properties remain unchangeable" (BhG.: 2.24). Then in Chapter 8 we can read in addition: "Yet there is another nature, which is eternal and is transcendental to this manifested and unmanifested matter. It is supreme and is never annihilated. When all in this world is annihilated, that part remains as it is" (BhG.: 8.20)

Thus, it seems The Bhagavat-Gita discloses, in particular, the information on a structural brick of the real space that exists in the form of a web net. This brick, the subtle particle cannot annihilate; it is eternal and cannot be destroyed. This knowledge on the structural brick of space is an additional confirmation of the correctness of Roy's [2] deciphering presented briefly above, first of all that the real space has the structure of a web net (and each cell of the net is occupied by a "subtle particle").

Now you may compare this article with others in this brief encyclopedia, in particular, see physical space and charge.

P.S. Today of course nobody can guarantee a 100% that Vedic gods would be associated with elementary particles. However, a true researcher cannot reject such a possibility in principle. If the majority of physicists abandon their prejudices regarding the study of ancient heritage under the target of modern knowledge, they findings would similar to the conclusions of Dr. Roy [2]. Who know? And why not? In any case the verses of The Bhagavat-Gita presented above explicitly reveal a substructure brick, a subtle particle, of the real space...

Bibliography


Experimental verification of inertons

Owing to the overlapping of inerton clouds of vibrating atoms in a metal, those inertons should contribute to the effective potential of interaction of atoms in the crystal lattice. The possibility of separating this inerton contribution from the value of the atom vibration amplitude is analysed.

The experiment which assumes the presence of the hypothetical inerton field is performed. We anticipated that the rotating Earth should generate the motion of inertons from the west to the east and also along the diameter of the globe. In this case we can install a resonator of inerton waves of the Earth, which has to satisfy the following conditions:

\[
\frac{2\pi R_{\text{Earth}}}{4R_{\text{Earth}}} = \frac{\pi}{2},
\]

Here, \(R_{\text{Earth}}\) is the radius of the Earth; \(2\pi R_{\text{Earth}}\) in the path of inertons generated in a point A, which run along the surface of the Earth coming back to the source in which they were generated, \(4R_{\text{Earth}}\) is the path of inertons back to the source A located on the surface of the globe, when these inertons start along the diameter of the globe.
If we install a device in point A which shape satisfies conditions (1), i.e. the ratio of the base $a$ and the height $h$ is also equal to $\pi / 2$, the device will act as a resonator of inerton waves of the Earth.

To test the hypothesis, we put in such a resonator a razor blade and studied its morphological structure in an electron microscope. As is visible, the fine morphological structure indeed changed; a crude morphological structure remained the same.

The expected changes in the structure of the test specimens caused by the inerton field were in fact convincingly fixed in micrographs ($a$ - reference specimens; $b$ - test specimens).

The two opposite concepts – multiphoton and effective photon – readily describing the photoelectric effect under strong irradiation when the energy of an incident light is essentially smaller than the ionization potential of gas atoms and the work function of a metal are treated. Taking into account that the electron is an extended object that is not point-like, the study of the interaction between the electron and a
photon flux is carried out in detail. A comparison with numerous experiments is performed.

Laser pulses with an intensity $10^{12}$ to $10^{18}$ W/cm$^2$ of low energy photons is able to ionize gas atoms, which was studied in many experiments. To describe the phenomenon, researchers concentrated on the multi photon concept by L. Keldysh (1964), which modified the simple photoelectric to a nonlinear consideration in which the atom is ionized by absorption of several photons. The $N$th-order time dependent perturbation theory changes the usual Fermi golden rule to $N$-photon absorption that produces a complicated expression for the probability $w^N$. However, in the 1970s E. Panarella stressed that many experiments could not be explained in the framework of the multi photon theory. The multiphoton concept just failed to interpret fine details revealed in the experiments. E. Panarella suggested an effective photon concept in which $N$ photons would gather together in a clump that bombard as a whole an atom ejecting photons. So, in Panarella’s model the photoelectric effect became linear again. This concept could explain many experiments carried out both in gases and metals.

The submicroscopic concept started from the idea that electrons in atoms or in a metal should be treated as extended objects, but not point-like: an electron together with its inerton cloud has the length equal to their de Broglie’s wavelength $\lambda$ and the electron's inerton 'wings' spread up to the distance $\Lambda = \lambda c/v$ in transferal directions around the particle. Hence, the cross-section of the electron’s inerton cloud: $\Lambda \lambda \approx 100$ nm$^2$ (because the velocity of electrons is around $3 \cdot 10^6$ m/s). Thus, such an object is able to absorb $N$ photons simultaneously, which can be considered an anomalous photoelectric effect. The corresponding probability was calculated and was applied to describe tens of different experiments on generation of photoelectrons in gases and a metal. The results are completely satisfactory. Indeed, If the intensity of a laser pulse $I = 10^{16}$ to $10^{18}$ W/cm$^2$, we can estimate a mean distance between photons in the flux of laser pulse as $d \approx 3$ to $4$ nm.
The picture above shows the electron surrounded by its cloud of inertons. Then the number of photons (yellow points and arrows), which bombard the electron’s inerton cloud is: $\Lambda\lambda/d^2 \sim 10$. In other words, the size of the electron (jointly with its inerton cloud) is large enough and can absorb up to 10 photons from a laser flux simultaneously. The total energy of these 10 photons exceeds the ionized potential of atoms in a gas (or the work function in a metal).

3) V. Krasnoholovets, Collective dynamics of hydrogen atoms in the $\text{KIO}_3\cdot\text{HIO}_3$ crystal dictated by a substructure of the hydrogen atoms' matter waves, [http://arXiv.org/abs/cond-mat/0108417](http://arXiv.org/abs/cond-mat/0108417)
The behavior of the subsystem of hydrogen atoms of the $\text{KIO}_3 \cdot \text{HIO}_3$ crystal, whose IR absorption spectra exhibit equidistant submaxima in the vicinity of the maxima in the frequency range of stretching and bending vibrations of OH bonds is studied in the present work. It is shown that hydrogen atoms co-operate in peculiar clusters in which, however, the hydrogen atoms do not move from their equilibrium positions but vibrate synchronously. The interaction between the hydrogen atoms is associated with the overlapping of their matter waves, i.e. inertons. The exchange by inertons results in the oscillation of hydrogen atoms in clusters, which emerges in the mentioned spectra. The number of atoms which compose the cluster is calculated and the spectrum of such cluster is computed.

Below numerical calculations of IR spectra are imposed upon experimental curves (solid line) of IR spectra of the $\text{KIO}_3 \cdot \text{HIO}_3$ crystal. Theoretical curves show that the cluster state of hydrogen atoms features sub maxima that are very close to the appropriate experimental maxima.
Electron clusters, X-rays and nanosecond radio-frequency pulses are produced by 100 mW continuous-wave laser illuminating ferroelectric crystal of LiNbO$_3$. A long-living stable electron droplet with the size of about 100 µm and velocity ~ 0.5 cm/s moves freely in the air near the surface of the crystal, experiencing the Earth gravitational field.

The microscopic model of cluster stability, which is based on submicroscopic mechanics developed in the real physical space, is suggested. It was assumed that the laser beam knocked not photoelectrons, but also inertons from the crystal. Inertons are knocked out from overlapping inerton clouds of atoms that form the crystal lattice. Therefore, knocked photoelectrons surrounded by knocked inertons become unstable to the formation of a cluster.

In the cluster, the role of a restraining force is played by the inerton field, a substructure of the electrons’ matter waves, which can elastically withstand the electrons' Coulomb repulsion. It is shown that electrons in the droplet are in fact heavy electrons whose mass at least 1 million times exceeds their rest mass. Their mass has increased owing to the absorption of inertons ejected from the crystal by laser.

Nonlinear enhanced back-reflected scattering from the ferroelectric crystal surface as seen on the screen with the hole (left side of each picture). On the right side is the specular reflected beam with a ‘droplet’ for two frames (separated by 1 sec) from the video.

5) V. Krasnoholovets, S. Skliarenko and O. Strokach, On the behavior of physical parameters of aqueous solutions affected by the inerton field of Teslar
We present studies of the behavior of the permittivity of such liquid systems as pure distilled water, alcohol and 50%-aqueous solutions of alcohol as affected by the inerton field generated by a special signal generator contained within a wrist-watch or bracelet made by so-called Teslar technology. It has been found that the changes are significant. The method employed has allowed us to fix the value of frequency of the field generated by the Teslar chip. The frequency has been determined to be approximately 8 Hz. The phenomenological consideration and submicroscopic foundations of a significant increase of the permittivity are studied taking into account an additional interaction, namely the mass interaction between polar water molecules, which is caused by the inerton field of the Teslar chip.
The samples represented a mixture of water and alcohol: 50% of water and 50% of alcohol. With time alcohol evaporated and the capacity of samples has to drop, which is seen on the upper graph. However, when a Teslar watch is approached to the cuvette, the inerton field of the watch strongly suppresses the movement of water and alcohol molecules, which also decreases the capacity of the sample; this is seen in the lower figure.

The possibility of recording physical changes in aqueous solutions caused by a unique field generated by the Teslar chip (TC) inside a quartz wristwatch has been studied using holographic interferometry. We show that the refraction index of degassed pure distilled water and aqueous solutions of L-tyrosine and b-alanine affected by the TC does not change during the first 10 minutes of influence. In contrast, a 1% aqueous solution of plasma extracted from the blood of a patient with heart vascular disease changes the refractive index when affected by the TC. The characteristic time of reaction is about $10^2$ seconds.

In the photograph the dynamics of the fringe pattern of the aqueous solution of plasma of human blood affected by 2 Teslar chips is presented. The strong disturbance of the optical density of the solution emerges already after 72 s.

Thus we could unambiguously prove that the Teslar watch generates the inerton field, which is associated with a substructure of the matter waves (and does not depend on the electromagnetic nature). Consequently, the defect of mass $\Delta m$ becomes an inherent property not only of atomic nuclei but also of any physical, physical chemical and biophysical systems.