The Structured Vacuum Theory

Part I: Brief exposition of the Structured Vacuum Theory (STV)

A. Axelrod

Contacts: e-mail Alex@Remot.Energy

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The presented in this paper model sheds light on the matter spatiotemporal organization in the universe and mechanisms standing behind physical laws. The model describes origins of such basic phenomena as inertial and gravitational masses, electrical charge, and magnetic momentum. The model provides geometrical interpretation of traditional physical concepts. Brief exposition of the proposed by the SVT model of the universe organization appears in the following table. Detailed discussion of the matter spontaneous evolution from complete disorder to the structured universe may be found in the chapter entitled "Chain of the superfluid flow transformations and the vacuum lattice genesis" in Axelrod (2023).

Physical concept	The model interpretation of the concept
The universe energy	The entire energy of the universe is stored in perpetual streamline flows of the inviscid incompressible superfluid substance. The substance flows form 3D structure known as physical vacuum and occupying the entire volume of the universe. Actually, the structured matter forms a space in which physical laws are observed. The process of the space genesis and the inner logic of this process are exposed below in this section in greater details.
Algorithm of the superfluid flow dynamical evolution	Adopting as an axiom the energy conservation principle and its supreme role in the entire physics, we may logically come to the conclusion that the primary goal of the universe existence is efficient conservation of the stored in it energy. The universe system is in permanent process of self-optimization. Recognition of the energy conservation law primacy leads to logical conclusion that the optimized parameter is the *energy storage efficiency*. In Axelrod (2023a) the traditional Lagrange-Hamilton optimization principle is reformulated as the steepest ascent of the system to the state of its optimally high quality factor, $Q = \frac{P_{TOT}}{P_{LOSS}}$. Here P_{TOT} is the reactive power of all

inner oscillations comprising the physical system, and P_{LOSS} is the active power of the system radiation losses. The commandment of the steepest quality factor maximization may be interpreted as the system behavioral algorithm leading to the following actions:

a) pursuit to storage of maximum possible amount of the total power P_{TOT} of its inner oscillations, and
b) diminishing efflux of the stored power through its boundaries, i.e. minimization of its radiation losses P_{LOSS}.

The novel formulation of the system dynamics algorithm allows us to take a fresh look at the system organization and leads us to the clue on the optimal way to accomplishment of the energy conservation task. The new formulation of the Lagrange-Hamilton principle appears to be very fruitful since it reveals the real motivation standing behind several well-known phenomena:

a) **spontaneous generation of natural harmonic oscillators:** resonance is the basic method to bind some amount of free *kinetic* energy, either gravitational or electromagnetic, to the same amount of *potential* energy, either gravitational or electromagnetic, forming basic harmonic oscillator. In the SVT kinetic and potential energy components have physical meaning of energy carried by longitudinal and transverse velocity components in helical flows of the superfluid substance. Resonance features equal division of the oscillation energy between kinetic and potential components, averaged along the oscillation period. The SVT interprets such a behavior as an attempt to share the total energy of the superfluid stream between all available degrees of freedom: translational and rotational. Isolated resonant massive physical objects are shaped as tori with large aspect ratio of toroidal and poloidal radii of rotation. As will be explained below, this curved shape plays the key role in the resonant process of energy exchange.

b) **abundance of coherent collective oscillations in the nature:** global coherent oscillations is the optimal modus operandi for creation of the optimally stable systems. Coherent oscillations of a large system of coupled oscillators prevent collisions within the system and diminishes generation of free randomized energy;

c) **the systems strive to generation of clustered resonant structures, including lattices:** the agglomeration proved to be very efficient algorithm for the long-range energy storage and attraction in a broad frequency spectrum of oscillations. Lattices are the ultimate form of the agglomeration of a large number of identical objects. Quantum-scale lattices have crystalline structure with hexagonal symmetry. The hexagon shape is the result of topological constraint of isolated ring resonators agglomeration into the lattice. In a course of the agglomeration, curved double-helical streams are straightened, but the curvature is relocated into vortex sites at the hexagon's corners. Lattices of coherent oscillators are systems with enhanced stability (Q-factors) and optimally large number of degrees of freedom of their inner coherent oscillations;

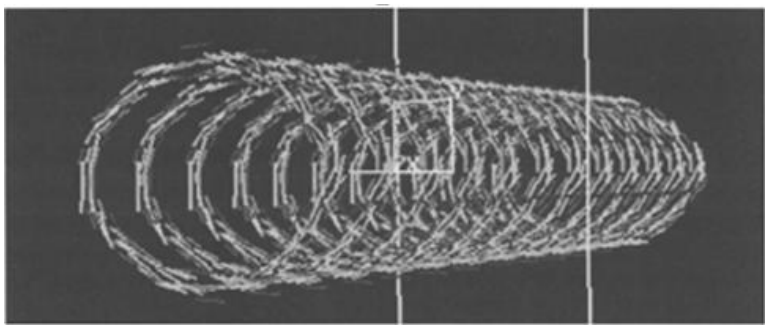
d) **abundance of systems with multiple-scale hierarchal nested architecture:** nesting is the optimal strategy for complex physical system to reach the highest possible Q-factor. Fractal architecture of nested systems features maximal energy density and minimal losses. Fractals are multidimensional objects with self-similar detail across

	size and/or time scales. Visualization of a fractal structure requires the creation in our imagination of a new axis, along which we will place objects of different sizes. Thinking of fractals in categories of this new axis, gives birth in your imagination to a multiple-scale architecture with the series of discrete rigid ordered structures building the system backbone. The nested ordered structures of different scales occupy the same volume. Gaps along this axis of spatial dimensions are filled by the material medium which motion carries the fraction of randomized energy. In this image, the coherent areas of the ordered structures are intermitted with apparently randomized medium. The impression is that the backbone of discrete ordered structures is immersed in the continuous amorphous and vibrant medium (see Fig. 1); This randomized fraction energetically interconnects the rigid ordered structures of different dimensions granting to the entire system its vitality and ability for adaptive variations. Such architecture appears to be the optimal solution for stable energy storage since energy losses of objects of one scale are consumed by the objects of the other scale, saving the total system losses. Effective energy coupling between objects of different scales is done by the method of *spatial resonance*. The spatial resonance employs the technique of complete potential-to-kinetic (and vice versa) energy exchange between two stable states of the system belong to two different adjacent spatial scales. For instance, the high-Q *toroidal resonance* in double-helical torus structure with high aspect ratio is the private case of spatial resonance. The toroidal resonance is due to full exchange between energies of toroidal and poloidal rotations, whereas the poloidal rotation represents fine-scale structure compared with the much larger spatial scale of toroidal rotation. In summary, multi-scaling is the optimal method of energy compression and long-term storage.
Vacuum quantization to discrete plurality of lattices. Vacuum lattice of Planck scale	The vacuum structure was generated as the system response to the demand for confinement and storage of certain amount of energy in some limited space. Such vision does not exclude and even invites the hypothesis on existence of some larger supreme structure in which the universe is just one of its ordinary members, and is the result of some larger-scale energy quantization to multiple universes. But this issue is out of scope of this paper limited by the scale of a single universe. The vacuum is the dominant holder of the universe energy and has fractal multiple-scales hierarchal structure quantized to nested 3D sub-lattices of different spatial scales. The 3D sub-lattice of each scale is composed of four sets of parallel 2D honeycomb sheets (see Fig.2). A relatively recent work (Bos, James, M., et.al. (2018)) is devoted to the collective behavior in a two-dimensional system of a self-propelled active fluid, the elements of which were given the initial energy of chaotic motion. Computer simulation showed a transient process accompanied by multiple collisions of fluid elements culminated by spontaneous generation of a hexagonal lattice structure of vortices. The authors of the paper come to the conclusion that *"the emergence of a dynamic hexagonal vortex lattice state after an extended turbulent transient, can only be explained taking into account turbulent energy transfer across scales."* To the question

	of where the kinetic energy of the initially chaotic motion of the superfluid elements went, the authors answer that as a result of the transition process, this energy is concentrated in the motion within the vortex sites. At each given location, honeycomb sheets belonging to different sets intercept, and have relative orientation of 120° (see Fig. 3). In the dimension of spatial scales, the *vacuum lattice* is the boundary sub-lattice of the largest spatial scale and of the lowest (among other sub-lattices) frequency and energy density. It is composed of hexagonal cells with perimeters equal to the Planck wavelength, all involved in coherent oscillation at the Planck frequency $\mathrm{F_{PL}} = 2.952 \cdot 10^{42}\mathrm{Hz}$. The vacuum lattice plays a special role in our physical reality. All together, the hierarchy of 3D sub-lattices of all spatial scales smaller and including the Planck scale, form the entire vacuum multiple-scale fabric storing the dominant amount of the universe energy within the frequency band $[f \geq F_{PL}]$. Geometry of the vacuum lattice is given in Fig. 3 and its pivotal role in the hierarchy of spatial scales of the matter organization is illustrated on Fig.1.
The matter quantization to tightly coupled vortices	Each sub-lattice of any spatial scale may be presented as a 3D lattice of identical hexagonal vortices tightly energetically coupled by straight filament sections of double-helices (see Fig.4). The vortex site also has the hexagonal shape and belongs to the sub-lattice of the next smaller scale. The geometry shown in Fig.4 explains the energy coupling mechanism. In cases of abnormally high or abnormally low energy level in one scale, the self-regulation takes place, and the energy flows between sub-lattices of different scales until the balance in all lattices is restored. This mechanism enables also periodical nonlinear anharmonic energy oscillations, in which are involved sub-lattices of several spatial scales.
Quantization of the lattice of each scale to identical hexagonal cells. Curvilinear trajectories of monochromatic excitations in the 3D vacuum lattice.	In alternative presentation, the same 2D honeycomb lattices may be viewed as composed of numerous *tightly coupled* identical hexagonal *cells* with superfluid bidirectional circulations around each cell. Both presentations of the lattice are equivalent. Ayzenberg-Stepanenko, M., et.al. (2008) demonstrated for the 2D case that monochromatic excitations of frequencies close to the lattice resonance frequency propagate along the straight beam trajectories, and that the beams are directed along the lattice axes of symmetry. In the vacuum lattice the resonance frequency corresponds to F_{PL}, and the Planck-frequency waves propagate strictly along three axes of symmetry *without dispersion*. This effect is equivalent to superconductivity of the vacuum lattice at this specific

	frequency (*). These waves serve as the energy carriers for all observable excitations in the universe. All observable reality is the result of the Planck carriers modulations by frequencies $\Omega \ll F_{PL}$. The modulation frequencies are usually named the De Broglie frequency. These excitations occupy side harmonics located on the frequency axis very close to the F_{PL}. Hence the detectable excitations should propagate *nearly* strictly along the straight trajectories coinciding with axes of symmetry and should exhibit small energy dispersion effect. The dispersion effect steadily grows at larger modulation frequency Ω. Any monochromatic excitations may be viewed as low-frequency modulation $[f < F_{PL}]$ of the carrier wave oscillating with the Planck frequency, and spectral component corresponding the excitation is very close to the Planck frequency since $(F_{PL} - f)/F_{PL} \approx 1$. Hence all monochromatic excitations carrying energy of any elementary particle propagate along 1D curvilinear trajectories. This result supports the basic axiom of the String Theory. (*) The superconductivity Type II effect was revealed for Bose-Einstein condensate (BEC) lattices of much larger spatial scales, but the dispersionless energy propagation mechanism is the same Abrikosov A. A. (2003).
Stable vs. unstable physical objects	All physical objects including lattices may be characterized by the parameter of temporal stability, i.e. longevity. The objects stability makes them abundant, and we may assert that they belong to the category of *really existing*. In contrast, the unstable object may be ad-hoc generated due to sporadic contribution of random energy, but is so short-living that it is not detectable. Within the structure of any temporarily *stable object* belonging to any spatial scale, is satisfied the resonant condition of full exchange between *equal* amounts of energies of symmetric and anti-symmetric propagation modes in a course of the modes circulation along the perimeter of the object structure or, if we observe the lattice stability, along the perimeter of each cell of the lattice. The necessity to comply with this resonance condition stands behind existence of the *discrete* frequency (or energy) spectrum of the universal vacuum structure and behind the phenomenon of matter structuring to energetically separated series of nested spatial scales.
The object temporal stability	The temporal stability of each physical object may be characterized by its Q factor. The most important for our physical reality object is the Planck-scale vacuum lattice, the largest-scale among the plurality of lattices exhausting the universe‘s free energy. The undetectable unperturbed vacuum lattice is much more stable compared with detectable objects, particles. The lattice is the energetic backbone of our reality. It provides mechanisms for all observable by us energy transformations and gives birth to

	all elementary particles in the form of its own phononic excitations. The energy remnant after the vacuum lattice generation is stored within the massive particles and is redistributed to long ranges mainly by means of zero-rest-mass particles, like photons and their analogs carrying gravitational energy, gravitons.
The mechanism of energy exchange between objects of different scales	The curved geometry of the double-helical ring resonators breaks the double-helical symmetry and enables mutual transformation between anti-symmetric (gravitational energy) and symmetric (electromagnetic energy) propagation modes.
Mechanisms of conservation of linear and rotation momenta in 3D vacuum lattice	In the case of 3D lattices small deviation Ω from the Planck frequency also causes the energy dispersion. The dispersion broadens the propagation path, which becomes broader, and appears a mechanism of gradual switching of the excitation energy from one axis of symmetry to the other, gradually changing the direction by 60°. Eventually, small sections directed along the symmetry axes, comprise propagation along the straight axis of *arbitrary direction* in space. For the large-scale observer the propagation propagates along the straight line of arbitrary direction, which is in line with the principle of linear momentum conservation. Such behavior is typical for propagation of photon excitation along the vacuum lattice. In the vacuum lattice areas with abnormally increased (or decreased) energy density, the system finds another ingenious way to compress (or dilute) the energy density in confined structures with abnormally high (or low) energy density. The lattice ability to change the direction of propagation for monochromatic excitation is employs in these cases for spontaneous generation of closed ring resonators tuned to the resonant frequency equal to the excitation frequency Ω. This effect is akin to the formation of tobacco smoke rings by an initially linear fast flow in a viscous medium. This effect is of special significance, since it is the basis for generation of massive particles with either positive or negative masses. In the nonlinear crystalline structures this effect is responsible for generation of rotating bright (or dark) solitons of circular shape possessing topological charge, e.g. Afanasjev, V. V. (1995). As it will be discussed in length below, in the SVT this mechanism explains generation of mass and electrical charge effects. Both effects are due to creation of ring resonant structures with abnormally large energy densities.
Creation of helical trajectories of monochromatic	In addition to the nonlinear effect of circular structures generation, the linear Mechanism A of energy conversion shown in Fig.3 performs gradual transition of the excitation energy from one 2D lattice to the other, oriented by 120°. In these sites two

excitations with $f \ll F_{PL}$ propagating along the vacuum lattice.	energy flows belonging to two different sets of 2D lattices intercept at 90° angle. Such interception site does not violate symmetry of the intercepting double-helical flows, but is able to couple some amount of the excitation energy from the excitation in one 2D honeycomb lattice to the other 2D lattice, relatively oriented by the angle of 120°. This lattice-to-lattice coupling mechanism is akin the worm-gear mechanism, transmitting motion from one plane to a perpendicular plane. Eventually, the excitation energy transfers from the longitudinal to transverse rotation and the originally linear trajectory of the excitation is converted to helical. This means that the excitation switches from one Planck-frequency carrier to the other (*). (*) Alike vacuum lattice, structures of wave-like and particle-like excitation, e.g. photons, are also composed of helices of much larger spatial scales. Actually, they are replicas of the vacuum lattice helical or double-helical architectures, but of much larger scale. The following figure shows the fine structure of large helix composed of thin elements belonging to the fine scale. Actually, the thin lines comprising the large-scale helix are also double-helices supporting oscillations of Planck frequency.  This image was generated by numerical simulations of Nonlinear Schrödinger Equation (NLSE), copied from the paper by Nore, C., et.al.(2006), reproducing the instabilities of non rotating and rotating cylindrical jets confirm the author's hypothesis on helical-shaped photons. The authors performed numerical simulations of the NLSE, and studied a swirling jet of liquid. The ARGLE software converged solution consists in locked-up helices. Under NLSE dynamics, the helices undergo a cork-screw like motion, with little acoustic emission. The dynamics corresponding to an helix with a (small) random perturbation is rich and complex and includes reconnection phenomena.
Energy exchange between longitudinal and transverse velocity components	Besides changing the shape of the excitation structure, the mechanism A gradually converts energy of linear motion along the propagation axis to energy of the transverse rotation. Eventually, the energy exchange between longitudinal and transverse velocity components is complete, and the entire excitation energy is concentrated in the transverse rotation. This process is bidirectional, and there are areas of high energy density of longitudinal component intermittent with areas of high energy of transverse velocity component. For the large-scale observer this is equivalent to generation of orbital momentum, experimentally observed phenomenon of the photon propagation

	with De Broglie frequency much smaller than F_{PL}.
Different behavior patterns of monochromatic excitations below and beyond the Planck frequency	Above discussion focused by two alternative scenarios of monochromatic excitation in the vacuum lattice. The excitation frequency was assumed to be Ω, and we assumed that the excitation is in a form of modulated Planck-frequency carrier. We assumed that the spectral line is below the F_{PL}. We may assert that the Planck frequency is the highest frequency of the vacuum lattice conductance band. In the stop band above the boundary Planck frequency, the excitation energy stops its longitudinal propagation along the vacuum lattice and starts the immersion process deeper into the cascade of discrete sub-lattices with resonance frequencies $[f \geq F_{PL}]$ thus feeding fractal vacuum structure. The Fig.6 provides pictorial illustration of the vacuum structure, including excitations behavior below and beyond the Planck frequency.
Hidden energy of the anti-symmetrical structures. Anti-symmetric double-helical flows.	Due to its ideal anti-symmetry of streamline shapes, the entire *unperturbed* vacuum structure is not experimentally detectable. All structural elements comprising the vacuum lattice, including straight sections and vortex sites, are either straight or curved ideally anti-symmetric *double-helices*. In our experiments we are able to detect only the result of broken symmetry in the double-helical vortex structures. In the Fig.4 we showed the hexagonal shape of the vortex sites, which leads to conclusion that areas with broken symmetry of double-helices are confined in corners of hexagons. Asymmetric elements in the vacuum lattice are able to emit energy into the surrounding vacuum lattice, which is mostly ordered structure featuring the property of perfect energy attractor. The attraction mechanism is straightforward: (a) the radiated energy spectrum occupies frequency band with the upper frequency much smaller than the Planck frequency, (b) the random excitation is the phononic excitation modulating the Planck-frequency carrier waves, propagating along the curvilinear trajectories, (c) the Planck-scale cells located along these trajectories form finite-length sections of curvilinear transmission lines of practically arbitrary length, which resonate with practically any wavelength of the randomized spectrum, (d) these spontaneously generated curvilinear sections attract the energy of the resonating spectral component, (e) the attracted to the lattice randomized energy is condensed to observable stable resonant structures of elementary massive particles and to photons forming background electromagnetic radiation, known as relict radiation.
The anti-symmetric excitation mode is the major energy	The only energy resource of the superfluid flows is its velocity. In the unperturbed vacuum, the longitudinal velocity is limited by the light velocity *c* and the total velocity is $c\sqrt{2}$. Within the structure of massive particle energies of the flows are increased by

holder in the universe	amplitude modulation of the velocity and may reach the peak value of $2c\sqrt{2}$. It may be easily shown that the anti-symmetric excitation mode is the preferable energy carrier as compared with the symmetric mode. Let us add the same amount v of the longitudinal component of the excitation velocity of the unperturbed vacuum. First let us do this in the anti-symmetric way: $v^{\parallel}_{(1)exc} = c + v, \quad v^{\parallel}_{(2)exc} = -c - v$. This operation led to the change of the kinetic gravitational energy carried by the longitudinal component by an amount equal to $\Delta E_a = (c+v)^2 + (-c-v)^2 - 2c^2 = 4cv + 2v^2$. If the same velocity v is added in the anti-symmetric way, taking into account that in the unperturbed vacuum the symmetric velocity component is zero, the added kinetic electromagnetic energy will be $\Delta E_s = v^2 + v^2 = 2v^2$. Obviously, the amount stored in the anti-symmetrical excitation mode is greater by an amount of $\Delta E_a - \Delta E_s = 4cv$. In addition, the radiation losses of the anti-symmetric component in curved double-helical flows are much less than of the symmetric component. This leads us to conclusion that the energy storage with the highest Q-factor may be achieved in anti-symmetric flows of anti-symmetric excitations of the vacuum lattice. We can observe manifestation of this in all surrounding us reality, where the dominant portion of the observable physical objects is stored in the anti-symmetric flow of gravitational masses. In the universe, the electromagnetic excitation plays only secondary role of long-range energy transmission and of the binding additive of energy needed for binding gravitational energy to confined structures of quark particles. In the ideally ordered fraction of the unperturbed vacuum the energy of anti-symmetrical flow is due to radiation losses, and constitutes miserably small part of the total stored energy.
The Matter and Anti-Matter	The double-helices may be either right-hand, in areas of the universe occupied by the *Matter*, or left-hand in the areas occupied by the *anti-Matter*. The following discussion is limited by the case of Matter dominant in our area of the universe and featuring the right-handed chirality. It is logical to speculate that both types of chirality have equal right to exist in the universe, but most probably that our local area has some preferable type of chirality. At least the Matter is much more abundant in our local area than the anti-Matter.
The light velocity	Refer to Fig.5a and Fig. 5b. The helical flow may be decomposed to longitudinal and transverse velocity components. Correspondingly, energy storage is implemented by means of longitudinal and transverse flow motions. In the SVT model, members of this

	decomposition are distinguished as carriers of kinetic and potential energies, respectively. Fig.5b. shows only one of two elementary helices comprising the double-helix. Elementary infinitesimally small section δl performs 360° azimuthal rotation and simultaneous translational motion along central axis $\hat{\boldsymbol{z}}_0$. As shows the picture, superfluid flows are assumed to be stream-like. All streams comprising the Planck-scale lattice have uniform cross-section S_0 and constant per-unit-length superfluid density ρ_0. In the unperturbed state, the helical streams' velocity vector has transverse and longitudinal components, each equal to $c = 3 \cdot 10^8 m/sec$, known as the light velocity. The c value depends on the local energy density in the universe and may be nonuniform in structures of galactic scales.
The lattice excitations and their division to symmetric and anti-symmetric propagation modes.	Straight and curved double-helical filaments operate simultaneously as energetic backbones of 3D sub-lattices of each spatial scale and as transmission lines supporting wavelike propagation of the lattice excitations. All physical objects, the traditional object of the physics science, are just different types of the vacuum lattice phononic excitation. The excitation waves in double-helical transmission lines may be decomposed to two propagation modes: anti-symmetric and symmetric. The SVT postulates that the anti-symmetric excitations are perceived by us as carrying the *gravitational energy*, while the symmetric excitation mode carries the energy of *electromagnetic excitations*.
The role of straight double-helical sections	Six straight sections of each hexagonal cell are shaped as straight double-helical filaments operating as transmission lines. These sections serve as energy highways within the lattice, or within the excitation objects of *the same spatial scale*. Within these straight sections, symmetric and anti-symmetric excitation modes are decoupled, and exchange between gravity and electromagnetic energies is not feasible.
The role of vortex sites	The hexagon corner sites are occupied by vortices. In lattice of any scale, each vortex is composed of nested double-helices curled to hexagons (see Fig.4) and belonging to the lattice of smaller spatial scale. Hexagon vortices of nested spatial scales collectively form the vortex site. Each hexagon of each scale is composed of clockwise and counterclockwise right-hand helical flows forming double-helical ring resonators. The hexagon-shaped ring resonators of different scales are energetically coupled by randomized energy of the radiation (or dispersion) losses of curved structures of all scales. As a result, vortices operate as multiple-scale multiple-frequency resonators with discrete resonant spectrum. The entire frequency spectrum of the vortices is a

	combination of randomized broadband background and discrete spectrum of resonant frequencies of lattices of a variety of spatial scales. The vortices energetically couple a discrete plurality of 2D lattices of all spatial scales and serve as highways for the flow of excitation energy from scale to scale. In summary, the vortex site has two additional functions (a) of the energy storage site, and (b) of the structural element enabling spectrum broadening which is critically important for the processes of energy exchange between lattices of different scales.
Phase delay	The phase delay is the parameter traditionally used as the qualitative indicator of stage of the process of energy exchange between kinetic and potential energies. In the SVT model, all energy exchange processes take place in a course of excitation wave propagation along double-helical transmission lines. Hence the large-scale observer may use the phase delay as an averaged parameter. In classical electrodynamics phase delay is perceived as the inherent feature of the empty space. The SVT model teaches us that the energy exchange takes place exclusively within the vortex sites, and is the process occurring in discrete steps. The phase delay may be assigned to energy transformation processes within the same spatial scale, or for the energy transformation in a course of energy exchange between lattices of different scales.
Two facets of the phase delay concept	In classical mechanics and Maxwell's electromagnetic theory phase delay is associated with energy exchange between kinetic and potential energies of the wave propagation process. In quantum mechanical treatment of the superfluid dynamics, the superfluid has the special property of having phase parameter. The superfluid is deemed irrotational; however, if the enclosed region actually contains a smaller region with an absence of superfluid, for example a rod through the superfluid or a vortex, then the circulation is $$\int_C \vec{\boldsymbol{v}} \cdot d\vec{\boldsymbol{l}} = \frac{\hbar}{m} \int_C \nabla\phi_v \cdot d\vec{\boldsymbol{l}} = \frac{\hbar}{m} \Delta^{tot} \phi_v$$, where $\hbar$ is Planck's constant divided by 2π, m is the mass of the superfluid particle, and $\Delta^{tot} \phi_v$ is the total phase difference around the vortex (see Wikipedia chapter on Quantum Vortex). Formally, the phase is contributed by the wavefunction describing the superfluid matter that obeys the Schrödinger wave equation. In the presented in this paper SVT model, there are two categories of exchange between kinetic and potential energies: (a) within the linear wave processes occurring within the same spatial scale, and (b) within the nonlinear wave process of energy exchange between lattices of different spatial scales.

	The energy exchange sites of both categories are marked in the Fig.3 as points **A** and **B**, respectively. Correspondingly, the phase delay concept is twofold. For instance, in the linear electromagnetic wave processes the phase delay reflects the status of energy exchange between the electrical and magnetic modalities of electromagnetic energies. In contrast, in the nonlinear wave process of energy exchange between lattices of two adjacent spatial scales, the phase delay is the measure of energy exchange between kinetic/potential energy components of symmetric and anti-symmetric constituents of the curled double-helical flow. The phase delay is developed along the superfluid flows at any spatial scale, and is specific for each given scale: there are many periods of small-scale oscillations in a single oscillation periods of the large-scale propagation process. Phase delay is the inherent attribute of the wavelike bidirectional motion of the superfluid substance. In each spatial scale, the energy exchange, and correspondingly phase delay, are both attributes of the curved sections (a part of the multi-scale vortex sites) and is not present in straight sections of the same spatial scale. Nevertheless, the large-scale observer belonging to the much larger spatial scale than the Planck lattice, cannot distinguish the wave process with the fine-scale resolution, and experiences an illusory impression that phase delay phenomenon is continuously distributed property of any wave process of his macroscopic scale. Moreover, such observer is unable to observe the wave process of energy exchange between different scales of the matter organization. This is the major difficulty of experimental exploration of the Planck-scale mechanism of energy exchange between electromagnetic and gravitational phenomena.
The role of broken symmetry	In the SVT, any detectable physical phenomenon is either the consequence of broken symmetry in the vacuum lattice, or due to existence of confined area with abnormally large energy density. Closer observation reveals that the abnormally large energy density is also the result of the broken symmetry in curved (typically ring) double-helices. In other words, in our physical reality we are aware only of the result of the broken symmetry, but have no experimental information on the presence of the absolutely balanced vacuum structure, symmetry of which is broken. Paradoxically, in our traditional physics models we take into account any slight ripple of the broken symmetry of a big whole, but neglect the big whole itself! As a result, we count all energies not from the absolute zero level of motionless superfluid matter, but from the average energy level of the unperturbed vacuum, in which matter streamlines move with the velocity equal to $c\sqrt{2}$. The broken symmetry of the vacuum structure is (a) the source of the free energy involved in wave processes taking place within structures of

	ordered stable physical objects of any spatial scale, and (b) the source of wideband randomized energy necessary for energy exchange between objects belonging to different spatial scales.
Order vs. chaos in the universe	Stable physical objects store in their resonant structures the ordered fraction of the universe energy, while the randomized energy is released by the ordered fraction and is the origin of random events, chaos. The ordered and the randomized fractions are in permanent dynamic energy exchange. Due to the wideband randomized free energy emitted from the vortex sites, any lattice within the multiple-scale vacuum structure behaves as an active medium. The emitted free energy with spectral components below the Planck frequency, induces excitations propagating exclusively along 1D curvilinear trajectories traced in the vacuum lattice. Excitation energy of each wavelength is stored in coherent motions of chained cells of the vacuum lattice located along the excitation 1D propagation path. Collectively, the chained vacuum cells constitute the structured body of the monochromatic excitation. Traditionally, in quantum mechanics, the monochromatic excitation and its spatiotemporal distribution are solutions of Schrödinger equation, but the concept of continuous particle's structure with finite length is denied. In the STV model, the Schrödinger equation survives, but the interpretation of its solutions is quite different. The matter restructuring process is going on also for monochromatic excitations within the frequency spectrum above the Planck frequency. The beyond-the-Planck-scale sub-lattices operate as energy attractors restructuring the released randomized energy. Similarly, the Planck-scale vacuum lattice, representing the largest boundary scale of the vacuum hierarchal structure, is the energy attractor restructuring the randomized free energy within the frequency band below the Planck frequency.
Elementary particles	The randomized energy released by the Planck-scale vacuum lattice is sufficient only for structuring of discrete spatially isolated resonant 1D curvilinear structures, known as *particles*. In parallel to the chaos condensation to the ordered particles, there is a reverse process of the particles decay due to inherent dispersion radiation losses. The lossy mechanisms are inherently built into the curved structures of the double-helical ring resonators representing massive particles, and into helical structures of photons and gravitons. Energy of active losses is released by the ordered particles in a form of randomized phononic excitation of the vacuum lattice. As a result of this bidirectional process of condensation and dispersion, the vacuum and the particles are in permanent balanced dynamical energy exchange.

Particles as phononic excitations of the vacuum lattice	Each stable elementary particle may be addressed as the resonant phononic excitation of the vacuum crystalline structure. The utmost elementary massive objects, quarks, are shaped as double-helical ring resonators. Remarkably, experimental investigation, Michel Hehn, et.al. (1996), of 3D lattices revealed two types of stable phononic structures, one shaped as ring, and the other shaped as helical spiral. The ring resonators correspond to fermionic massive particles, whereas the photon boson particle is the excitation shaped as helical spiral.
Photon	Photons are phononic excitation generated by means of *phase modulation* of the Planck-frequency carriers comprising the vacuum lattice. The photon generation is equivalent to creation of specific phase distribution along the chain of vacuum cells constituting the curvilinear photon's structure. It never changes the total velocity of the superfluid stream, and just dynamically redistributes the total energy between potential (transverse velocity) and kinetic (longitudinal velocity) components. The phase modulation does not require investment of additional energy. Hence, the total energy density within the structure of photon excitation is identical to that of the unperturbed vacuum, and this is the reason of its zero rest mass. Nevertheless, the photon possesses momentum vector, longitudinal part of which points towards the direction of its propagation. All its energy is confined in the linear and rotational motion momenta. Hence photon may be viewed as severe violation of symmetry of the original double-helical flow. In photon excitation having the shape of a single helix, one of helical flows comprising the double-helix simply does not exist. Photons are employed by the universe system for energy redistribution in space. The helical boson structure of photon has 2π phase delay at its De Broglie frequency along its structure. In each given moment of time, the helical photon excitation of the vacuum lattice may be formally decomposed to symmetric and anti-symmetric excitations carrying equal amounts of energy. The symmetric part of the photon excitation carries equal amounts of positive and negative electric/magnetic energies, and this makes it electrically/magnetically neutral. Photon excitation possesses the same energy density as the unperturbed vacuum. Hence it does not experience Newton's gravity force. Nevertheless, due to the anti-symmetric part of its energy, the photon excitation reacts to vacuum lattice anti-symmetric polarizations. In the vicinity of massive body it moves along geodesic surfaces featuring the same amount of the gravity polarization energy. This effect is predicted by the Einstein's General Relativity Theory.

Massive particles	Unlike photons, massive particles are phononic *amplitude modulation* of the Planck-frequency carriers, and its creation needs energy investment. The extra energy required for its creation is taken by one (e.g. symmetrical) propagation mode from the other (e.g. anti-symmetrical) propagation mode. Both propagation modes share the common structure along which takes place the energy exchange between the modes. Massive particles are generated as a system response to abnormally large local energy density imposed by some external excitation. Their existence is justified by the fact that the massive particle is perfect implementation of an additional and very efficient method of high-Q energy storage. The massive particle structure resolves the problem of the steepest spatial confinement of the local excessive energy density. The confined structures of massive particles may stay motionless relatively the surrounding vacuum lattice and may store all its energy in its inner oscillations at its De Broglie frequency. The abnormally large local energy density within the structure of the massive particle yields such universal-scale phenomena as static gravity and electrical polarizations of the surrounding vacuum lattice. Traditionally, these vacuum polarization phenomena are described, respectively, by the Newton's Gravity Law and the Coulomb Law.
Energy conversion mechanisms, built into the vacuum lattice, standing behind traditional physics laws.	The vacuum lattice possesses two types of Planck-scale energy conversion mechanisms: (a) bidirectional energy conversions between longitudinal and transverse velocity components of the same (either symmetric or anti-symmetric) excitation mode carried by double-helical flows comprising the vacuum lattice, and (b) bidirectional energy conversions between the anti-symmetric (gravitational) and symmetric (electromagnetic) excitations of the same double-helical transmission lines. The latter conversion mechanisms exist only in curved double-helical structures, and are of special interest since they are responsible for hardly explored bidirectional conversions of electromagnetic and gravity energies. This phenomenon is known as direct and reverse Gertsenshtein effects, Gertsenshtein**,** M. E. (1962) & (1962a). Fig.3 shows locations A within the vacuum lattice where energy transformations of type (a) take place. The type (b) transformations occur in sites B also shown in Fig.3.
Geometrical significance of kinetic and potential energy components	In the SVT model, energy of the longitudinal velocity components is associated with kinetic energy, whereas the transverse velocity components carry the potential energy. This conclusion is valid for gravitational and electromagnetic excitations of the vacuum lattice, as well as for the superfluid streams comprising the vacuum lattice itself.

Fundamental categories of energy in the universe	As a result of above classification, the following four fundamental categories of energy may be distinguished: a) E_g^k, kinetic gravitational energy giving birth to macroscopic effects of inert mass; b) E_g^p, potential gravitational energy associated with the gravity mass; c) E_e^k, kinetic electromagnetic energy, known as magnetic energy, and d) E_e^p, potential electromagnetic energy responsible for electric polarization effects, including electric charge phenomenon. The chart in Fig.7 illustrates division of the total energy to four fundamental categories and shows a variety of energy transformations performed by the vacuum lattice by means of Planck scale mechanisms. The SVT model does not need introduction of some other independent categories of energy for explanation of weak and strong nuclear interactions. Above four fundamental energy categories are deemed to be sufficient to explain energy transformations occurring in a course of quarks agglomeration into protons and neutrons, as well as the higher-scale agglomeration of nucleon to the nucleus.
Geometrical interpretation of four fundamental energies in terms of the superfluid velocity components	Each fundamental energy category has its geometrical interpretation in terms of the superfluid velocity components: $\vec{\boldsymbol{v}}_a^p$, $\vec{\boldsymbol{v}}_a^k$, $\vec{\boldsymbol{v}}_s^p$ and $\vec{\boldsymbol{v}}_s^k$, where the index *"a"* stands for the anti-symmetric (gravity) excitation mode, and the index *"s"* – for the symmetric (electromagnetic) excitation mode. The indices *"p"* and "*k*" symbolize potential and kinetic energy components, respectively. Each energy category corresponds to some specific degree of freedom in the double-helical flows. In the unperturbed vacuum two degrees of freedom existing in the helical flow belong to the anti-symmetric mode. Both velocity components of helices in the anti-symmetrical double-helical flow carry the same amount of energy: $\left\|\vec{\boldsymbol{v}}_{a0}^p\right\| = \left\|\vec{\boldsymbol{v}}_{a0}^k\right\| = \mathrm{c}$, whereas the symmetrical mode does not exist: $\left\|\vec{\boldsymbol{v}}_{s0}^p\right\| = \left\|\vec{\boldsymbol{v}}_{s0}^k\right\| = 0$.
Stable physical objects	Structure of each stable physical object is the agglomerate of elementary particles. Each particle supports resonant oscillation at its De Broglie frequency, in which are exchanged optimally balanced amounts of kinetic and potential energies. Energy of any phononic quasi-particle is directly proportional to its resonance frequency. In the SVT, elementary particles are also phononic excitations of the vacuum crystalline structure. Hence the energy stored in the elementary particle should be in accordance with the $\mathrm{E} = \mathrm{h}\nu$ the Planck equation, where ν is the De Broglie frequency of its inner oscillations.
The principle of the steepest	The energy content of any physical object or physical event can be represented using Fourier spectral decomposition of inner resonant oscillations. At any frequency (or

maximization of the quality factor (the Q-factor).	wavelength) component of this Fourier expansion, the physical object tends to perform the steepest descent of its free energy content, namely, the system strives to perfect balance between kinetic and potential energies of its inner oscillations. The Lagrange principle calling for the steepest descent of the system free energy appears to be equivalent to the principle of the steepest maximization of the ratio between the reactive power of inner oscillations and the object's active losses. We shall name this ratio as a quality (Q) factor.
Conditions for spatial resonances between symmetric and anti-symmetric excitation modes, known also as toroidal resonances.	In spatial resonance, full power exchange between the stimulus and the system occurs due to spatial matching instead a time period matching as in the conventional frequency resonance. For instance, Zhenyu Wang et. al. (2017) revealed a creation of spatial resonance when the stimulus matches the space pattern of a normal mode in an oscillating system. The spatial resonance may be generated between two oscillation modes of the system if there is some coupling mechanism between the modes. Such conditions exist between symmetric and anti-symmetric propagation modes in the double-helical structure. The spatial resonance in double-helical ring structure may occur if one of two conditions are satisfied: *Condition A:* Within curved double-helical structure of any massive particle takes place full exchange between the kinetic energy of large-scale symmetric excitation and the potential energy of the smaller-scale anti-symmetric excitation, creating a phenomenon of spatial resonance. *Condition B:* similarly, the same structure is able to support full exchange between the potential energy of large-scale symmetric excitation and the kinetic energy of the smaller-scale anti-symmetric excitation. These two conditions may serve as definitions of spatial resonance in double-helical structures. Structures supporting spatial resonance exhibit enhanced stability and have the optimally large value of quality factor. Category of physical objects generated due to the spatial resonance in double-helices includes all massive elementary particles, quarks, and complex clusters of different spatial scales up to objects of cosmic scales.
Special role of toroidal shape	When considering quark, the smallest elementary massive object, it turned out that the conditions of spatial resonance are realized in objects having the form of a double helix curled into a torus. Such structure may also be named as double-helical ring resonator. Similar resonant behavior may also characterize a wide range of stable physical objects

	from elementary particles and up to objects of cosmic scale, including black holes and even the entire universe.
Hypothetical quark structure	Structure of electrically charged massive particle, e.g. quark, supports spatial resonance based on full exchange between kinetic and potential energies of gravity and electromagnetic excitations. This observation is in line with the Glashow-Salam-Weinberg electroweak theory and experimentally verified by (Noecker M.C., et.al., 1988). The double-helical ring structure simultaneously performs two types of resonant transformations: a) Kinetic gravity energy (the energy of inert mass) is exchanging with potential electromagnetic energy (electric charge), and b) Potential gravity energy (the energy of gravity mass) is exchanging with kinetic electromagnetic energy (magnetic moment). Remarkably, both spatial resonances take place along the same particle structure created by the dominant energy of the gravity resonance. Bending of double-helices to the closed-loop contour violates symmetry of the structure. Both types of spatial resonance generate areas with abnormally high densities of gravitational and electromagnetic energies. These energy density abnormalities are confined in two poles on opposite sides of the ring structure (see Fig.10). There are three possibilities following from the two options of spatial resonances described above: a) Quark type #1 possessing one pole with $\frac{1}{2}e$ electric charge (abnormally large density of potential electromagnetic energy) and the other pole hosting the inert mass (abnormally large density of kinetic gravitational energy). The kinetic mass pole enforces both poles rotation around the ring structure; b) Quark type #2 possessing one pole with $\frac{1}{2}\hbar$ magnetic moment (abnormally large density of kinetic electromagnetic energy) and the other pole with gravity mass (abnormally large density of potential gravitational energy); c) Quark type #3 hosting both types of spatial resonances in its structure. Additional three possibilities exist for the cases when spatial resonances drive one of poles of the ring structure to abnormally high and the other to abnormally low energy densities of electromagnetic and gravitational energies. This completes the total number of quark's types to six. Different types of the quark structure are either electrical or magnetic monopoles. As such, they mutually attract each other forming much more stable nucleons, like proton and neutron. This simple model promises to explain the phenomena of electrical charge and magnetic moment generation in quark particles. Both phenomena are electromagnetic, but are generated at the expense of the much greater amount of gravity energies stored in the quark structure. Energy of the anti-symmetrical mode is confined in the inner volume between two helices and is just slightly open for interactions with the symmetric mode of the electromagnetic excitation, which occupies mostly the outer areas of the double-helical hydrodynamic structure. Amounts of gravitational and electromagnetic energies involved in the spatial resonance exchange are equal, but this amount is only a small

	part of the total gravity energy, mc^2, enclosed in the anti-symmetric excitation mode. Here m is the total quark's mass.
Fractal structure of the detectable universe. Spatial scaling phenomenon.	The entire observable part of the universe stores energy of the spectrum band $[F_{PL} > f > 0]$. It appears to be a fractal each spatial scale of which is populated by numerous massive physical objects united by collective coherent oscillations. The *scaling* concept is the embodiment of the idea that originated with the ancient Greek philosophers that "*big thing consists of many small things*". Now we can rephrase it as "*each object belonging to some macroscopic scale consists of many small objects, each of which, in turn, consists of many more subtle objects, etc.*". In the observable part of the universe we witness apparently isolated physical objects. This is the evidence of the depleted vacuum energy unable to generate continuous lattice, similar to the vacuum lattice. All observable physical objects are condensates of the random energy released by the vacuum lattice. The first impression is that observable objects are isolated. This impression is illusory since apparently isolated objects are coupled by long-range gravitational and electromagnetic interaction mechanisms, and are involved in collective coherent oscillations. The mutual interaction effect is observable in the realm of objects of cosmic scales, where each object possesses maximum degrees of freedom. Actually, each spatial scale is a network spread over the entire universe, exactly like the Planck-scale vacuum lattice. The special role of the vacuum lattice is that its structure is composed of tiny hydrodynamic mechanisms responsible for all energy transformations which are necessary for generation of larger-scale networks. The other major difference between the vacuum lattice and the matter organizations of larger scales is the bandwidth of coherent oscillations. Bandwidths of oscillations supported by objects of larger scales are much broader than of the vacuum lattice, and this enriches the larger-scale networks with the diversity of physical phenomena. In certain sense, the words "lattice" and "scale network" are synonyms. The lattice spontaneous generation proved to be the best way to produce the system possessing the optimally large quality factor. According to performance criterion of the optimally large quality factor, lattices (or scale networks) are the best-performing creations in the entire nature, and among them, the most successful object is the vacuum lattice. All other utmost stable objects are more or less successful imitations of a perfect and unsurpassed vacuum: crystals, gaseous and liquid media, biological systems and

	eventually the cosmic web. Two alternative conditions A & B of spatial resonance are satisfied at discrete opportunities of very specific ratios of toroidal-to-poloidal rotation radii of toroidal structures of double-helical ring resonators, named the torus aspect ratio. Each such opportunity is created for ring structures of different spatial scales. Actually, the scaling phenomenon itself is the result of spatial resonance. When applied to the double-helical torus structure, the spatial resonance may also be named as the *toroidal resonance*. The spatial resonance phenomenon is responsible for creation of smallest massive particles, quarks, which are continuous ring structures. At larger scales, the spatial resonance unites spatially isolated physical objects, like in the case of cosmic web. Any given scale network within the fractal serves as an energy attractor and is relatively densely populated by a variety of stable physical objects of similar spatial scales. Densely populated zones are separated by wide not populated spectral gaps. In accordance with the SVT, each spatial resonance is due to exchange of equal amounts of kinetic/potential *electromagnetic* energy and potential/kinetic *gravitational* energy. At the Planck scale, the energy exchange is between symmetrical and anti-symmetric excitations, whereas the anti-symmetrical counterpart are the vacuum lattice oscillations of much higher frequency and of much finer spatial scale of the matter organization. Hence the energy exchange during the spatial resonance takes place within the structure supporting some small frequency and some large frequency. In the case of spatial resonance occurring in double-helix curled to torus (see Fig.9), the ratio of anti-symmetrical resonant oscillation frequency to the symmetrical mode resonant oscillation frequency is the universal constant for all scales. Hence the De Broglie frequencies of the nested spatial resonances are likely to constitute geometrical progression.
Quarks agglomeration to proton and neutron	Tree quarks clustering to protons and neutrons forms massive structures of enhanced stability. As illustrated in the Fig.8a, clustering of two ring resonators yields straightening of their common border and generation of two vortices. This in turn, reduces the circumference of each quark involved in the agglomerate and limits its ability to generate mass, electric charge and magnetic moment effects. Hence the quark involved in the cluster has non-integer electric charge. The lost in the agglomeration process free energy is reduced from the agglomerate total free energy and is the guarantee of its stability. This also explains why break of the neutron or proton nucleons consumes so much energy. This investment of external energy is absorbed in increased masses of the isolated (and less stable) quarks, which are generated as a result of the nucleons

	disintegration.
Bonded electron	The model exposition is culminated by a short description of the bonded electron phenomenon. It may be shown how free (not compensated) quark's energy of inert and gravity masses, electric charge and magnetic moment generate the phenomenon of bonded electron orbits. The orbital structure is a planar ring resonator located on a sphere concentric with the atom's nucleus. Some specific proton, a part of the nucleus cluster, induces co-centric gravity and electric potentials. This is equivalent to vacuum gravitational and electric polarization. Simultaneously, the vacuum lattice surrounding the nucleus reacts to inert mass and to magnetic energy stored in the proton by rotations. All four vacuum excitations induced by the proton generate the conditions for spatial resonances of the types A and B, and both resonant conditions are satisfied when the excitations encircle the orbital structure of the bonded electron. The bonded electron is just the energy of these spatial resonances. The energy of electric polarization constitutes the negative electric charge, the energy of induced magnetic moment is the electron's spin energy, the potential component of the gravitational vacuum polarization constitutes the energy of electron's gravitational mass, while the gravitational kinetic momentum creates the electron's orbiting around the circular trajectory. Alike proton, the resonant induced excitation has double-helical structure. The double-helical flow maybe decomposed to two helices which correspond to two electrons with oppositely directed spins but occupying the same orbit. Each bonded electron and the associated with it proton form nonlinear vortex resonator with conical shape. The cone apex is located at the nucleus location, and the cone basis coincides with the plane of the electron circular orbit. The electrically neutral atomic structure may be presented as an agglomerate of several conical vortex structures produced by several spatial resonances of gravitational and electromagnetic polarizations in the vacuum lattice surrounding the positively charged massive nucleus. The conical resonator exists due to energy exchange between a single nucleon and two associated bonded electrons occupying the same stationary orbit.

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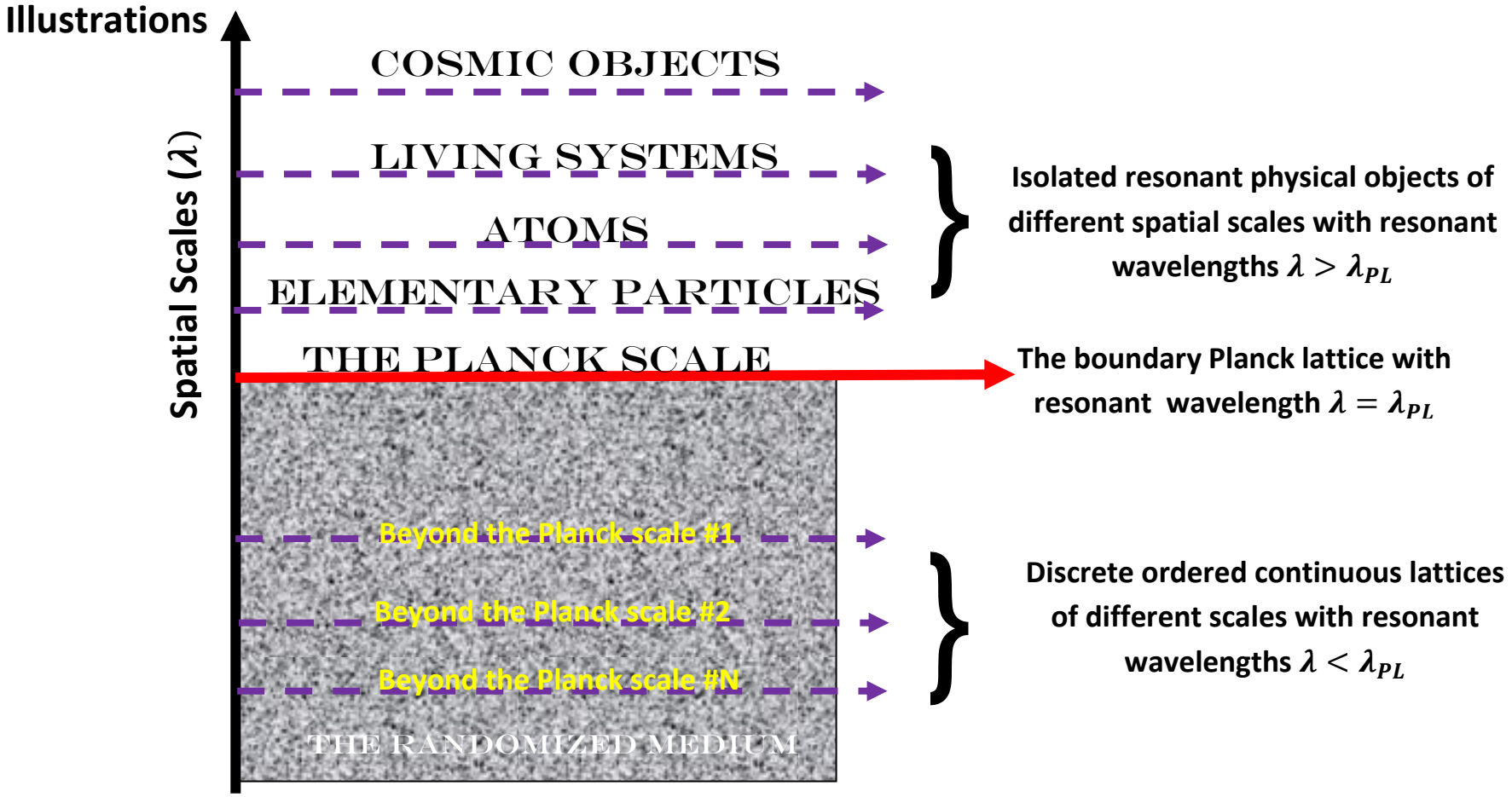


Figure 1: Illustration of the universe quantization to physical objects of different scales

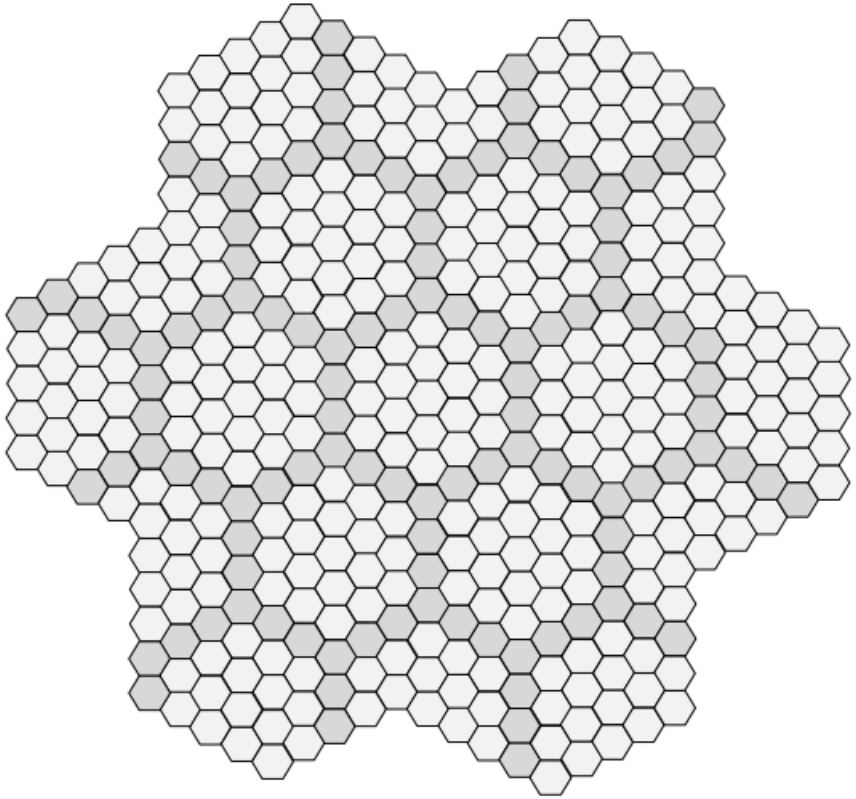


Figure 2: Example of nested honeycomb lattices, in which only two scales of quantization are shown.

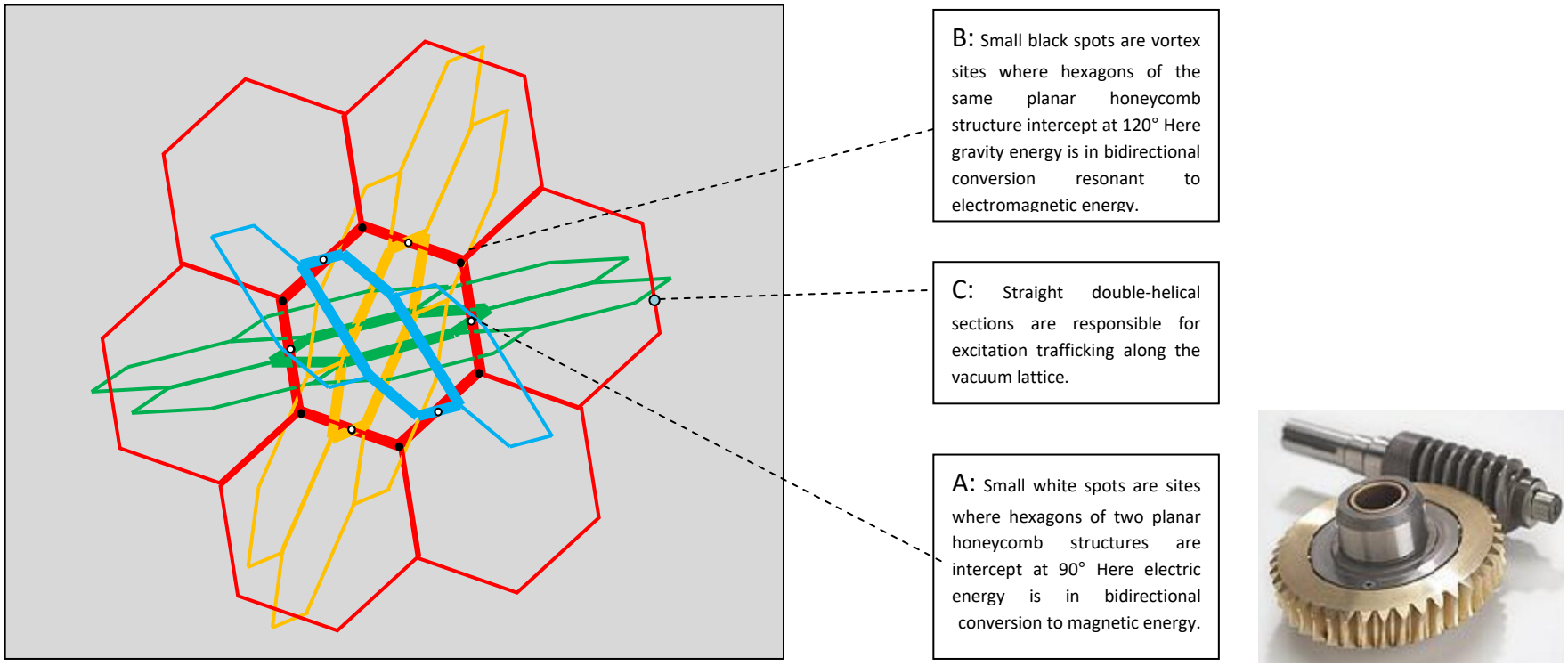


Figure 3: Illustration of the vacuum lattice structure geometry

Four sets of parallel planar honeycomb lattices with a relative orientation of 120° fill the entire volume of the universe. All hexagonal contours are produced by double-helices of the superfluid flows. Perimeters of elementary hexagons tiling the vacuum lattice are known as Planck's length, and equal to $\lambda_P = 1.616 \times 10^{-35} m.$

The vacuum lattice performs several functions for the universe activity below the Planck frequency barrier and beyond it. Some of its mechanisms performing these functions are listed below.

Elements A: of this structure perform the function of energy conversion within the same spatial scale. This mechanism is responsible for propagation of electromagnetic and gravitational excitations.

Elements B: perform energy transmission between a variety of spatial scales, and this function is required for energy compression and decompression.

Elements C: are responsible for providing the trafficking path for the excitation energy for its propagation along the double-helical structures, as required for energy redistribution in space.

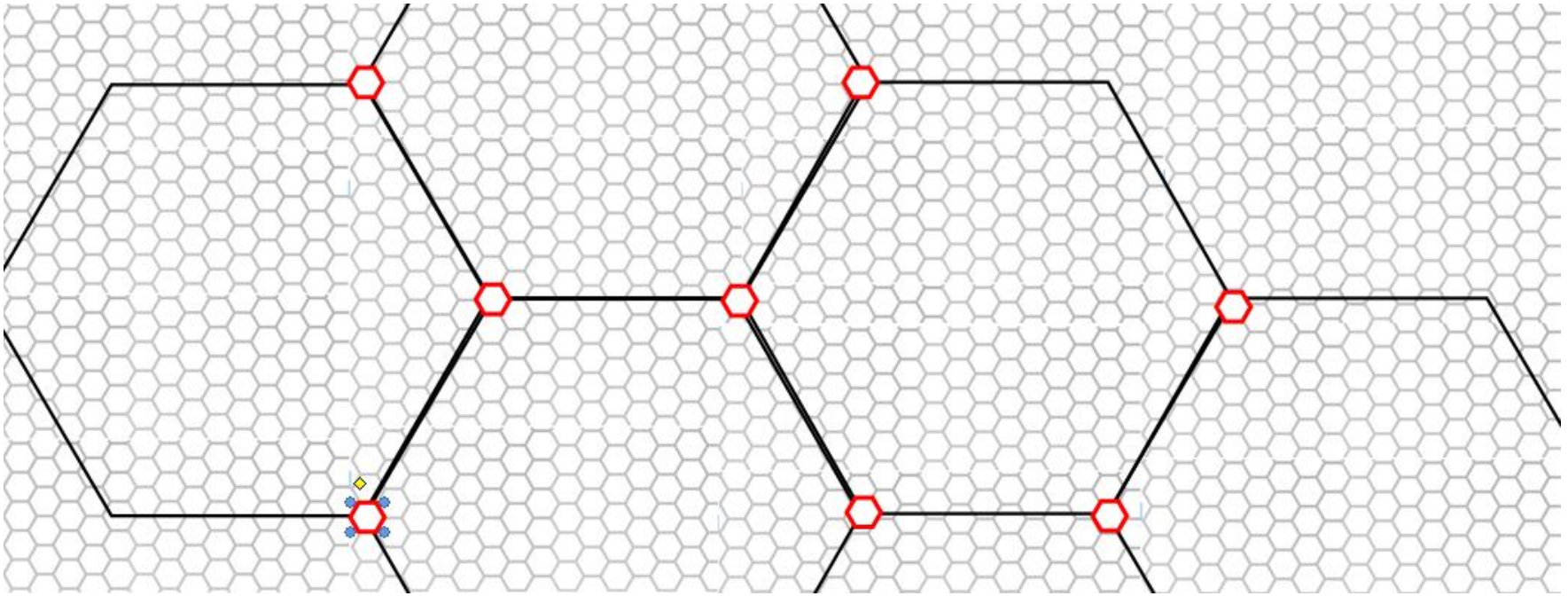
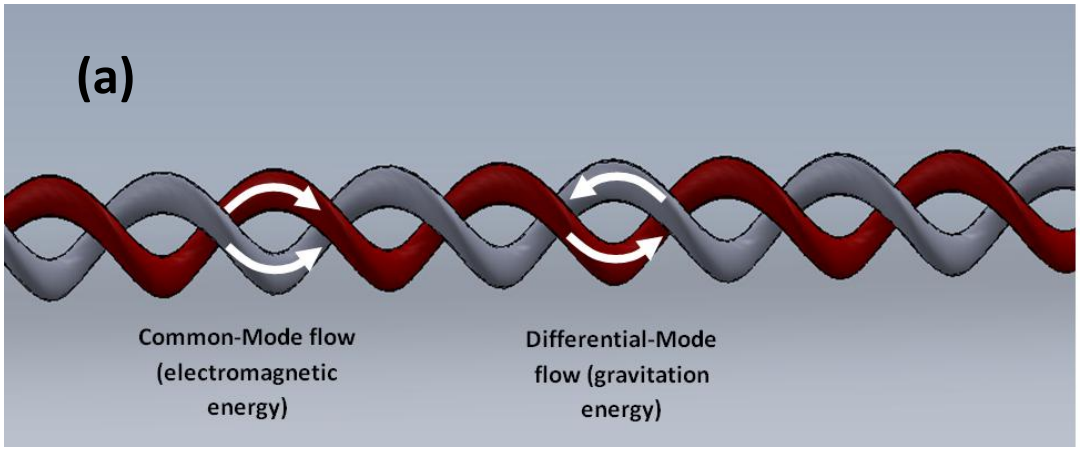


Figure 4: Illustration of resonant coupling between hexagon structures of two adjacent spatial scales. Each solid line in this image is double-helical superfluid flow. Straight sections of each scale are double-helical flows. The coupling sites are red-colored hexagonal vortices along which are satisfied conditions of spatial resonance. The spatial resonance is due to full exchange between kinetic and potential energies of symmetric and anti-symmetric propagation modes of double-helices of different scales.



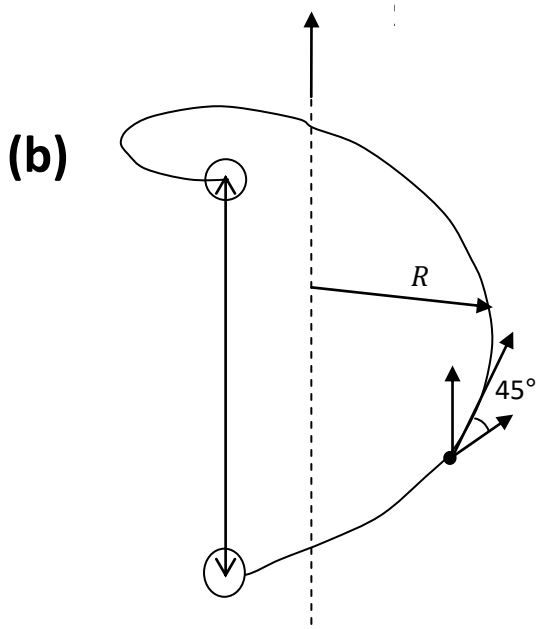
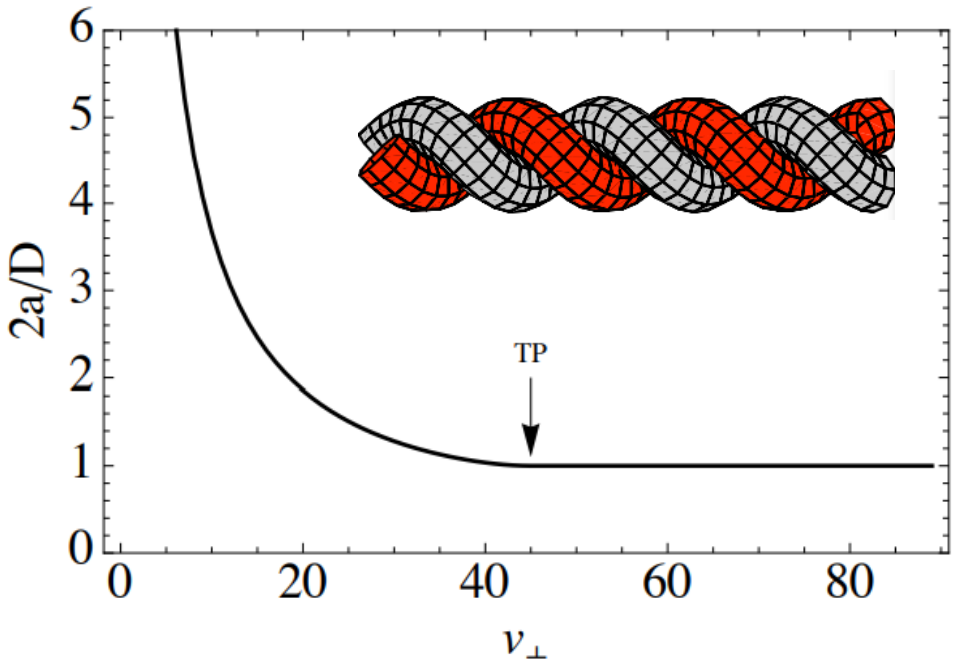


Figure 5: (a) Double-helical geometry of straight sections and definition of the symmetrical (the Common-Mode) and anti-symmetrical (the Differential-Mode) components of superfluid streams; (b) The one-turn section of helical steam-line as the most primitive resonant structure carrying equal amounts of kinetic and potential energies. The kinetic and potential energies are carried by the longitudinal and transverse velocity components, respectively.



Note: Graph showing the ratio 2a/D as a function of pitch angle, v⊥ [deg.], where *a* is the helix radius and *D* the diameter of the helical tubes. The tightly packed double helix has a pitch angle of 45◦ ; it is the helix with the smallest pitch angle obeying the criterion that *2a = D*. Geometrically, the double helix is given by two tubes of diameter D, whose centerline defines two helices with simple parametric equations. A helix is a curve of constant curvature, κ, and torsion, τ , and it can be specified by two parameters, for example a and H, where a is the helix radius (the radius of the cylinder hosting the helical lines) and H the helical pitch (the raise of the helix for each 2π rotation).

Courtesy of Kasper Olsen and Jakob Bohr, The geometrical origin of the strain-twist coupling in double helices, arXiv:1003.5358v2 [physics.bio-ph] 7 May 2010

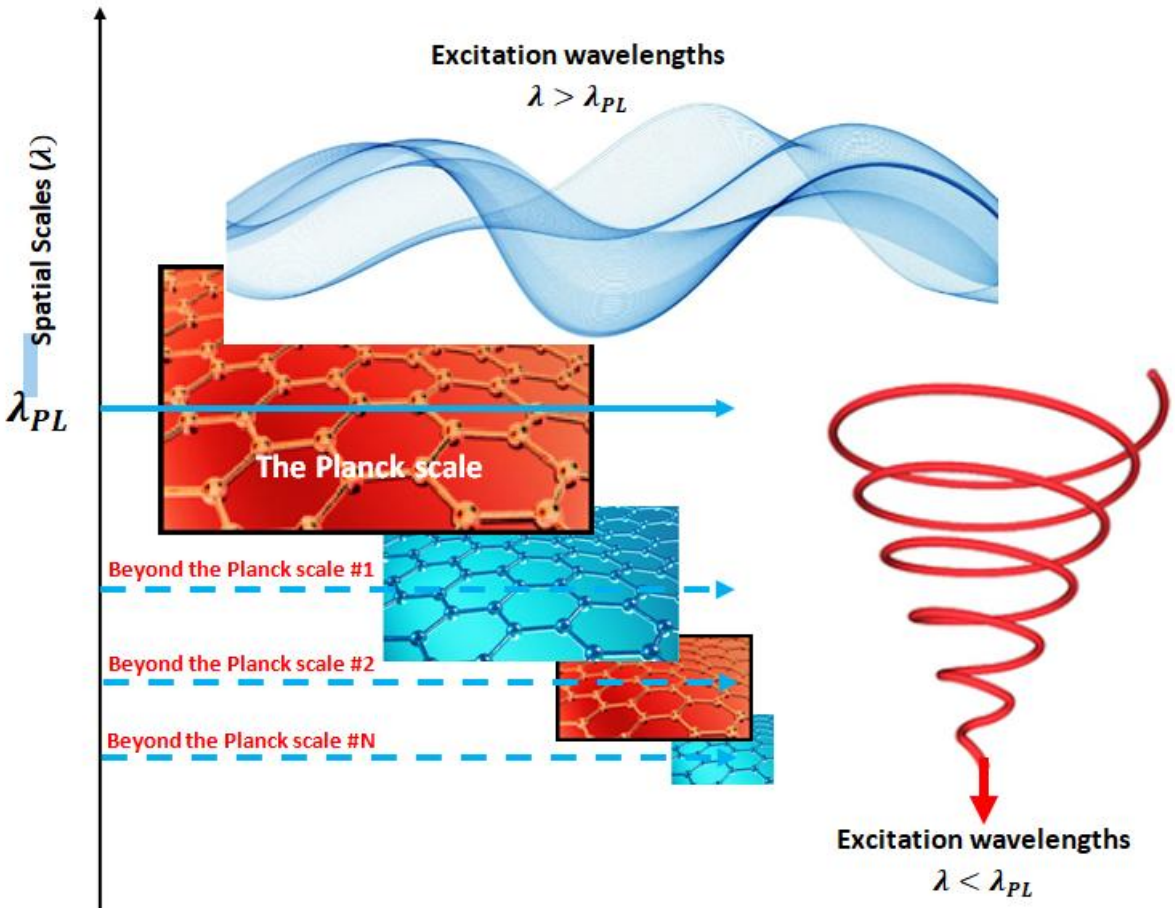


Figure 6: Illustration of fractal multi-scale architecture of the vacuum structure.

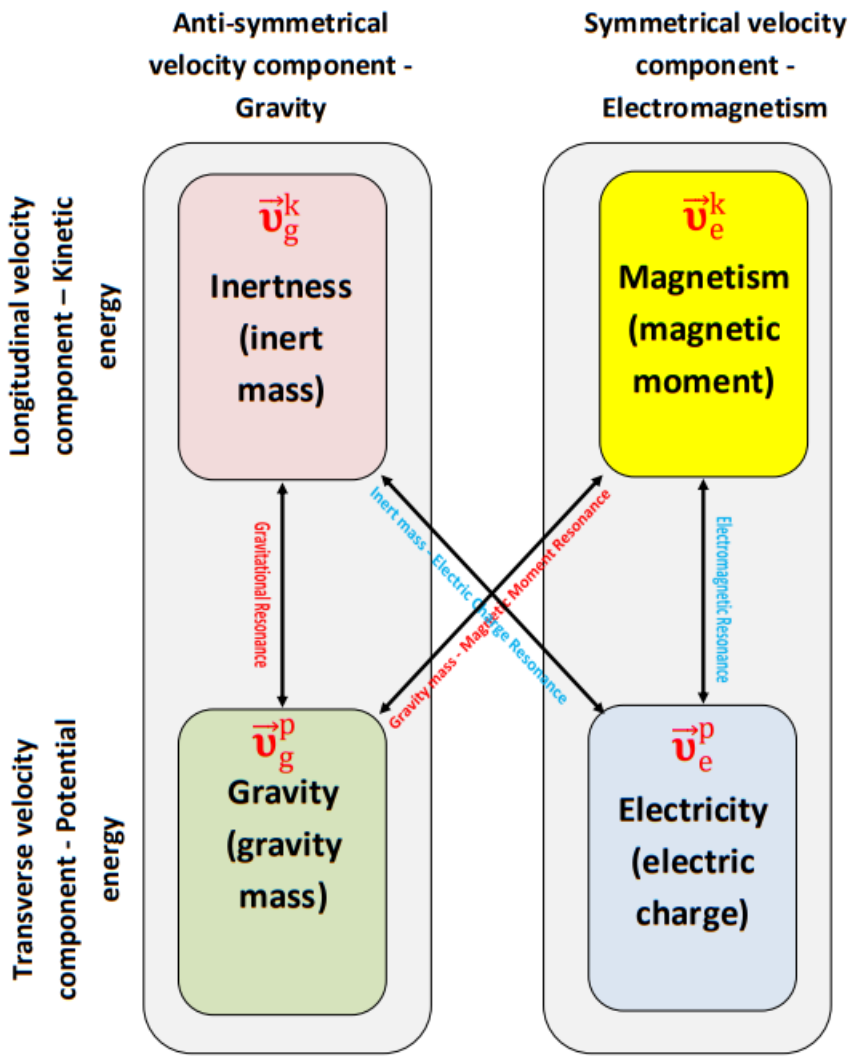


Figure 7: Assignment of four fundamental energy categories to different velocity components & mechanisms of resonant energy exchange between a variety of energy categories

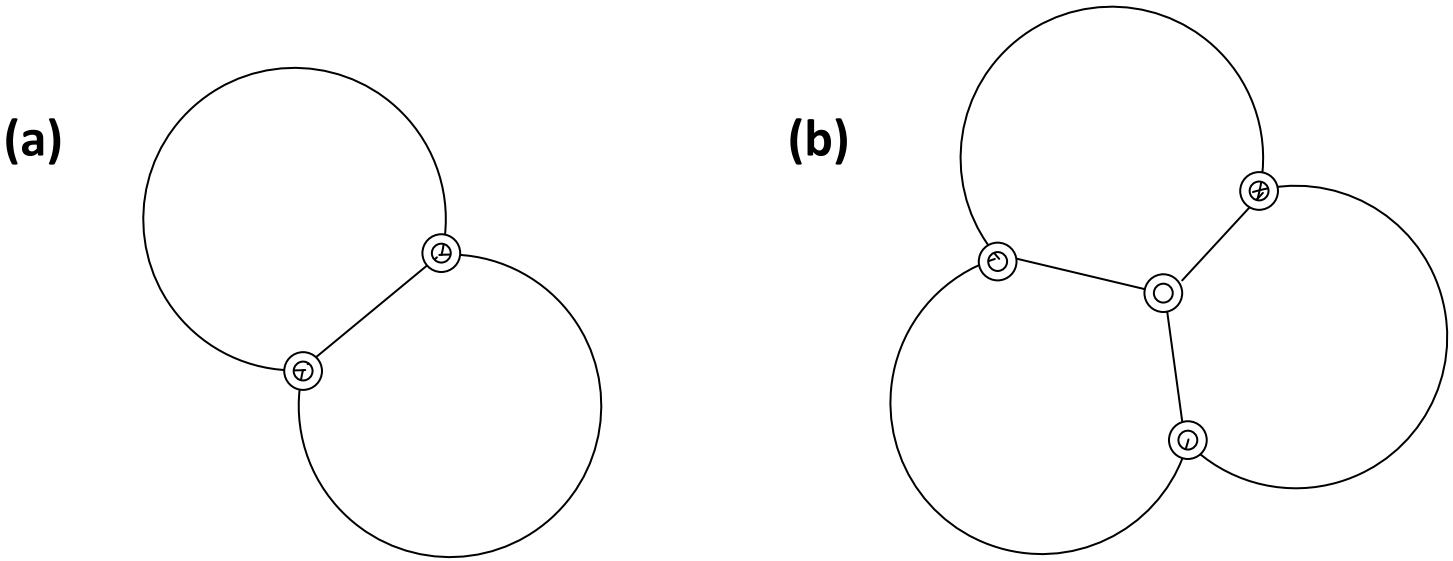


Figure 8: Clustering of three helical ring resonators to a single particle

Figure 9: The circular double helix, Courtesy of Olsen, K. et.al. (2012)

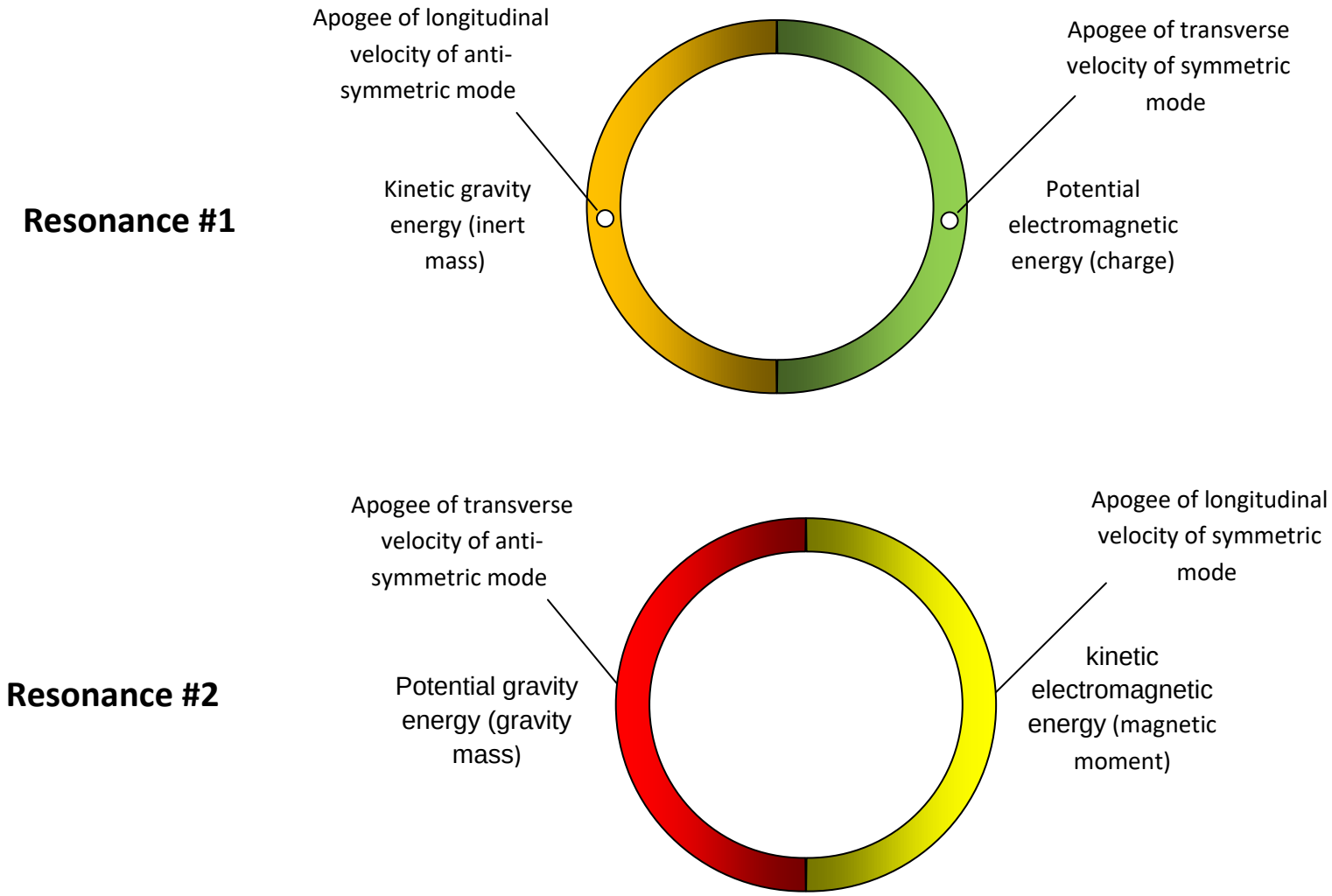


Figure 10: Two possible energy distributions along the ring structure of massive particle, result of two spatial resonances