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Physics and Space Science

Highlights

- The Digital Space Structure
- Laser Technology and Weapons
- Reduction of Radiation Dose
- Anterior-Posterior Chest X-Rays

Discovering Thoughts, Inventing Future

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The Digital Space Structure, Superconductor, and Superstar

By Ding-Yu Chung

Abstract- In the digital space structure, space is digitalized by 1 and 0 for attachment space and detachment space, respectively. A special force field (the short-range extreme force field) can be derived from the digital space structure to generate superconductor at extremely low temperature and superstar at extremely high density. Singularity-free superstar is a model for the collapse of large stars and for GRBs, and as an alternative to black hole. Attachment space allows object to attach to account for rest mass and reversible movement, while detachment space allows no object to attach to account for irreversible kinetic energy. The combination of attachment space and detachment space brings about the three structures: binary partition space, miscible space, orbinary lattice space. Binary partition space $(1)_n(0)_n$ consists of separated continuous phases of attachment space and detachment space to account for quantum mechanics and extreme force field. In miscible space $(1+0)_n$, attachment space is miscible to detachment space without separation to account for special relativity.

Keywords: *space structure, quantum mechanics, force fields, superconductor, superstar, black hole, gravastar, GRB, collapsar, singularity.*

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The Digital Space Structure, Superconductor, and Superstar

Ding-Yu Chung

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Keywords: space structure, quantum mechanics, force fields, superconductor, superstar, black hole, gravastar, GRB, collapsar, singularity.

I. Introduction

In the conventional space structure, space is homogeneous. In the digital space structure, space can be homogeneous or heterogeneous, and is digitalized by 1 and 0 for attachment space and detachment space, respectively. Attachment space denoted as 1 allows object to attach to account for rest mass and reversible movement, while detachment space denoted as 0 allows no object to attach to account for irreversible kinetic energy. Different combinations of attachment space (as 1) and detachment space (as 0) result in different physical phenomena. The conventional space structure cannot explain clearly the important phenomena, such as the differences in measurement between quantum mechanics and special relativity, the origin of superconductivity, and singularity in black hole. These phenomena can be derived directly by the different combinations of 1 and 0 in the digital space structure. A special force field (the short-range extreme force field) can be derived from the digital space structure to generate superconductor at extremely low temperature and superstar at extremely high density. The extreme force fields are manifested as the bonds among electrons in superconductor, as the bonds among atoms in superfluid, and as the bonds among all materials in superstar. Singularity-free superstar is a model for the collapse of large stars and for GRBs (gamma-ray bursts), and as an alternative to black hole. In Section II, the digital space structure and superconductor are described. In Section III, various astronomical phenomena, such as neutron star, supernova, collapsar, GRB, and pair instability supernovae are described. In Section IV, superstar as a alternative to black hole is explained.

II. The Digital Space Structure and Superconductor

The digital space structure [1][2][3] consists of attachment space (denoted as 1) and detachment space (denoted as 0). Attachment allows object to attach, while detachment space allows no object to attach. Attachment space attaches to object permanently or reversibly. Detachment space detaches from the object at the speed of light. Attachment space relates to rest mass and reversible movement, while detachment space relates to irreversible kinetic energy. Different stages of our universe have different space structures[4].

The transformation between mass (massive particle) in attachment space and kinetic energy (massless particle) in detachment space is through the scalar Goldstone boson. For example, massive

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particles with n units of attachment space, denoted as $(1)_n$, are converted into massless particles with n units of detachment space, denoted as $(0)_n$ through the Goldstone bosons. The addition of the Goldstone bosons to massless particles in detachment space results in massive particles in attachment space, while the removal of removal of the Goldstone bosons in attachment space leads to massless particles in detachment space.

$$\textit{massive particles in } (1)_n \xleftarrow[\textit{boson}]{+\textit{Goldstone}} \textit{massless particles in } (0)_n$$

$$\textit{massive particles in } (1)_n \xrightarrow[\textit{boson}]{-\textit{Goldstone}} \textit{massless particles in } (0)_n$$

The Goldstone boson provides the longitudinal degree of freedom for massive particle in attachment space. The Goldstone boson itself is a zero-energy virtual particle by taking energy from and returning energy to the object transformed by the Goldstone boson. The Goldstone boson in the Standard Model for electroweak interaction is the Higgs boson[5].

The combination of attachment space (as 1) and detachment space (as 0) brings about three different space structures: binary partition space, miscible space, or binary lattice space as below.

$$\underset{\textit{attachment space}}{(1)_n} + \underset{\textit{detachment space}}{(0)_n} \xrightarrow{\textit{combination}} \underset{\textit{binary partition space}}{(1)_n(0)_n}, \quad \underset{\textit{miscible space}}{(1+0)_n}, \textit{ or } \underset{\textit{binary lattice space}}{(1\,0)_n}$$

Binary partition space, $(1)_n(0)_n$, consists of two separated continuous phases of multiple quantized units of attachment space and detachment space. In miscible space, attachment space is miscible to detachment space, and there is no separation of attachment space and detachment space. Binary lattice space, $(1\ 0)_n$, consists of repetitive units of alternative attachment space and detachment space.

Binary partition space is the space for wavefunction in quantum mechanics. In wavefunction,

$$|\Psi\rangle = \sum_{i=1}^{n} c_i |\phi_i\rangle$$

Each individual basis element, $|\phi_i\rangle$, attaches to attachment space, and detach from the adjacent basic elements by detachment space. In binary partition space, a basic element contains both attachment space and detachment space. Neither attachment space nor detachment space is zero in binary partition space for a basic element. The measurement in the uncertainty principle in quantum mechanics is essentially the measurement of attachment space and momentum in binary partition space: large momentum has small non-zero attachment space, while large attachment space has low non-zero momentum. In binary lattice space, an entity is both in constant motions as wave for detachment space and in stationary state as a particle for attachment space, resulting in the wave-particle duality.

Detachment space contains no object that carries information. Without information, detachment space is outside of the realm of causality. Without causality, distance (space) and time do not matter to detachment space, resulting in non-localizable and non-countable space-time. The requirement for the system (binary lattice space) containing non-localizable and non-countable detachment space is the absence of net information by any change in the space-time of detachment space. All changes have to be coordinated to result in zero net information. This coordinated non-localized binary partition space corresponds to nilpotent space. All changes in energy, momentum, mass, time, space have to result in zero as defined by the generalized nilpotent Dirac equation by B. M. Diaz and P. Rowlands[6].

$$(\mp\mathbf{k}\partial/\partial t \pm \mathbf{i}\nabla + \mathbf{j}m)(\pm i\mathbf{k}E \pm \mathbf{i}\mathbf{p} + \mathbf{j}m)\exp i(-Et + \mathbf{p.r}) = 0.$$

where E, p, m, t and r are respectively energy, momentum, mass, time, space and the symbols ± 1, ± *i*, ±*i*, ± *j*, ± *k*, ± i, ± j, ± k, are used to represent the respective units required by the scalar, pseudo scalar, quaternion and multivariate vector groups. The changes involve the sequential iterative path from nothing (nilpotent) through conjugation, complexification, and dimensionalization. The non-local property of binary partition space for wavefunction provides the violation of Bell inequalities [7] in quantum mechanics in terms of faster-than-light influence and indefinite property before measurement. The non-locality in Bell inequalities does not result in net new information.

In binary partition space, for every detachment space, there is its corresponding adjacent attachment space. Thus, no part of the object can be irreversibly separated from binary partition space, and no part of a different object can be incorporated in binary partition space. Binary partition space represents coherence as wavefunction. Binary partition space is for coherent

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system. Any destruction of the coherence by the addition of a different object to the object causes the collapse of binary partition space into miscible space. The collapse is a phase transition from binary partition space to miscible space.

$$\underset{binary\ partition\ space}{(0)_n\,(1)_n} \xrightarrow{collapse} \underset{miscible\ space}{(0+1)_n}$$

Another way to convert binary partition space into miscible space is gravity. Penrose [8] pointed out that the gravity of a small object is not strong enough to pull different states into one location. On the other hand, the gravity of large object pulls different quantum states into one location to become miscible space. Therefore, a small object without outside interference is always in binary partition space, while a large object is never in binary partition space.

The information in miscible space is contributed by the miscible combination of both attachment space and detachment space, so information can no longer be non-localized. Any value in miscible space is definite. All observations in terms of measurements bring about the collapse of wavefunction, resulting in miscible space that leads to eigenvalue as definite quantized value. Such collapse corresponds to the appearance of eigenvalue, E, by a measurement operator, H, on a wavefunction, Ψ.

$$H\Psi = E\Psi$$

In miscible space, attachment space is miscible to detachment space, and there is no separation of attachment space and detachment space. In miscible space, attachment space contributes zero speed, while detachment space contributes the speed of light. A massless particle, such as photon, is on detachment space continuously, and detaches from its own space continuously. For a moving massive particle consisting of a rest massive part and a massless part, the massive part with rest mass, m_0, is in attachment space, and the massless part with kinetic energy, *K*, is in detachment space. The combination of the massive part in attachment space and massless part in detachment leads to the propagation speed in between zero and the speed of light. To maintain the speed of light constant for a moving particle, the time (t) in moving particle has to be dilated, and the length (L) has to be contracted relative to the rest frame.

$$t = = t_0 \Big/ \sqrt{1-\upsilon^2/c^2} = t_0\gamma,$$

$$L = L_0/\gamma,$$

$$E = K + m_0c^2 = \gamma m_0 c^2$$

where $\gamma = 1/\sqrt{1-\upsilon^2/c^2}$ is the Lorentz factor for time dilation and length contraction, *E* is the total energy, and *K* is the kinetic energy.

As described in Reference 4, before the beginning of our current universe, the universe contained only attachment space, and at the beginning of the current universe, the 10d particle universe was sliced into six particles: 9d, 8d, 7d, 6d, 5d, and 4d equally by mass. Detachment space (0) involves in the slicing of dimensions. Attachment space is denoted as 1. For example, the slicing of 10d particles into 4d particles is as follows.

$$\underset{10d\ attachment\ space}{(1_{4+6})_m} \xrightarrow{slicing} \underset{4d\ core\ attachment\ space}{(1_4)_m} \quad \underset{6\ types\ of\ 4d\ units\ force\ fields\ in\ binary\ lattice\ space}{\sum_{k=1}^{6}((0_4)(1_4))_{n,k}}$$

where m is for the number of units of core particles, n is for the number of units of force fields, and k is number of types of force fields. The two products of the slicing are the 4d-core attachment space for core particle and 6 types of 4d quantized units for ordinary force fields. The 4d core attachment space surrounded by 6 types of many (n) 4d-quantized units corresponds to the core particle surrounded by 6 types of many small 4d particles. The ordinary force fields are the force fields in binary lattice space.

Unlike quantum mechanics for particle-wave based on the uncertainty principle in binary partition space, ordinary force fields in binary lattice space do not follow the uncertainty principle. The uncertainty principle for quantum mechanics is expressed as follows.

$$\sigma_x\sigma_p \geq \frac{\hbar}{2}$$

The position, x, and momentum, p, of a particle cannot be simultaneously measured with arbitrarily high precision. The uncertainty principle requires every physical system to have a zero-point energy (minimum momentum) greater than zero, and to have a maximum energy equal or less than the energy at the minimum wavelength as the Planck length. The uncertainty principle has non-zero momentum and non-zero wavelength. In terms of the space structure, detachment space relating to kinetic energy as momentum is σ_p, and attachment space relating to space (wavelength) for a particle is σ_x. Neither detachment space nor attachment space is zero in the uncertainty principle.

Quantum mechanics for a particle follows the uncertainty principle. It is proposed that at the extreme conditions of absolute zero and infinite density, the binary lattice space for ordinary force fields (electromagnetic, strong, weak, and gravitational force fields) follows the certainty principle $\sigma_x \ \sigma_p \ = 1/\infty \approx 0$ instead of the uncertainty principle. At absolute zero with infinitesimal movement, all detachment space (momentum) in binary lattice space virtually ceases to exist, so the binary space as the force field collapses into infinite attachment space (wavelength) with infinitesimal momentum, resulting in the inactivation of force field. At infinite density to produce infinite interacting energy (infinite momentum) from the interaction among particles, all attachment space (rest mass) in the binary lattice space virtually ceases to exist, so the binary lattice space as the force field collapses into infinite detachment space (momentum) with infinitesimal wavelength, resulting in singularity as infinite interacting energy.

To prevent the inactivation of force fields at absolute zero and singularity (infinite interacting energy) at infinite density in ordinary force fields requires the presence of the special force fields that follow the uncertainty principle. The special force fields are "extreme force fields" that are in binary partition space. Binary partition space has one continuous detachment space and one continuous attachment space. The binary partition space for extreme force fields follows the uncertainty principle. Neither detachment space nor attachment space is zero in the binary partition space. To follow the uncertainty principle, extreme force fields have non-zero momentum and non-zero wavelength to prevent the inactivation of force field at absolute zero and singularity (infinite interacting energy) at infinite density, respectively.

At the critical temperature above absolute zero and the critical extreme density below infinite density, extreme force fields emerge in between particles and their ordinary force fields (electromagnetic, strong, weak, and gravitational force fields) to prevent the inactivation of force fields at absolute zero and singularity (infinite interacting energy) at infinite density in ordinary force fields as follows.

$$\underbrace{\begin{pmatrix}1\end{pmatrix}_m}_{\text{core particles}} \ \underbrace{\sum_{k=1}^{k}\left(\begin{pmatrix}0\end{pmatrix}\begin{pmatrix}1\end{pmatrix}\right)_{n,k}}_{\text{ordinary forces in binary lattice space}} \xrightarrow{\text{extremely low temperature or high density}} \underbrace{\begin{pmatrix}1\end{pmatrix}_m}_{\text{core particles}} \ \underbrace{\{\sum_{k=1}^{k}\begin{pmatrix}0\end{pmatrix}_{n,k}\begin{pmatrix}1\end{pmatrix}_{n,k}\}}_{\text{extreme forces in binary partition space}} \ \underbrace{\{(\sum_{k=1}^{k}\left(\begin{pmatrix}0\end{pmatrix}\begin{pmatrix}1\end{pmatrix}\right)_{n,k}\}}_{\text{ordinary forces in binary lattice space}}$$

where m is for the number of units of core particles, n is for the number of units of force fields, and k is number of types of force fields. The whole system of core particles, extreme force fields, and ordinary force fields never reaches absolute zero and infinite density. Extreme force fields do not change the normal properties of ordinary force fields in the same system.

All extreme force fields are identical and short-range, and are the dominant force fields over ordinary force fields in the interior of core particles, such as superconductor and superfluid. In the BCS theory of superconductivity [9], the superconducting current is explained as a superfluid of Cooper pairs, pairs of electrons interacting through the exchange of phonons. In the explanation by the extreme force, the Cooper pairs correspond to pairs of electrons interacting through the exchanges of extreme force bosons. The overlapping (connection) of two extreme bosons from two different sites brings about the "extreme bond". The product is the "extreme molecule". Therefore, at extremely low temperature, the extreme force fields are manifested as the bonds among electrons in a superconductor and as the bonds among atoms in superfluid.

The extreme force field is incompatible to the ordinary force field. The incompatibility of the extreme force field and the ordinary force field manifests in the Meissner effect, where superconductor repels external magnetism. The energy (stiffness) of external magnetism can be determined by the penetration of ordinary force field into extreme force field as expressed by the London equation for the Meissner effect.

$$\nabla^2 H = -\lambda^{-2} H$$

where H is an external ordinary force field (magnetism) and λ is the depth of the penetration of magnetism into the extreme shell.The Meissner effect is explained by the outward pressure of the extreme force fields to eject applied magnetic fields from the interior of the superconductor as it transitions into the extreme force fields at nearly absolute zero temperature.

III. Neutron Star, Supernova, Collapsar, GRB, and Pair Instability Supernova

The formation of neutron star involves the core collapse of a large star. When a star with the initial mass of about 8 to 25 solar masses depletes its nuclear fuel, it has no outward radiation pressure to support its bulk. The core of the star collapses into a neutron star by fusing electrons and protons into neutrons, sending out huge numbers of neutrons. The neutrino shock wave from these neutrinos causes a violent expulsion of the surrounding material, resulting in supernova [10]. The collapse in terms of the compression from a large size progenitor to a very small neutron star leads to a fast-rotating neutron star with a high angular momentum and a strong magnetic field.

Gamma-ray bursts (GRBs) are the flashes of focused gamma rays associated with extremely energetic explosions that have been observed in distant galaxies. The energy of a GRB is approximately equal to turning a star like the Sun into pure energy. GRB can be explained typically by collapsar (collapsed star) [11] that refers to a specific model for the gravitational collapse of a fast-rotating star, resulting in a stellar mass black hole.

In the collapsar model, when a star with initial mass about 25 to 90 solar masses collapses into a fast-rotating black hole, the black hole immediately begins to pull in more stellar material, and very quickly a rotating disk of material as black hole accretion disk (BHAD) forms. The inner portion of the disk spins around the superstar at near light speed. With rotating conducting fluids, the BHAD creates a strong magnetic field. Because the inner portion of the BHAD is rotating more quickly than the outer portion, the magnetic field lines twist violently. This causes a jet of material to blast outward at almost the speed of light perpendicularly to the BHAD. The jet contains matter and antimatter in the form of electrons, positrons, and protons. The gamma rays are produced by the "internal shocks" as the collisions of the shells of matter and energy pushed by the jet.

One of the problems in the collapsar model of GRB is to explain how some gamma-ray bursts may convert as much as half or more of the explosion energy into gamma-rays [12]. Another problem in the collapsar model of GRB is to explain the complexity of the light curves of GRBs [13]. The duration of observable emission can vary from milliseconds to tens of minutes. The numbers, the shapes, and the intensities of the peaks in the light curves vary. No two light curves are identical.

A hypernova [14] is a type of supernova with energy much higher than standard supernovae. One of the models for hypernova is pair instability supernova. Pair-instability supernova occurs in stars with an initial mass range from around 130 to 250 solar masses. The stellar core is occupied by gamma rays whose outward pressure keeps the star from collapse by the inward gravity. Electron-positron pairs can be created from gamma rays, resulting in the reduction of outward pressure by the decrease of gamma rays. This outward pressure drop leads to a partial collapse, resulting in an accelerated thermonuclear burning in a runaway thermonuclear explosion which blows the star completely apart without leaving a star remnant behind. The result is a hypernova.

For the star with an initial mass of 100 to 130 solar masses as in Eta Carinae [15], the partial collapse is not large enough to cause a runaway thermonuclear explosion. The thermonuclear explosion to only leads to the ejection of a part of outer layer. The repetition of the partial collapse finally depletes enough mass, resulting in a normal supernova. For a star with an initial mass higher than about 250 solar masses, the energies from the thermonuclear reactions are absorbed in photodisintegration.The stellar collapse continues without explosion.

IV. Superstar

Black hole has been a standard model for the collapse of a large star. Singularity in black hole remains contentious. Gravastar (gravitational vacuum star) [16] by P. O. Mazurand and E. Mottola is a model for the collapse of a large star without singularity. In gravastar, quantum effects would change space-time around a collapsing star, initiating a radical phase transition like when liquid water becomes ice, for the infalling matter. For gravastar, the phase transition involves the transformation into a "gravitational vacuum" with an interior de Sitter condensate surrounded by a Bose-Einstein condensate (BEC) bubble, similar to the transformation of a cloud of atoms into one huge "super-atom", a BEC at an extremely low temperature above absolute zero degree. The BEC is prevented from complete collapse by the interior de Sitter condensate exerting a balance pressure outwards on the condensate. A thin phase boundary (shell) for the phase transition is in between the interior region and the exterior region.

In this paper, singularity-free superstar is proposed as a model for the collapse of large stars and GRBs. Superstar is an alternative to black hole and gravastar. When a star with initial mass of about 25 to 90 solar masses collapses, the huge amount of collapsing materials allows the neutrino shock wave to have a weak or no supernova. The stellar collapse by inward gravity continues. The fast-rotating star resulted from the stellar collapse creates a strong magnetic field.The stellar core is a small size gamma ray core. The outward pressure from this small size gamma ray core is too weak to stop the stellar collapse. The stellar

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collapse continues. When the stellar core reaches the critical extreme density by the stellar collapse, the stellar core is transformed into the super matter core with the extreme force fields that prevent singularity in the ordinary force fields by infinite density.

For a pre-superstar, the ordinary matter region is outside of the super matter core. The phase boundary is in between the super matter core and the ordinary matter region. The phase boundary is for the phase transition from ordinary matter to super matter. As in the Meissner effect to repel applied magnetic field in short-range, the super matter core exerts an outward pressure to repel the phase boundary in short-range with the strength proportional to the total mass of the super matter.

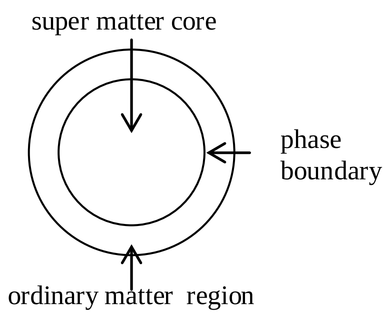

Figure 1 : The pre-superstar

During the stellar collapse, the infalling energy that reaches the phase boundary is stored first as gamma rays in the phase boundary that is repelled by the super matter core. The infalling matter particles that reach the phase boundary are also stored first in the phase boundary. The density in the phase boundary is less than the critical extreme density. The further stellar collapse that increases the density in the phase boundary to the critical extreme density converts the gamma rays and matter particles in the phase boundary into super matter particles that move to the super matter core. The whole conversion process then starts over again. As a result, the stellar collapse increases the super matter core, and decreases the ordinary matter region.

Eventually, the ordinary matter region becomes small, and the inward gravity of the ordinary matter region is too weak to allow the ordinary matter region and the phase boundary to attach to the super matter core that repels the phase boundary. The result is the stellar breakup to detach the phase boundary and the ordinary matter region from the super matter core. The stellar breakup starts from the phase boundary that is repelled by the super matter core. During the stellar breakup, the detached phase boundary and ordinary matter region that are broken into pieces by the fast-rotation become the superstar accretion disk (SAD) as the black hole accretion disk (BHAD) in the collapsar model of GRB. With the additional energy from the gamma rays in the phase boundary, the SAD contains much higher energy than the BHAD. As the BHAD, the SAD produces a jet of material in the forms of electrons, positrons, and protons to blast outward at almost the speed of light perpendicularly to the SAD. The higher energy SAD produces the higher energy jet than the jet from the BHAD. The higher energy jet from the SAD produces more gamma rays from the internal shocks than gamma rays produced from the jet from the BHAD. The different parts of the ordinary matter region in a compact pre-superstar break up nearly simultaneously, so the GRB duration is short [17], and there is only one light peak in the light curve. The different parts of the ordinary region in a large pre-superstar do not break up at the same time, so the GRB duration is long, more than one light peak are in the light curve, and different light peaks are different in intensities and shapes. The short duration GRBs have the average about 0.3 seconds and the long duration GRBs have the average about 30 seconds [18].

The observed high conversion of the explosion energy into gamma rays in a pre-superstar breakup comes from the SAD that contains higher energy than the BHAD. For the light curves of GRBs, the additional complication that is not in the collapsar model is from the complex stellar breakup in a pre-superstar. Therefore, the superstar model of GRB solves the two problems of the collapsar model of GRB for the high conversion of the explosion energy into gamma rays and the complex light curves in GRBs. After the stellar breakup, the remnant is a pure superstar with only the super matter core. A pure superstar with a high gravity hinders the emission of light.For the stellar breakup of a non-rotating pre-superstar, energies are not focused by the magnetic field of a fast-rotating superstar. The stellar breakup is similar to a supernova.

For a star with an initial mass of 100 to 130 solar masses, the stellar core is a medium size gamma ray core that has a strong outward pressure to stop the stellar collapse and to prevent the formation of the super matter core. The core collapse by pair instability leads to a thermonuclear explosion, but not a runway thermonuclear explosion. The thermonuclear explosion leads to the ejection of a part of the ordinary matter region.

For a star with an initial mass of 130 to 250 solar masses, the stellar core is a large size gamma ray core that has a strong outward pressure to stop the stellar collapse and to prevent the formation of the super matter core. The core collapse by pair instability leads to a runway thermonuclear explosion, resulting in a hypernova (pair instability supernova) without any star remnant. For a star with an initial mass of higher than about 250 solar masses, photodisintegration prevents thermonuclear explosion, resulting in continuing stellar collapse to convert the stellar core into the super matter core for a supermassive pre-superstar.

From outside, black holes, gravastars, and superstars look the same. From inside, they are different in terms of information. The extreme force field that prevents singularity in gravity is an alternative to a gravitational vacuum (with the equation of state $p = - \rho$) in a gravastar. In a gravastar, the gravitational vacuum is located in one specific region. In a superstar, while the extreme force fields alone without other materials are not in one special region. The phase boundary in superstar is an alternative to the phase boundary in gravastar for the phase transition with equation of state $p = + \rho$ between the interior region and the exterior region (with the equation of state $p = \rho = 0$). In a gravastar, infalling matter that hits the phase boundary is converted into energy by proton decay, adding to the energy of the space-time vacuum within the phase boundary. Some information such as baryon number conservation is lost during the transition from the exterior region to the interior region. In a black hole, all information other than the total mass, charge, and angular momentum is lost. In a superstar, all ordinary force fields in the super matter core are recoverable under ordinary condition, so no ordinary information is lost in a superstar.

Black holes and gravastars lose the information about ordinary force fields, while superstars keep all information about ordinary force fields. Quantum mechanics is built on the principle that information cannot be lost. Violating this basic principle of quantum mechanics, black holes and gravastars do not exist. In compliance with this basic principle, superstars exist.

V. Summary

It is proposed that the digital space structure consists of attachment space (denoted as 1) and detachment space (denoted as 0). Attachment space (as 1) allows object to attach to account for rest mass and reversible movement, while detachment space (as 0) allows no object to attach to account for irreversible kinetic energy. The combination of attachment space and detachment space brings about the three structures: binary partition space, miscible space, or binary lattice space, Binary partition space $(1)_n(0)_n$ consists of separated continuous phases of attachment space and detachment space to account for quantum mechanics and extreme force field. In miscible space $(1+0)_n$, attachment space is miscible to detachment space without separation to account for special relativity. Binary lattice space $(1\ 0)_n$ consists of repetitive units of alternative attachment space and detachment space to account for ordinary force fields as force orbitals.

Through the detachment space, a higher dimensional particle in attachment space is sliced into infinitely surrounding a lower dimensional core attachment space, resulting in a particle surrounding by ordinary force fields (gravitational, weak, electromagnetic, and strong) in the form of binary lattice space. At extreme conditions, such as extremely low temperature and high density, the ordinary force field in the form of binary lattice space is transformed into the short-range extreme force field in the form of binary partition space to avoid inactivation and singularity. Unlike the ordinary force fields, the extreme force fields are free of inactivation at extremely low temperature and singularity at extremely high density. The extreme force fields are manifested as the bonds among electrons in a superconductor, as the bonds among atoms in superfluid, and as the bonds among all materials in superstar.The Meissner effect is explained by the outward pressure of extreme force fields to eject applied magnetic fields from the interior of the superconductor as it transitions into the extreme force fields at nearly absolute zero temperature.

When the stellar core of a large star reaches the critical extreme density during the stellar collapse, the star is transformed into a pre-superstar containing the super matter core with extreme force field, the ordinary matter region with ordinary force fields, and the thin phase boundary between the super matter core and the ordinary matter region. The stellar collapse increases the super matter core by converting the infalling ordinary energy and matter from the ordinary matter region into the super matter, and decreases the ordinary matter region. As in the Meissner effect to repel applied magnetic field in short-range, the super matter core exerts an outward pressure to repel the phase boundary in short-range with the strength proportional to the total mass of the super matter. Eventually, the stellar breakup occurs to detach the ordinary matter region and the phase boundary from the super matter core, resulting in GRB to account for the observed high amount of gamma rays and the observed complex light curves in GRBs. Unlike black holes and gravastars that lose information, singularity-free superstars that keep all information exist.

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Laser Technology and Weapons

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Abstract- The experience of designing strategic laser systems in the previous years and a strong belief in the attainability of the goal - the development of high-power laser weapons - help to significantly accelerate the pace of work in the field of new technologies. World press has recently published the articles where it was suggested that the anti-missile airborne laser project suffers cost overruns and delays and may fall victim to budget cuts. Just after that mass media immediately reported that the Pentagon refuses to develop combat lasers. As a result, there has appeared an epic set of myths about combat lasers. The task of this paper is to consider the most ridiculous statements and to reject them by sufficient analysis. An additional goal is to focus the interests of laser physics community to the mono-module disk laser geometry, which is possible now for implementation.

Keywords: *laser, weapons, epic myth, efficiency, combat lasers, technology, beam divergence, mirrors, reflectivity, interaction, continuous and pulsed lasing.*

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LASERTECHNOLOGYANDWEAPONS

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Laser Technology and Weapons

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Keywords: laser, weapons, epic myth, efficiency, combat lasers, technology, beam divergence, mirrors, reflectivity, interaction, continuous and pulsed lasing.

I. Introduction

The Wall Street Journal has recently published an article in which it was suggested that the anti-missile airborne laser (ABL) project suffers cost overruns and delays and may fall victim to budget cuts. Mass media have immediately happily reported that the Pentagon refuses to develop combat lasers. However, this euphoria seems very misleading, if not tougher.

Today, chemical lasers are being widely replaced by solid-state diode-pumped lasers. It is these lasers that the Pentagon counts on, because they are more compact, simpler and cheaper to use than chemical lasers. Besides, they are reliable, easily compatible (without any transformation of the output voltage) with nuclear and solar energy, allow for further scaling of output parameters and the efficiency of their operations is significantly higher. Northrop Grumman Corporation has already presented a 105-kW solid-state laser and intends to significantly increase its output power [1]. According to data from U.S. laboratories work is on the way to develop a prototype of a 500-kW laser. Subsequently, 'hyperboloids' will be truck-mounted [high energy laser technology demonstrator (HEL TD) program], ship-mounted [maritime laser demonstrator (MLD) project], and airborne [high energy liquid laser air defense system (HELLADS); a laser for F-35, B-1, CH-47 aircrafts). Another direction is largely supported by Raytheon, which stakes on fiber systems. A 50-kW laser weapon system (LaWS) will be integrated with the Phalanx Close-In Weapons System (CIWS) against anti-ship missiles and its land based version of Centurion C-RAM. In addition, the officials in the U.S. have recently reported on the progress of works on a combat free electron laser. At the same time, we should not forget about "Alpha" system (a laser with an output power of 4.5 MW), lying on the ground and waiting for the decision to be launched.

Anti-missile airborne laser

Brining solid-state lasers to megawatt powers takes time and considerable resources. However, the experience of designing strategic laser systems in the previous years and a strong belief in the attainability of the goal - the development of high-power laser weapons – help to significantly accelerate the pace of work in the field of new technologies. It should be noted, however, that tactical laser systems with lower power outputs have already been tested in the U.S. and now find applications in the army. All this testifies that the Pentagon experts clearly do not think about cancelling the promising laser programs. We are talking here about an effective system of disinformation. Last year's report 'Technology Horizons' by the Pentagon refers to the global changes in the 'rules of the game' after the proliferation of 'high energy weapons', which will turn the traditional symbols of military power into outdated stuff like cannonballs and cavalry... And while the U.S. develops laser programs, many other counties show 'laser apathy.' Incompetent bloggers and pseudoscientific workers, who had something to do with the laser program thirty years ago, speculate that 'lasers are a bluff.' As a result, there has appeared an epic set of myths about combat lasers. Consider the most ridiculous of them.

II. Ten Myths

a) *Myth 1. 'Combat lasers have been developed for four decades with no progress in sight.'*

Let us quote one of the Russian papers: "In the 1970s the Americans took a 150-ton Boeing-707 and 'stuck' a laser to it, which successfully burned small rockets. In the 2000s, they took a 350-ton Boeing-747 and 'stuck' a heavier and more powerful laser, which

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successfully burned larger size rockets. In 20 years they will buy in Ukraine a decommissioned "Antonov AN-225 Mriya" (640 tons), and here it is, the Death Star [2]. Yes, probably it will be able to shoot down a "Scud", and even a "Taepodong". However, only at the site, and once, no more."

Under the '150-ton Boeing-707,' to which a laser was 'stuck,' is apparently meant a 137-ton Boeing KC-135 stratotanker based on the" 707 "of the first), modified in 1973 into NKC-135ALL [airborne laser laboratory (ALL)]. In 1983, a laser mounted on the aircraft shot down several Sidewinder air-to-air missiles at a distance of 5 km and some other 'little' things. What has changed since then? According to the above quotation – only the size of the aircraft.

Airbased military laser

But what about the reality? Even the so-called 'megawatt' CW lasers of the 1980s did not emit light at megawatt power levels, they consumed more power. The 2.2-megawatt Miracle laser system, which later in the combat version was called a tactical high energy laser (THEL) ('MIRACLE' with the 'SEALITE' guidance system) did not possess a supernatural power [3]. What to say about the earlier and five times weaker ALL. Has there been any progress since then? An ABL has a power of 1.1 MW and it is not the power to be consumed; this is the power in the beam. Thus, a 'more powerful' (50 times) laser was 'stuck' to a 350-ton Boeing... However, it should be understood that the actual capabilities of the laser rely not on the power as such, but on the concentration of the radiation, i.e., the ability of the 'guns' to emit not only a powerful, but also a narrow beam. The ALL had the level of the radiation concentration equal to 10^{13} J/(sr·s). An ABL has the level of about 10^{18} J/(sr·s) – that is, 10 thousand times higher. These achievements are made up not only of the straight-line growth in the power. The last 30 years have seen a period of extremely rapid development of adaptive optics to compensate for the effects of atmospheric turbulence and laser path on the transmitted beam. In addition, the lasers of the same class are radically reduced in size. The first version of a THEL weighed 180 tons and could be hardly installed into six trailers. The laser used a hydrogen–fluoride mixture which is very unfriendly to the environment. The second generation of advanced tactical lasers (ATLs) relies on oxygen–iodine mixtures [so called chemical oxygen–iodine lasers (COILs)] and is more compact. Finally, a new solid-state laser of Northrop Grumman weighs 1.5 tons, including the cooling system. In the future its weight is expected to be reduced to 750 kg. As a result, the land based version of the system consists of a heavy expanded mobility tactical truck (HEMTT A3), command post on a high mobility multipurpose wheeled vehicle and a towed single-axle trailer with the AN/MPQ-64 radar. At the same time, the U.S. works hard to convert the CW regime of the lasers in the pulse-periodic one, which will dramatically increase their range of actions.

Mobile laser system

Talks about the fact that "combat lasers have been developed for forty years and so they are hopeless," only show ignorance in technical matters. Breakthrough technologies are first tested for a few decades before the entry into a phase of maturity. Thus, aircrafts at the time of the first flight had almost 60 years of history – the first flying models were built in 1840 and the attempts to build full-size airplanes date back to 1868. It is, in fact, a classical scheme of development of any technology using new physical principles: First, a long 'incubation period' with no apparent practical results, and only then a 'great leap forward.'

b) *Myth 2. "Lasers cannot be used for a long time, usually they work several seconds."*

It is not so! In fact, chemical and solid-state combat lasers ensure continuous wave operation for minutes and tens of minutes. The next step in the development of high-power laser systems, of course, will be the implementation of a variable temporal structure of radiation in order to raise the peak radiation power for the ablation mechanism and to eliminate the effect of the screening of the target by plasma [4].

c) *Myth 3. "Energy of laser weapons is negligible compared to the fire arms."*

For comparison, the power of a 76.2-mm F-22 divisional gun (1936) is at 150 MW. This power is 150 times higher than that of the ABL! Besides, we ignore here the energy of the explosive in the shell, which is the same. Ponder upon this simple fact: A small ancient gun of the Second World for the price of scrap metal is hundreds of times more powerful than the ultramodern 'combat' laser weighing tens of tons and valued at over five billion USD. Only one shot from the ABL costs millions of dollars. And this shot comparable in energy with the burst of a machine-gun fire.

Such a comparison of the power achieved in 0.01 s with the power of CW light, and the 'proof' of inferiority of 'long-play' weapons (by using this comparison) contradicts even the school physics course. Let us try to compare everything in the correct way, i.e., by counting the energy sent to the target.

The muzzle energy of a 12.7-mm heavy machine gun is 15 – 17.5 kJ at a rate of 80 – 100 shots per minute. In other words, a 100-kW laser can be 'replaced' by three and a half heavy machine guns (6000 kJ/min vs. 1750). But let us return to the gun. The muzzle energy of F-22 is 1.35 MJ, while the power of the ABL is 1.1 MW, i.e., 1.1 MJ every second. Thus, the laser shoots 48 'shells' per minute. By converting the MW power to the TNT equivalent, we will obtain 240 grams of explosives per second and 14.4 kg per minute, which corresponds to the content of 18 high-explosive shells from the same gun. However, the actual 'value' of the laser is higher. The matter is that even with accurate firing of firearms, most of the 'energy' goes not to the enemy, but dissipates. The reason for that includes a dozen factors (wind, fluctuations in humidity, air pressure and temperature, the Coriolis force, etc.), making the bullet or shell spread inevitable. A steady flux of photons flies to where it was sent, excluding the huge amount of unnecessary loss.

d) *Myth 4. "Efficiency of lasers is a few percent."*

In fact, the efficiency of combat lasers is about 20.6%, and this is not the limit. According to the RELI program, the efficiency is planned to be raised up to 25%. Fiber lasers, which are adapted by Raytheon for military applications, now have an efficiency of about 30%. The efficiency of firearms is 20%–40%. At the same time, the efficiency of (smaller but steadily growing in power) solid-state diode-pumped systems is more than 50%, and soon it will approach its physical limit of about 85%.

e) *Myth 5. "The laser beam has a huge diffraction divergence."*

Here we deal a physically insuperable law of diffraction, which states that the laser beam always diverges with an angle proportional to the ratio of the wavelength to the diameter of the beam. If we take a specific combat IR laser with a wavelength of 2 μm (this wavelength is typical of combat THELs, etc.) and a beam diameter of 1 cm, we obtain a divergence angle of 0.2 mrad (this is a small angular divergence; for example, standard laser pointers/rangefinders have a divergence angle of 5 mrad and higher). However, because of 0.2-mrad divergence the beam

spot diameter will increase from 1 cm to 3 cm at a distance of 100 meters. That is, only 100 meters away the beam density will decrease (proportionally to the area of interaction) by 7 times. At a distance of a kilometer the density of the beam falls by 300 times.

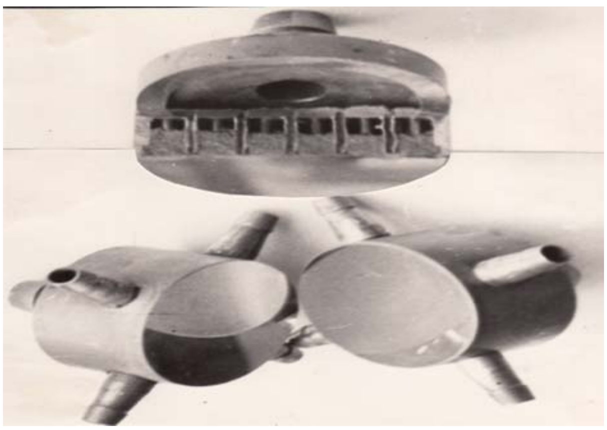
Actually, a combat laser emitting a beam with the initial diameter of 1 cm is a fruit of an unhealthy imagination, not burdened with some knowledge in this area. In fact, when using the focusing optics the diffraction divergence is about λ/D, where λ is the wavelength, and D is the diameter of the mirror and also the initial beam diameter, tapering due to focusing as the beam approaches the target; a large beam diameter (meters in this case) provides a low diffraction divergence. In the case of the ABL the wavelength is 1.315 μm, and the diameter of the mirror is 1.5 m; by dividing one by the other, we obtain the divergence of about 10^{-6} rad. In other words, at distance of only one kilometer the laser beam from the Boeing diverges by (oops!) 1 mm. At a distance of 200 km, the diffraction divergence will be 20 cm. The actual ABL beam divergence exceeds the diffraction limit by only 1.2 times.

f) *Myth 6. "One can easily be protected from laser weapons using, for example, an aluminum mirror."*

Yet another malapropism. Indeed, some metals may have near-100% reflection coefficients. First, however, these coefficients are not equal 100%. Thus, at a wavelength of 1 μm the reflection coefficient drops to 75% for most structural metals. A real missile after its launch will be also significantly contaminated with combustion products. Meanwhile, modern 'hyperboloids' emit light in the vicinity of 1 μm (the ABL has a wavelength of 1.315 μm). In this case, 25% of hundreds of kilowatts will be sufficient even in the cw regime to heat up and melt down the thin skin layer of the missile. Thus, reflectivity will decrease because the absorption of laser radiation increases rapidly with increasing temperature, and abruptly jumps after the start of melting. In the pulse-periodic regime the situation is even more favorable.

i. *Water cooled mirrors*

Besides, there arises also a 'childish' question: If the laser beam can be focused and directed by a mirror, why cannot the same mirror protect us from the laser beam? In lasers use is usually made of multilayer dielectric mirrors that can reflect very much – but in a very narrow range and only under strictly defined angles [5]. In addition, they are cooled, which is impossible to do with the entire surface of the target. In other words, simple, effective and affordable protection from high-power lasers does not exist.



Mirror with porous cooling system

g) *Myth 7. "The problem of overheating of lasers cannot be solved."*

Four megawatts of heat, which can heat red-hot an aircraft and burn to the ground, are generated per each megawatt of laser power. The cooling system with the gas flow rate of 1800 m/s (de Laval nozzle) is unable to release the generated heat from the fuselage.

In reality, the 'disposal' of the amount of heat in the megawatt units is quite trivial. Has anyone seen a red-hot diesel locomotive? Meanwhile, a decent diesel engine with a capacity of 2 MW releases more than 1 MW of heat into in the oil and cooling system. Far less easy is the problem of heat release from the limited volume of the laser weapon. In the case of a chemical ABL, the heated reaction products are simply blown out of the cavity by the well-known de Laval nozzle, and then liquid ammonia is used for cooling. Fairly cumbersome is the system with cryogenic components; however, it really is able to 'recycle' a very impressive amount of heat. Tactical solid-state lasers, which need more than 400 kW of heat to be released, do well without cryogenic 'refrigerators.' Thus, the HELLADS makes use of a unique cooling technique; the circulation of a liquid releases excess heat outside the 'laser cannon.' Remarkable also is General Atomics' advanced thermal energy storage device capable of cooling directed energy weapons. Heat is stored in the 35 kilogram module by melting a wax-type phase change material. As a result, the HELLADS provides for the interception of missiles within two minutes at the specified cw power followed a thirty- second break.

h) *Myth 8. "High-power and compact energy sources for combat lasers do not exist."*

This is partially true: It is not yet possible to mount a 100-kW solid-state laser on anything less than a truck because of the need to have at hand a 500-kW generator and suitable capacitors. In fact, this is a real problem, which has nothing to do with fantasy. In practice, the hybrid version of the HEMTT (HEMTT A3), even in the basic version has a 350-kW generator, which can provide up to 200 kW. When the engine power is increased up to 505 hp, HEMTT A3 can produce 400 kW of continuous exportable power. A nice addition is the 1.5-MJ capacitor bank. In other words, where the bloggers fancy an electric power plant, in fact, there is a high-tech truck. However, the issue of energy in the space can be solved by other, more efficient ways.

For example, well developed are nuclear power sources, solar energy, with its unlimited possibilities.

Mobile laser system

i) *Myth 9. "Every shot a laser is worth millions of dollars."*

In fact, one shot of the ABL costs 10 thousand USD, whereas the domestic 16 million rubles are the propaganda and exaggeration. This is comparable with the cost of a Fagot anti-tank guided-missile system. More complex anti-tank guided-missiles cost tens of thousands of dollars; for example, a Maverick air-to-ground missile for hitting targets ranging from a distance of a few thousand feet to 13 nautical miles at medium altitude costs 154 thousand USD, a Patriot missile – 3.8 million USD. The cost of a shot from tactical lasers is less than from the ABL. Even in a hydrogen fluoride THEL it was 2-3 thousand USD; in this case, the laser used not hydrogen but deuterium which is quite expensive.

Sketch space based laser system

j) *Myth 10. "All the problems that can be solved with laser weapons, are easier and cheaper to solve by traditional means."*

This conclusion has already been proven to be ineffective; see, for example, at Israel's attempts to defend against missile attacks by Hamas missiles (the Iron Dome system). One interception costs 30-40 thousand USD. The cost of a rocket for a Grad multiple rocket launcher system is about 1 thousand USD, the cost of a Qassams rocket does not exceed 200 USD. Thus, the interception will be 40-200 times more expensive than the rocket launched by the enemy. In this connection Tariq abu Nazar, the Hamas spokesman, once said "if every rocket launch of our missilemen costs tens of thousands of dollars for Israelis, we will assume that the goal is achieved." As a result, some newspaper people accuse not developers of laser systems but those who are responsible for termination of the Israeli-American program. The Centurion missile defense system has not found wide application because of the short-range and great ammunition consumption.

III. Legends

Of course, this is not a complete list of the legends about lasers. Most of them are built on the same principle: either outrageous lie or painstaking making of a mountain out of a molehill. In fact, lasers on the battlefield are real and the army, which possesses such weapons, will receive an impressive advantage. Thus, the air force, able to actively defend against anti-aircraft and air-to-air missiles, will be much less vulnerable to air defenses. Thus, the development of laser technology is critically important not only for well developed countries. Combat lasers are an obvious asymmetrical response to the superiority of the precision weapons. The 'ideology' of the latter in a very rude manner is to ensure that instead of a dozen of shells, a guided munition (though much more expensive) is used to precisely hit a specific target, and to minimize collateral damage. However, such a scheme is particularly vulnerable to laser defense systems, which make no difference between an archaic shell for two hundred dollars or an expensive high-tech device or military equipment. The number of targets is not so great, and their cost is ten times higher than that of the most expensive laser 'shot.'

IV. Disk laser

It is already evident that the world has entered a new round of technological race. It does not depend on our wishes, it is the willing of time. Most developed countries, based on their technological advantages, are spending billions of dollars to develop high-tech next-generation lasers [6]. According to Japanese media U.S. invested up to now more than 100 billion USD in the development of semiconductor laser pumping of solid-state lasers.

The mono-module disk laser concept is one of the most effective design for diode-pumped solid-state lasers, which allows the realization of lasers with super-high output power, having very good efficiency and also excellent beam quality. Since the first demonstration of the principle in 1966 [7] the output power of mono-module disk has been increased to the level of few kW in continuous wave (CW) mode of operation. "Zig-Zag" disk laser geometry does not look like as a perspective one for further output parameters growing. The scaling laws for mono-module disk laser design show that the limits for CW mode of operation is far beyond 100 kW for output power and the energy can be higher than 100 J in pulsed mode of operation. Due to the efficient porous cooling technology and possibility of amplified spontaneous emission (ASE) suppression the operation of the mono-module disk laser geometry is possible in CW and pulse-periodical (P-P) modes at extremely high output power.

This is due to the indisputable advantages of the disk geometry in terms of the minimal thermal lens in the active media and the high radiation resistance of the disk in the P-P regime because of the large area of the optical surface to couple out the radiation. So, the necessity to find a solution to the problem of the ASE suppression along the diameter of the disk was the major problem (matter of patent). In our case, the size of the disk at a multi-megawatt level of the average power output should be at least 50 cm, i.e., at least hundred time bigger the size of the disk that is used today in the existing systems. Radiation from such a laser, obtained during generation in the active medium of a single disk, does not require additional phase-locking. At the same time, such a laser in a mono - module geometry will be very well combined with a large-diameter telescope for ensuring high peak power density of the laser pulse on space debris. It is known that the disk geometry of a laser was proposed 51 years ago; however, to this day, the solution to the problem of the ASE suppression with increasing transverse dimensions of the active medium in the mono-module disk geometry is found! Thus, the

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prospects of new versions of the mono-module disk laser creation for new class of cutting edge problems are open!

V. Conclusion

The need to accelerate the development of high technology is the major topic of many political leader speeches. It is important to note the opinions of Western experts, who say that today laser technology is one of the most effective ways to gain technological superiority in the world. And today, laser technology makes it possible:

- to provide a new level of development of industry, science and technology for your country, the revival of scientific and technological strength of the country on the basis of modern high-techs;
- to make your country a leader in the field of technical, scientific and technological progress;
- to revive a large number of enterprises in many sectors of industry, which are well known for their developments in previous years;
- to strengthen your country leading position in space and to ensure strategic and geopolitical priorities in the modern world;
- to derive benefit from the sale of a wide range of laser programs, which is today comparable to the benefit from the sale of traditional products and resources.

VI. Literature

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Motion in a Medium Composed of Particles and Antiparticles

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Abstract- From quantum field theory, the vacuum is not empty space but a medium composed of particles and antiparticles. It has been shown that the process for pair creation also can yield real particles and antiparticles. The motion of objects through a medium consisting of matter and antimatter is considered. It shall be demonstrated that certain laws for the planetary orbits will follow in this system.

I. Introduction

It is known that the interchange of the virtual photon is sufficient to explain the central potential in electromagnetic interactions. This has been achieved by comparing the force between particles of given charge through a summation of diagrams with virtual photons and the Coulomb force. A major success of quantum electrodynamics is the prediction of the inverse square law in the classical limit from the exchange of virtual photons.

Furthermore, the creation of particles and antiparticles in the vacuum can affect the motion within the medium. This has been examined previously with respect to the Lorentz transformations and the constancy of the speed of light. It will established that there is an effect also on the rotation motion of objects as a result of developing couples. Exploring further the possibility of linking angular momentum couples, the particles and antiparticles can be combined to create a substantial torque that will convert linear motion into orbital motion. Laws for this motion then can be formulated including a relation for the radii of these orbitals.

The possibility of an electromagnetic component to the force between between the Sun and the planets has been considered previously (Nieto, 1972). The similarity in the constants of proportionality in the relation between the total angular momentum and the squared mass has been verified from microscopic to astronomical scales (Wesson, 1981; Tassie, 1987). Furthermore, a linear combination of the gravitational and electromagnetic gradients yields the value for planetary systems for a ratio that coincides with the percentage of mass that can be attributed to dark matter (Davis, 2007).

It is known also that the strength of the electromagnetic force would require a reduction in the size of the source. A theoretical explanation of the distances in the planetary orbits can be found found in models describing both gravitational and electromagnetic interactions and gravi-electromagnetic solitons (Belinski, V. and Verdaguer, E., 2001). An exponential scale factor in the metric yields a connection between the source of the electromagnetic force and the gravitational effect at larger distances.

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II. The Creation of Particles and Antiparticles in the Medium

While the creation of electrons and positrons in quantum electrodynamics results from the non-zero inner product of the vacuum state with a state consisting of these particles and antiparticles, the process also can be modelled semiclassically with a balance between the electric and magnetic components of the potential and the energy of the electron (Batchelor, 2002). The Heisenberg time predicted by the uncertainty principle is determined by the mass of the electron to be

$$t_{He} = \frac{\frac{\hbar}{2}}{2m_e c^2} \simeq 3.220221702 \times 10^{-22} sec \qquad (2.1)$$

The time also may be evaluated through an integral over the trajectories of the the electrons and positrons representing the splitting and joining of the two paths. Substituting the values of the magnetic moment of the electron and its mass, the semiclassical time may be computed to be

$$t_{ve}^{(1)} \doteq \frac{R_{max}}{(1.0625)^{\frac{1}{3}} c} \int_0^1 \frac{d\tilde{\zeta}}{\sqrt{1-\tilde{\zeta}^{\frac{3}{2}}}} + \frac{R_{max}}{c} \int_{\frac{1}{(1.0625)^{\frac{1}{3}}}} \frac{d\zeta}{\sqrt{1-\zeta^{\frac{3}{2}}}} \approx 3.0896 \times 10^{-22} sec \qquad (2.2)$$

with R_{max} being half the maximum separation between the electron and positron (Davis, 2007). Since this value is less than t_{H_e}, the process might be examined to determine if there are any other effects that might contribute to the time of existence of the particle-antiparticle pair. In particular, since these processes are field theory limits of string processes which may have genus greater than or equal to two, the sum over diagrams would give a larger average for the time t_{ve}. This has been computed under two conditions. The process can be regarded as entirely virtual with the squares of the absolute values of the amplitudes determining the coefficients in the weighted average for the time, or the process may viewed as real with the magnitudes of the amplitudes substituted for the coefficients. The two methods give different results in keeping with the nature of the reaction. In the first instance, the total time was found to be

$$t_{ve}^{virt} \approx 3.09482893 \times 10^{-22} sec \qquad (2.3)$$

With the second technique,

$$t_{ve}^{real} \approx 3.227585405 \times 10^{-22} sec \qquad (2.4)$$

Since these times follow from an averaging procedure, in principle, there would be a distribution of values and the either process might occur. The reactions then would produce both virtual pairs and real particle-antiparticle pairs. The latter process would cause the medium to consist of these particle-antiparticle pairs, because the time exceeds t_{H_e} and the pair do not have the reaction does not have to be concluded by a pair annihilation (Davis, 2007). When the pair creation produces real electrons and protons, a moment $\vec{F} \times \vec{r}$ is generated, where $\vec{F}$ is generated by the magnetic force between the oppositely directed currents created by the moving charges and $\vec{r}$ is the position vector from the electron to the positron. Therefore, the particles and antiparticles form an electromagnetic couple which generates a torque. From the couplings of the electromagnetic and gravitational interactions and the size of the source of the centripetal force, it follows that the relative strengths of the forces are given by a factor

$$\begin{aligned} &\alpha^3_{cent.} \frac{1}{1.3 \times 10^6} (1.216545 \times 10^{36}) \\ &\alpha_{cent.} = \frac{R_{cent.}}{R_E} \end{aligned} \tag{2.5}$$

The classical Lagrangian of electromagnetism (Proca, 1936) and the Feynman diagrams of quantum electrodynamics may be used to deduce a $\frac{1}{r^2}$ Coulomb force in the classical limit through a Fourier transform of the momentum-space propagator (Feynman, 1949; 1965). While it is evident that scale of the effective interaction region in the Feynman diagram is the order of the Compton wavelength of the electron, the transition to a physical process would provide a realization of the $\frac{1}{r^2}$ electromagnetic force through a wave phenomena.

It follows that the model of a gravitational soliton in an electromagnetic field also would yield a description of material configurations a medium with pair creation and annihilation orbiting a central source. By choosing a metric

$$ds^2 = f_0(dz^2 - dt^2) + \alpha e^{2k\beta}(dx^1)^2 + \alpha e^{-2k\beta}(dx^2)^2 \tag{2.6}$$

and a potential $A^{(0)} = 0$, and dressing both the metric and potential through transformations constructed to give the soliton solution to the gravatitional and electromagnetic field equations (Garate and Gleiser, 1995; Belinski, V. and Verdaguer, E., 2001) the metric and potential are found to be

$$ds^2 = f(t,z)(dz^2 - dt^2) + g_{ab}(t,z)dx^a dx^b \tag{2.7}$$

where

$$\begin{aligned} g_{11} = \frac{q_0 sin\ tcosh\ z}{D_1} &[(cosh\ t\ cosh\ \sigma - sin\ \sigma + \nu_0^2 sinh\ t)^2 \\ &+ (sinh\ zsin\ \tau - cos\ \tau - \nu_0^2 cosh\ z)^2] e^{2kq_0 cosh\ t\ sinh\ z} \end{aligned}$$

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$$g_{22} = \frac{q_0 sinh\ t\ cosh\ z}{D_1}[(cosh\ t\ cosh\ \sigma + sinh\ \sigma + \nu_0^2 sinh\ t)^2$$
$$+ (sinh\ z\ sin\ \tau + cos\ \tau - \nu_0^2\ cosh\ z)^2]e^{-2kq_0 cosh\ t\ sinh\ z} \quad (2.8)$$
$$g_{12} = 2\frac{q_0\ sinh\ t\ cosh\ z}{D_1}[sinh\ zsinh\ \sigma\ sin\ \tau - cosh\ t\ cosh\ \sigma\ cos\ \tau$$
$$- \nu_0^2(cosh\ zsinh\ \sigma + sinh\ t\ cos\ \tau)]$$
$$f = \frac{D_1}{\sqrt{q_0\ sinh\ t\ cosh\ z}} e^{k^2 q_0^2 sinh^2 t cosh^2 z}$$

and

$$D_1 = (sinh\ tcosh\ \sigma + \nu_0^2 cosh\ t)^2 + (cosh\ z\ sin\ \tau - \nu_0^2 sinh\ z)^2$$
$$\sigma = 2kq_0 sinh\ z - 2s_0 \quad (2.9)$$
$$\tau = 2kq_0\ cosh\ t - 2t_0 + \frac{\pi}{2}$$

with

$$A_a = 4\frac{q_0\nu_0}{D_1} Re\Big\{ e^{i\delta_0}\bar{p}_a[\nu_0^2(sinh^2 z + cosh^2 t) + sinh\ t\ cosh\ t\ cosh\ \sigma - sinh\ z\ cosh\ z\ sin\ \tau$$
$$- i(sinh\ t\ sinh\ z\ cosh\ \sigma + cosh\ z\ cosh\ t\ sin\ \tau)]\Big\}$$
$$\bar{p}_1 = \frac{i}{2\sqrt{2}} e^{k\beta}\left(\frac{cosh[kq_0 sinh\ z - s_0 + i(kq_0\ cosh\ t - t_0)]}{\sigma_-} - \frac{sinh[kq_0 sinh\ z - s_0 + i(kq_0\ cosh\ t - t_0)]}{\sigma_+} \right)$$
$$\bar{p}_2 = \frac{i}{2\sqrt{2}} e^{-k\beta}\left(\frac{cosh[kq_0 sinh\ z - s_0 + i(kq_0\ cosh\ t - t_0)]}{\sigma_-} + \frac{sinh[kq_0 sinh\ z - s_0 + i(kq_0\ cosh\ t - t_0)]}{\sigma_+} \right)$$
$$\sigma_+ = \frac{\sqrt{q_0}}{2}\left[e^{\frac{(z+t)}{2}} + ie^{-\frac{(z+t)}{2}} \right]$$
$$\sigma_- = \frac{\sqrt{q_0}}{2}\left[e^{\frac{(z-t)}{2}} + ie^{-\frac{(z-t)}{2}} \right] \quad (2.10)$$

with the pole in dressing matrix occurring at $w_= iq_0$ and ν_0 and δ_0 are constants arising in T_{11}, which is derived from the expansion of this matrix (Belinski, V. and Verdaguer, E., 2001).

Consider the large-σ dependence of A_a. It is given by

$$lim_{\sigma\to\infty} 4q_0\nu_0 \left\{ Re\left(e^{i\delta_0}\bar{p}_a\right) \frac{sinh\ tcosh\ tcosh\ \sigma}{sinh^2 t\ cosh^2\sigma} + Im\left(e^{i\delta_0}\bar{p}_a\right) \frac{sinh\ t\ sinh\ z\ cosh\ \sigma}{sinh^t\ cosh^2\sigma} \right\}$$
$$\sim 4q_0\nu_0 lim_{\sigma\to\infty}\left\{ \frac{coth\ t}{cosh\ \sigma} Re\left(e^{i\delta_0}\bar{p}_a\right) + \frac{sinh\ z}{sinh\ t\ cosh\ \sigma} Im\left(e^{i\delta_0}\bar{p}_a\right) \right\} \quad (2.11)$$

Since

$$Re(e^{i\delta_0}\bar{p}_a) = cos\ \delta_0\ Re\ \bar{p}_a - sin\ \delta_0\ Im\ \bar{p}_a$$
$$Im(e^{i\delta_0}\bar{p}_a) = sin\ \delta_0\ Re\ \bar{p}_a + cos\ \delta_0\ Im\ \bar{p}_a, \tag{2.12}$$

and

$$Re\ \bar{p}_1 = -\frac{1}{2\sqrt{2}}e^{kq_0cosh\ tsinh\ z}\left\{\frac{sinh\ (kq_0sinh\ z-s_0)sin(kq_0cosh\ t-t_0)e^{\frac{z-t}{2}}}{\sqrt{2q_0}cosh(z-t)}\right.$$
$$-\frac{cosh(kq_0sinhz-s_0)cos(kq_0sinh\ t-t_0)e^{-\frac{z-t}{2}}}{\sqrt{2q_0}cosh(z-t)}$$
$$-\frac{cosh(kq_0sinh\ z-s_0)sin(kq_0cosh\ t-t_0)e^{\frac{z+t}{2}}}{\sqrt{2q_0}cosh(z+t)}$$
$$\left.+\frac{sinh(kq_0sinh\ z-s_0)cos(kq_0sinh\ t-t_0)e^{-\frac{z+t}{2}}}{\sqrt{2q_0}cosh(z+t)}\right\}$$
$$Im\ \bar{p}_1 = \frac{1}{2\sqrt{2}}e^{kq_0cosh\ t\ sinh\ z}\left\{\frac{cosh(kq_0sinh\ z-s_0)cos(kq_0\ cosh\ t-t_0)e^{\frac{z-t}{2}}}{\sqrt{2q_0}cosh(z-t)}\right.$$
$$+\frac{sinh(kq_0sinh\ z-s_0)sin(kq_0cosh\ t-t_0)e^{-\frac{z-t}{2}}}{\sqrt{2q_0}cosh(z-t)}$$
$$-\frac{sinh(kq_0sinh\ z-s_0)cos(kq_0sinh\ t-t_0)e^{\frac{z+t}{2}}}{\sqrt{2q_0}cosh(z+t)}$$
$$\left.-\frac{cosh(kq_0sinh\ z-s_0)sin(kq_0cosh\ t-t_0)e^{-\frac{z+t}{2}}}{\sqrt{2q_0}cosh(z+t)}\right\} \tag{2.13}$$
$$Re\ \bar{p}_2 = -\frac{1}{2\sqrt{2}}e^{-kq_0cosh\ t\ sinh\ z}\left\{\frac{sinh(kq_0sinh\ z-s_0)sin(kq_0cosh\ t-t_0)e^{\frac{z-t}{2}}}{\sqrt{2q_0}cosh(z-t)}\right.$$
$$-\frac{cosh(kq_0sinh\ z-s_0)cos(kq_0sin\ t-t_0)e^{-\frac{z-t}{2}}}{\sqrt{2q_0}cosh(z-t)}$$
$$+\frac{cosh(kq_0sinh\ z-s_0)sin(kq_0cosh\ t-t_0)e^{\frac{z+t}{2}}}{\sqrt{2q_0}cosh(z+t)}$$
$$\left.-\frac{sinh(kq_0sinh(kq_0sinh\ z-s_0)cos(kq_0sin\ t-t_0)e^{-\frac{z-t}{2}}}{\sqrt{2q_0}cosh(z+t)}\right\}$$
$$Im\ \bar{p}_2 = \frac{1}{2\sqrt{2}}e^{-kq_0cosh\ t\ sinh\ z}\left\{\frac{cosh(kq_0sinh\ z-s_0)cos(kq_0cosh\ t-t_0)e^{\frac{z-t}{2}}}{\sqrt{2q_0}cosh(z-t)}\right.$$
$$+\frac{sinh(kq_0sinh\ z-s_0)sin(kq_0cosh\ t-t_0)e^{-\frac{z-t}{2}}}{\sqrt{2q_0}cosh(z-t)}$$
$$+\frac{sinh(kq_0sinh\ z-s_0)cos(kq_0sinh\ t-t_0)e^{\frac{z+t}{2}}}{\sqrt{2q_0}cosh(z+t)}$$
$$\left.+\frac{cosh(kq_0sinh\ z-s_0)sin(kq_0cosh\ t-t_0)e^{-\frac{z+t}{2}}}{\sqrt{2q_0}cosh(z+t)}\right\}.$$

when $\alpha = q_0 sinh\ t\ cosh\ z$ and $\beta = q_0 cosh\ t\ sinh\ z$,

$$lim_{\sigma\to\infty}A_1 =$$

$$4q_0\nu_0 lim_{\sigma\to\infty}\left\{\frac{coth\ t}{cosh\ \sigma}\left[cos\ \delta_0\left(-\frac{1}{4\sqrt{q_0}}\right)e^{kq_0cosh\ t\ sinh\ z}\right.\right.$$

$$\left(sinh(kq_0sinh\ z - s_0)sin(kq_0sinh\ t - t_0)e^{-\frac{z-t}{2}}\right.$$

$$\left.- cosh(kq_0sinh\ z - s_0)sin(kq_0sinh\ t - t_0)e^{-\frac{z+t}{2}}\right)$$

$$- sin\ \delta_0\left(\frac{1}{4\sqrt{q_0}}\right)e^{kq_0cosh\ t\ sinh\ z}$$

$$\left(cosh(kq_0sinh\ z - s_0)cos(kq_0\ cosh\ t - t_0)e^{-\frac{z-t}{2}}\right.$$

$$\left.\left.- sinh(kq_0sinh\ z - s_0)cos(kq_0cosh\ t\ sinh\ z)e^{-\frac{z+t}{2}}\right)\right]$$

$$+ \frac{sinh\ z}{sinh\ t\ cosh\ \sigma}\left[sin\ \delta_0\left(-\frac{1}{4\sqrt{q_0}}\right)e^{kq_0cosh\ t\ sinh\ z}\right.$$

$$\left(sinh(kq_0sinh\ z - s_0)cos(kq_0sinh\ t - t_0)e^{-\frac{z-t}{2}}\right.$$

$$\left.- cosh(kq_0sinh\ z - s_0)cos(kq_0sinh\ t - t_0)e^{-\frac{z+t}{2}}\right)$$

$$+ cos\ \delta_0\left(\frac{1}{4\sqrt{q_0}}\right)e^{kq_0cosh\ t\ sinh\ z}$$

$$\left(cosh(kq_0sinh\ z - s_0)cos(kq_0\ cosh\ t - t_0)e^{-\frac{z-t}{2}}\right.$$

$$\left.\left.- sinh(kq_0sinh\ z - s_0)cos(kq_0cosh\ t\ sinh\ z)e^{-\frac{z+t}{2}}\right)\right]$$

$$lim_{\sigma\to\infty}A_2 = 4q_0\nu_0 lim_{\sigma\to\infty}\left\{\frac{coth\ t}{cosh\ \sigma}\left[cos\ \delta_0\left(-\frac{1}{4\sqrt{q_0}}\right)e^{-kq_0cosh\ tsinh\ z}\right.\right.$$

$$\left(sinh(kq_0sinh\ z - s_0)sin(kq_0cosh\ t - t_0)e^{-\frac{z-t}{2}}\right.$$

$$\left.+ cosh(kq_0sinh\ z - s_0)sin(kq_0cosh\ t - t_0)e^{-\frac{z+t}{2}}\right)$$

$$- sin\ \delta_0\left(\frac{1}{4\sqrt{q_0}}\right)e^{-kq_0cosh\ tsinh\ z}$$

$$\left(cosh(kq_0sinh\ z - s_0)cos(kq_0cosh\ t - t_0)e^{-\frac{z-t}{2}}\right.$$

$$\left.\left.+ sinh(kq_0sinh\ z - s_0)cos(kq_0sinh\ t - t_0)e^{-\frac{z+t}{2}}\right)\right]$$

$$+ \frac{sinh\ z}{sinh\ t\ cosh\ \sigma}\left[sin\ \delta_0\left(-\frac{1}{4\sqrt{q_0}}\right)e^{-kq_0cosh\ t\ sinh\ z}\right.$$

$$\begin{aligned}&\Bigg(sinh(kq_0sinh\ z-s_0)sin(kq_0cosh\ t-t_0)e^{-\frac{z-t}{2}}\\&\quad+cosh(kq_0sinh\ z-s_0)sin(kq_0cosh\ t-t_0)e^{-\frac{z+t}{2}}\Bigg)\\&+cos\ \delta_0\left(\frac{1}{4\sqrt{q_0}}\right)e^{-kq_0cosh\ tsinh\ z}\\&\Bigg(cosh(kq_0sinh\ z-s_0)cos(kq_0cosh\ t-t_0)e^{-\frac{z-t}{2}}\\&\quad+sinh(kq_0sinh\ z-s_0)cos(kq_0sinh\ t-t_0)e^{-\frac{z+t}{2}}\Bigg)\Bigg]\end{aligned} \tag{2.14}$$

While the exponential factor $e^{kq_0cosh\ tsinh\ z}$ is larger than the other terms in A_1 for large t, it can be cancelled near $t=0$. For $t\approx 0$,

$$\begin{aligned}&lim_{\sigma\to\infty}A_1\to-\sqrt{q_0}\nu_0\left(cos\ \delta_0e^{-\frac{z-t}{2}}+sin\ \delta_0e^{-\frac{z+t}{2}}\right)\\&lim_{z\to\infty}A_2\to-\sqrt{q_0}\nu_0\left(cos\ \delta_0e^{-2kq_0sinh\ z}e^{-\frac{z-t}{2}}+sin\ \delta_0e^{-2kq_0sinh\ z}e^{-\frac{z+t}{2}}\right)\end{aligned} \tag{2.15}$$

The z-dependence is different for two directions, until rescaled coordinates $\hat{x}_1=e^{kq_0cosh\ tsinh\ z}x_1$ and $\hat{x}_2=e^{-kq_0cosh\ tsinh\ z}x_2$ are used. In these coordinates

$$lim_{z\to\infty}A_{\hat{a}}\to-\sqrt{q_0}\nu_0e^{-kq_0sinh\ z}\left(cos\ \delta_0e^{-\frac{z-t}{2}}+sin\ \delta_0e^{-\frac{z+t}{2}}\right) \tag{2.16}$$

when $t\approx 0$.

Interpreting $e^{kq_0sinh\ z}$ as a radial distance $\mathcal{R}$ such that $A_{\hat{a}}\sim\frac{1}{\mathcal{R}}$, the Coulomb potential is recovered. It may recalled the pair annihilation length is $4.796\times 10^{-14}cm$ (Davis, 2007). In units of this length, the planetary distance equals 2.9087×10^{26}. Equating the exponential factor with this value gives $kq_0sinh\ z\simeq 60.9349212$. Then $z\approx 4.1098-ln(kq_0)$ which defines a surface of bounded genus. The late-time behaviour of the metric and potential is consistent with and exponential decay $e^{-2kq_0sinh\ z}$ as $\sigma\to\infty$ only in the coordinates $(\hat{x}_1,\hat{x}_2)$.

While this manifold possesses planar sections in the $(\hat{x}_1,\hat{x}_2)$ coordinates, the metric component g_{zz} distiguishes z coordinate. A metric which might allow approximate equivalence between the spatial coordinates is provided by the initial results on the gravitational soliton in an electromagnetic field. In the metric (2.6), with $f_0=\frac{e^{k^2t^2}}{\sqrt{t}}$ (Garate and Gleiser, 1995), g_{zz} is an exponential function of t^2 only in this metric, the identification is feasible when the other spatial coordinates are rescaled. By a similar calculation, e^{kz} may be chosen to represent a radial distance in rescaled coordinates, and the required value of z for planetary distances in terms of the pair annihilation length would be approximately 121.8698424.

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III. The Elastic Medium and the Absorption of Energy of the Waves

Regarding matter at Planck scales as strings, an electron-positron pair can combine with other electromagnetic couples to create a macroscopic system which shall be described again through strings providing a theoretical basis for a linear relationship between the total angular momentum and the square of the mass at astronomical scales.

In contrast to a string fixed length, the equation of motion in an elastic medium will contain a damping factor μ dependent on the properties of an elastic medium. Since the Green function decays exponentially with a characteristic exponent containing μ, the medium will observe any initial force within a distance proportional to $\frac{1}{\mu}$ of the application of this force (Morse and Feshbach, 1953). Independence of the propagation of the wave along the string with respect to the endpoint of the string is consistent with strings of macroscopic lengths being formed from the initial electromagnetic couples.

In a medium consisting initially of pairs of particles and antiparticles, the development of these macroscopic strings would be accompanied by the propagation of an amplitude. If there is an amount of matter that accrues at given distances from a central source, this mass could serve as an endpoint of a string of astronomical lengths.

Consequently, a standing wave could be created which has the property that complete wavelengths are fit precisely within the distances from the central source to the mass. At other distances, the standing wave is reflected back to the center and the amplitudes would cancel. Therefore, the only configurations with non-negligible probabilities of existence are those that support the standing waves.

Given the form of the standing waves, only those that form a complete wavelength are initially allowed. With the absorption of energy by the medium, the wavelengths can be allowed to be longer, and the next possible configuration consists of a half-wavelength at the same distance as the massive object. This half-wavelength cannot be completed unless it is attached to a mass at twice the distance. With the amalgamation of mass at twice the distance, the new wave will produce a complete wavelength and another standing wave.

Since the interference of the amplitudes reduces the probability of other configurations from arising, a rule for the radii of orbits in a medium consisting of particles and and antiparticles forming macroscopic rotating systems results. It has been established for example that a scattered electromagnetic field off a one-dimensional roughly random surface is stationary only when the incidence is normal (de Oliviera, et. al., 2010). The standing wave could not be maintained for configurations of a different type. The masses in the favoured configurations would have orbits with radii increasing approximately as 2^n.

The description of the motion in a gravitational field in the classical limit through waves can be made plausible by considering the time-dependent Schrödinger equation

$$i\hbar\frac{\partial\psi}{\partial t} = \sqrt{-\hbar^2c^2\nabla^2 + m^2c^4}\psi - G\frac{mm'}{r}\psi. \tag{3.1}$$

which can be transformed to

$$\hbar^2c^2\Box^2\psi + 2i\hbar G\frac{mm'}{r}\frac{\partial\psi}{\partial t} + \left(G^2\frac{m^2m'^2}{r^2} - m^2c^4\right)\psi = 0 \tag{3.2}$$

With the wavefunction $\psi = Ae^{-i(k_x x + k_y y + k_z z - \omega t)}$,

$$-\hbar^2c^2\left(k_x^2 + k_y^2 + k_y^2 - \frac{\omega^2}{c^2}\right) - 2\hbar\frac{Gmm'}{r}\omega + \left(G^2\frac{m^2m'^2}{r^2} - m^2c^4\right) = 0. \tag{3.3}$$

Then

$$\omega^2 - \frac{2}{\hbar}G\frac{mm'}{r}\omega + \frac{1}{\hbar^2}\left(G^2\frac{m^2m'^2}{r^2} - \hbar^2c^2k^2 - m^2c^4\right) = 0 \tag{3.4}$$

which has the solution

$$\omega = \frac{1}{\hbar}G\frac{mm'}{r} \pm \frac{c}{\hbar}\sqrt{\hbar^2k^2 + m^2c^2}. \tag{3.5}$$

The wavelength would be

$$\frac{2\pi}{\lambda} = \frac{1}{\hbar c}G\frac{mm'}{r} \pm \frac{2\pi}{\lambda^{free}}. \tag{3.6}$$

For the wavefunction to describe an aggregate of mass at distances which are remaining relatively unchanged over time, the momentum must satisfy the inequality

$$c\sqrt{\hbar^2k^2 + m^2c^2} \ll G\frac{mm'}{r} \tag{3.7}$$

such that $\frac{2\pi}{\lambda} \approx \frac{1}{\hbar c}G\frac{mm'}{r}$. The wavelength satisfies

$$\frac{hc}{\lambda} = E^{wave} \approx G\frac{mm'}{r} \tag{3.8}$$

and

$$\frac{dE^{wave}}{dr} = -G\frac{mm'}{r^2}. \tag{3.9}$$

The reaction to the force in the direction of decreasing energy would be transformed into tension along the macroscopic string representing the standing wave and equals the gravitational force $G\frac{mm'}{r^2}$.

For a gravitational system, it might be concluded that the radii of the orbits and the masses would increase because of the attraction of a larger amount of matter from the central source, which follows from the volume available at these distances. However, it is not evident that the dependence on n is predicted from a random rotation of uniformly distributed matter about a central source.

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While an elliptical orbit can be predicted from the inverse square law, it may be noted that it also follows from the existence of a linear string from the central source to the planet such that the sum of the distances from two fixed points to the planet remains fixed. Verification for the rule of the increasing radius is provided by the solar system, where the Titius-Bode law (Titius, 1766; Bode, 1777) for the length of the semi-major axis of the elliptical orbit in astronomical units equals

$$\begin{aligned} r_0 &= \frac{4}{10} \\ r_n &= \frac{3 \cdot 2^{n-1} + 4}{10} \qquad n \geq 1 \end{aligned} \tag{3.10}$$

The anomaly of Mercury might be attributed to the relative amount of size of Sun with respect to the distance to this planet and that of Neptune, together with the inclinations of the axes of Pluto and Eris, could be viewed as the result of interference with the planar orbits. The asteroid belt is known to take the place of the planet for $n = 4$. It may be concluded, therefore, that the radii approximately have the dependence predicted by a connection with the central source formed from a macroscopic string in a medium containing dark matter.

The geometric progression has been attributed to the disk phase, and, in part, electromagnetic effects in the medium, while the commensurability of the radii of the orbits is determined by the gravitational interactions (Nieto, 1972). Further characteristics of the eventual configuration of the planets follow from a study of the n-body problem. The symmetries of the three-body problem admit an invariable plane (Wintner, 1947). For the system of the Sun and the two large planets, the gravitational potential is sufficient to ensure that the motion of the other planets is constrained nearly to this plane. The central force given by the negative of the gradient of the Newtonian potential requires Kepler's law and closed orbits to be elliptical.

The evolution of the radii of the orbits according to the observed geometric progression $r_n = A + (1.7275)^n [B + f(\alpha + n\beta)]$ (Blagg, 1913; Richardson, 1945) may be derived from a variational principle of least interaction (Ovenden, 1973; Areoli, et. al., 2000; Bass, 2005). An example is provided by the nodes of the velocity distribution of a thin disk, such that matter can aggregate, with $\frac{r_{k+1}}{r_k}$ being equal to $e^{\frac{2\pi}{3\mu}}$ (Nowotny, 1979) , where μ is equal to a ratio of a velocity related to the gravitational force and that of pressure in the gaseous disk, and it is found to be give a consistent value of this ratio.

IV. Conclusion

It has been conjectured that the effects of pair creation in a vacuum have considerably more consequences that of virtual particle-antiparticle pairs. Whereas previously, the effect had been estimated for the effects at atomic distances, the occurrence of real pairs of particles and antiparticles would have a large effect at macroscopic scales. The prediction of the increase of the radii of orbits around a central source has been found to be confirmed by observations of gravitational systems.

The scales of planetary motion require an extension of the mechanism of electromagnetic coupling of electron-positron pairs to large distances. This effect can be achieved through a gravi-electromagnetic soliton to the Einstein-Maxwell equations. An exponential expansion of the size of a real process of annihilation of particles and antiparticles yields the order of the distances to the planetary orbits. The spacing between the orbits reflects a geometric progression that is related to wave mechanics, with the planets located at the end of a standing wave. After the accumulation of matter at the harmonic progression resulting partially from the electromagnetic interaction, the commensurability of the orbits of the planets is attributed to gravitational force.

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ΔI=2 Nuclear Staggering in Superdeformed Rotational Bands

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Abstract- A four parameters model including collective rotational energies to fourth order is applied to reproduce the ΔI=2 staggering in transition energies in four selected super deformed rotational bands, namely, ^{148}Gd (SD6), ^{194}Hg (SD1, SD2, SD3). The model parameters and the spin of the bandhead have been extracted assuming various values to the lowest spin of the bandhead at nearest integer, in order to obtain a minimum root mean square deviation between calculated and the experimental transition energies. This allows us to suggest the spin values for the energy levels which are experimentally unknown. For each band a staggering parameter represent the deviation of the transition energies from a smooth reference has been determined by calculating the fourth order derivative of the transition energies at a given spin. The staggering parameter contains five consecutive transition energies which is denoted here as the five - point formula. In order to get information about the dynamical moment of inertia, the two point formula which contains only two consecutive transition energies has been also considered. The dynamical moment of inertia decreasing with increasing rotational frequency for *A*~150, while increasing for *A* ~190 mass regions.

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ΔI=2 Nuclear Staggering in Superdeformed Rotational Bands

Madyha D. Okasha

Abstrast- A four parameters model including collective rotational energies to fourth order is applied to reproduce the **Δ**I=2 staggering in transition energies in four selected super deformed rotational bands, namely, ^{148}Gd (SD6), ^{194}Hg (SD1, SD2, SD3). The model parameters and the spin of the bandhead have been extracted assuming various values to the lowest spin of the bandhead at nearest integer, in order to obtain a minimum root mean square deviation between calculated and the experimental transition energies. This allows us to suggest the spin values for the energy levels which are experimentally unknown. For each band a staggering parameter represent the deviation of the transition energies from a smooth reference has been determined by calculating the fourth order derivative of the transition energies at a given spin. The staggering parameter contains five consecutive transition energies which is denoted here as the five - point formula. In order to get information about the dynamical moment of inertia, the two point formula which contains only two consecutive transition energies has been also considered. The dynamical moment of inertia decreasing with increasing rotational frequency for *A*~150, while increasing for *A*~190 mass regions.

I. Introduction

The observation [1] of a very regular pattern of closely spaced γ -transitions in the spectrum of ^{152}Dy, which assigned to a rotational cascade between levels of spin ranging from 60$\hbar$ to 24$\hbar$ and excitation energy varying from ~ 30 to 12 MeV may adopt a superdeformed (SD) at high angular momentum. The moment of inertia of the associated band was found to be close to that of a rigid rotor with a 2:1 axis rotation. Now more than 350 settled superdeformed rotational bands (SDRB's), in more than 100 nuclei have been studied in nuclei of mass A ~ 30, 60, 80, 130, 150, 160, 190 [2, 3]. Such nuclei are associated with extremely large quadrupole β_2 = 0:6 in the mass A ~ 150 region and β_2 = 0:47 in the mass A ~190 region. Hence, they are expected to have a different structures to normal deformed nuclei.

Unfortunately, despite the rather large amount of experimental information on SDRB's, there are still a number of very interesting properties, which have not yet been measured. For example, the spin, parity and excitation energy relative to the ground state of the SD bands. The difficulty lies with observing the very weak discrete transitions which link SD levels with levels of normal deformation (ND). Several related approaches to assign the spins of SDRB's in terms of their observed γ-ray transition energies were proposed [4–10]. For all approaches an extrapolation fitting procedure was used.

It was found that some SDRB's show an unexpected ΔI=2 staggering in their γ-ray transition energies [11-20].The SD energy levels are consequently separated into two sequences with spin values I, I+4, I+8, . .and I+2, I+6, I+10, . . respectively. The magnitude of splitting is found to be of some hundred eV to a few keV. Several theoretical explanation have been made. One of the earliest ones being based on the assumption of a C4 symmetry [21]. Also it was suggested that [22] the staggering is associated with the alignment of the total angular momentum along the axis perpendicular to the long deformation axis of a prolate nucleus. The staggering phenomenon was interpreted also as due to the mixing of a series of rotational bands differ by ΔI=4 [23] or arise from the mixing of two bands near yrast line [24] or by proposing phenomenological model [25, 26]. The main purpose of the present paper is to predict the spins of the bandhead of four SDRB's in A~150 and A~190 mass regions, and to examine the ΔI=2 staggering and the properties of the dynamical moments of inertia in framework of proposed four parameters collective rotational model.

II. Nuclear SDRB's in Framework of Four Parameters Collective Rotational Model

On the basis of collective rotational model [27] in adiabatic approximation, the rotational energy E for an axial symmetric nucleus can be expanded in powers of I(I+1), where I is the spin of state:

$$E(I) = A[I(I+1)]+B[I(I+1)]^2+C[I(I+1)]^3+D[I(I+1)]^4 \quad (1)$$

where A is the well-known rotational parameter for sufficiently small values of I and B, C, D are the corresponding higher order parameters. In the view of the above mentioned, it seems that the ground state energy bands of deformed even-even nucleus have quantum number K=0 (K is the projection of I along the symmetry axis), together with even parity and angular momentum. In SD nuclei, the experimentally determined quantities are the gamma ray transition energies

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between levels differing by two units of angular momentum, then we could obtain the reference transition energy.

Table 1: The calculated adopted best parameters and the bandhead spins for the selected SD nuclei to investigate the $\Delta I = 2$ staggering.

SD-Band	A (keV)	B (keV) $\times 10^4$	C (keV) $\times 10^8$	D (keV) $\times 10^{12}$	I ($\hbar$)	E_γ (MeV)
^{148}Gd (SD-6)	4.33360	1.17108	0.001135	-0.04435	41	802.200
^{194}Hg (SD-1)	5.40524	-1.86747	0.000338	-0.00213	8	211.700
^{194}Hg (SD-2)	5.24253	-1.577380	0.003991	-0.00269	8	200.790
^{194}Hg (SD-3)	5.21638	-1.48121	0.0006129	-0.006501	9	222.000

$$E_\gamma^{ref} = E(I) - E(I-2) \quad (2)$$

$$E_\gamma^{ref} = 2(2I-1)[A+2(I^2-I+1)B + (3I^4-6I^3+13I^2-10I+4)C + 4(I^6-3I^5+10I^4-15I^3+15I^2-8I+2)D]. \quad (3)$$

The rotational frequency is not directly measurable but it is related to the observed excitation energy E.

Let us define the angular velocity of nuclear rotation as the derivative of the energy E with respect to the angular momentum I in analogy with classical mechanics. Instead of I it is convenient to use the quantum mechanical analogies $\sqrt{(I(I+1))}$

$$\hbar\omega = \frac{dE}{d\left(\sqrt{(I(I+1))}\right)} \quad (4)$$

$$= 2A[I(I+1)]^{1/2} + B[I(I+1)]^{3/2} + 6C[I(I+1)]^{5/2} + 8D[I(I+1)]^{7/2}. \quad (5)$$

The rotational energy spectra can be discussed in terms of the dynamical moment of inertia calculated from the reciprocal second order derivative:

$$\frac{J^{(2)}}{\hbar^2} = \left(\frac{d^2E}{d\left(\sqrt{I(I+1)}\right)^2}\right)^{-1} \quad (6)$$

$$= \left([2A + 12B[I(I+1)] + 30C[I(I+1)]^2 + 56D[I(I+1)]^3]\right)^{-1}. \quad (7)$$

The experimental $\hbar w$ and $J^{(2)}$ for the SDRB's are usually extracted from the observed energies of gamma transition between two consecutive transitions within the band from the following formulae:

$$\hbar\omega = [E_\gamma(I) + E_\gamma(I+2)]/4, \quad (8)$$

$$J^{(2)} = \frac{4}{E_\gamma(I+2) - E_\gamma(I)}. \quad (9)$$

We notice that $\hbar w$ and $J^{(2)}$ does not depend on the knowledge of the spin I, but only on the measured gamma ray energies.

In order to see the variation in the experimental transition energies $E_\gamma(I)$ in a band, we subtract from them a calculated reference. The corresponding five-point formula is the fourth order derivative of the transition energies at a given spin

$$\Delta^4 E_\gamma(I) = \frac{1}{16}[E_\gamma(I+4) - 4E_\gamma(I+2) \quad (10)$$
$$+ 6E_\gamma(I) - 4E_\gamma(I-2) + E_\gamma(I-4)]. \quad (11)$$

One can easily see that $\Delta^4 E_\gamma(I)$ vanishes if our model contains two parameters A and B, due to the fact that the fivepoint formula is a normalized discrete approximation of the fourth derivatives of the function $E_\gamma(I)$. We define the staggering parameter $S^{(4)}(I)$ as the difference between the experimental transition energies and the auxiliary reference.

$$S^{(4)}(I) = 2^4[\Delta^4 E_\gamma^{exp}(I) - \Delta^4 E_\gamma^{ref}(I)] \quad (12)$$

III. Numerical Calculations and Discussions

The transition energies $E_\gamma(I)$ of equation (2) is used to fit the observed transition energies for our selected SDRB's with A, B, C, D and spin value of the bandhead I_0 as free parameters. I_0 is taken to the nearest integer of the fitting, the another fit is made to determine A, B, C and D by using a simulated search program [9] in order to obtain a minimum root mean square deviation

$$\chi = \left[\frac{1}{N}\sum_{i=1}^{N}\left(\frac{E_\gamma^{exp}(I) - E_\gamma^{Cal}(I)}{\Delta E_\gamma^{exp}(I)}\right)\right]^{1/2}$$

of the calculated transition energies E_γ^{Cal} from the measured energies E_γ^{exp}, where N is the number of data points considered, and ΔE_γ^{exp} is the uncertainty of the γ-transition energies. The experimental data for transition energies are taken from ref. [2]. Table (1) summarize the model parameters A, B, C, D and the correct bandhead lowest level spin I_0 and also the lowest γ- transition energies $E_\gamma(I_0 + 2 \to I_0)$ for our 4 SDRB's.

To investigate the appearance of staggering effects in the γ-transition energies of our selected SDRB's, for each band, the deviation of the γ-transition energies $E\gamma(I)$ from a smooth

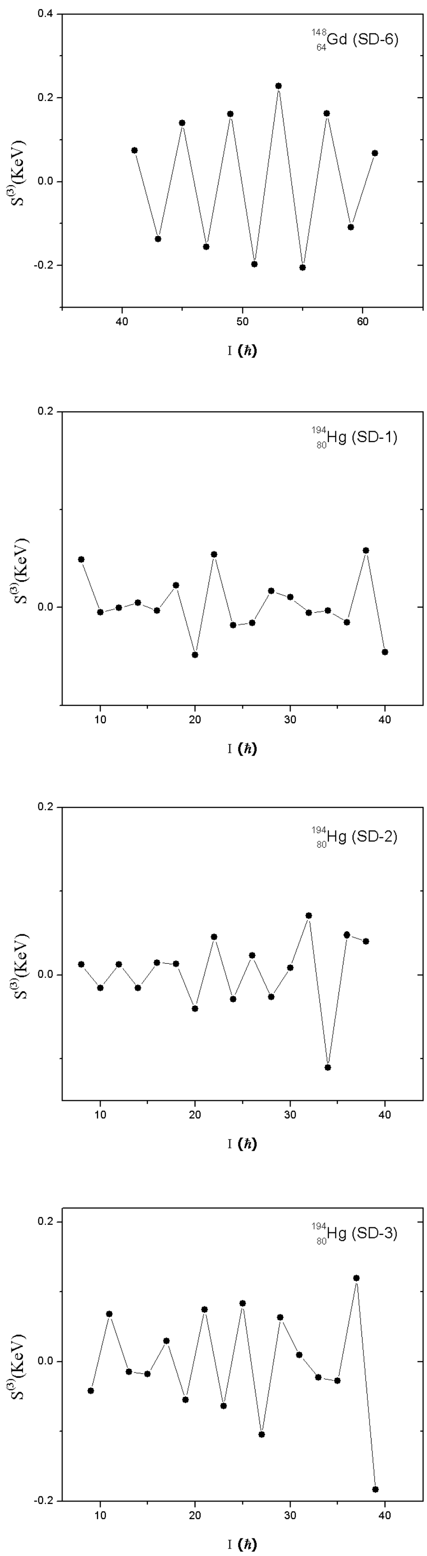

Figure 1 : The calculated $\Delta I = 2$ staggering parameters $S^{(4)}(I)$ obtained by five-point formula versus nuclear spin I for the SDRB's in ^{148}Gd and ^{194}Hg.

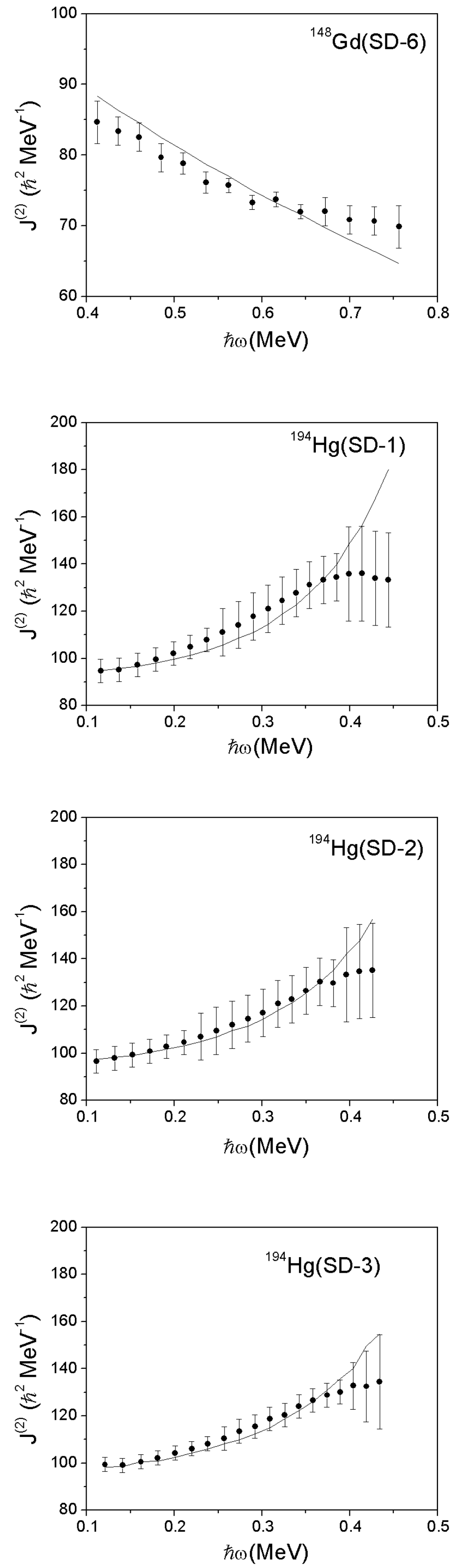

Figure 2 : The dynamical moment of inertia $J^{(2)}$ plotted as a function of the rotational frequency $\hbar w$ for the SDRB's in ^{148}Gd and ^{194}Hg nuclei. The solid curve represents the calculated results extracted from the proposed four parameters model. The experimental solid circles with error bars are presented for comparison.

reference (rigid rotor) was determined by calculating fourth - derivatives of $E\gamma(I)$ ($d^4E\gamma/dI^4$) at a given spin I by using the finite difference approximation. The resulting staggering parameters values against spin are presented in Figure (1). A significant ΔI=2 staggering was observed. At high spins the ΔI=2 rotational band is perturbed and two ΔI=4 rotational sequences emerge with an energy splitting of some hundred eV. That is the E2 cascades obtained from our model exhibit for spins I, I+4, I+8, . . and I+2, I+6, I+10, . . staggering behavior.

The systematic behavior of the dynamic moment of inertia $J^{(2)}$ is very useful to understand the properties and structure of SDRB's. Our best fitted parameters were used to calculate the theoretical $J^{(2)}$. The evolution of the dynamical moment of inertia $J^{(2)}$ against rotational frequency $\hbar w$ are illustrated in Figure(2). It is seen that the agreement between the calculated (solid lines) and the values extracted from the observed data (closed circles) are excellent. For A~190, the SDRB's have nearly the same $J^{(2)}$ which typically increase smoothly as rotational frequency increases due to gradual angular momentum alignment of a pair of nucleons occupying specific high-N intruder orbitals and the disappearance of pairing correlations. For A ~ 150 a smooth decrease of $J^{(2)}$ with increasing $\hbar w$ is reproduced well.

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Reduction of Radiation dose and Relative Risk of Cancer Induction to Neonates Receiving Anterior-Posterior Chest X-rays

By Annemari Groenewald & Willem A Groenewald
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Abstract- Background: Chest anterior-posterior (AP) x-ray imaging is used to diagnose and follow up conditions of the heart and lungs in neonates. As neonates are more sensitive to radiation and have longer life expectancies ionizing radiation may increase the risk of cancer induction in this patient population. By using a computed radiography (CR) system acceptable images, requiring lower doses of radiation, may be produced digitally. However, radiation dose reduction is often associated with reduced image quality.

Objectives: To derive exposure protocols that decrease the entrance surface dose (ESD) and relative cancer induction risk, while maintaining acceptable visual image quality.

Methods and materials: A phantom was designed and used to experimentally optimise x-ray imaging protocols by varying exposure technique factors, such astube voltage and current, exposure time and filtration. Images were ranked according to measured ESDs, visual image quality and relative cancer induction risks.

Keywords: *neonate, dose reduction, chest anterior-posterior x-ray, cancer induction risk, visual image quality.*

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Results: Comparison of derived protocols to a standard neonatal chest exposure protocol revealed that the ESD was reduced approximately by 63% while image quality was improved by about 27%. Relative cancer induction risk analysis showed that, despite reduced ESDs, the risk could be greater than the standard exposure risk.

Conclusion: Six exposure options that answer the aim were derived. The most optimal combination of decrease in the ESD and relative cancer induction risk with maintenance of visual image quality is a processed image at 57 kV, 2 mAs, 100 cm focus-to-film distance (FFD), fine focus, tight collimation and 0.1 mm Cu (copper) and 1 mm Al (aluminium) additional filtration.

Keywords: neonate, dose reduction, chest anterior-posterior x-ray, cancer induction risk, visual image quality.

I. Introduction

Newborn babies are called neonates for the first 28 days of life. Babies born preterm who have problems with their hearts and lungs are included in this population group. CR x-ray imaging is used in the diagnosis and follow-up of disease conditions of the heart and lungs using chest AP radiographs. Neonates are more sensitive to radiation, have rapid cell division and growth and longer life expectancies. Cancer induction, especially leukaemia [1], in the young child is therefore a concern with this population group, as cancer induction is a stochastic risk. [2,3,4,5,6] The dose per chest x-ray must be minimised in order to honour the as low as reasonably achievable (ALARA) principle. [7] However dose reductions are generally associated with a loss of image quality. So dose, image quality and cancer induction risks must be evaluated simultaneously. The goal should be clinically acceptable rather than best or maximal image quality. With CR imaging, due the availability of post-processing and image manipulation, ESD can thus be decreased, theoretically decreasing the image quality, up to a certain lower limit after which image quality will not be useful and retakes will be necessary, defying the purpose. [4,8] This relationship is investigated experimentally in this study for neonatal chest AP radiographs, in order to derive optimised exposure protocols with acceptable visual image quality at reduced ESD and most importantly reduced cancer induction risk.

The investigation was done using a neonatal simulation phantom. The phantoms described in literature were not acceptable anatomical and radiological simulations of a real neonatal chest. A water filled one litre bottle was used by Brindhaban and Al-Khalifah [9] to simulate a 1000 g neonate. Vergara et al [10] used a rectangular PMMA perspex phantom where air gaps were used to represent lungs. Akahane et al [11] constructed a rigid and rectangular shaped phantom from tough water and lung phantom materials. The Gammex RMI© 610 phantom was the best anatomical simulation of a real neonatal chest, but the radiological equivalence of the phantom could not be determined. [12] As a suitable anatomical and radiological simulation phantom is not available, an anatomical and radiological neonatal chest simulation phantom was designed and constructed for ESD and image quality analysis.

Recommendations on tube kilovoltage (kV), current-time product (mAs), FFD, focus, collimation and additional filtration as dose reduction mechanisms are discussed in literature. These are tabulated in Table 1. [9,13,14,15,16] The standard exposure protocol for

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neonatal chest AP imaging was 50 kV, 2 mAs, 100 cm FFD, inherent filtration and collimation as tight as possible.

Table 1 : Exposure technique factor ranges as proposed in literature [9,13,14,15,16]

Technique factor	Range in literature
kV	40 - 80
mAs	0.5 - 4
Filtration	1 – 3.5 mm Aluminium; 0.1 mm Copper
FFD	80 – 115 cm
Focus	Fine

II. Aim

The aim of this study was to use an anatomical and radiological simulation phantom of a real neonatal chest to derive optimised exposure protocols that decrease the delivered ESD, while maintaining acceptable quality of the clinical image at a reduced relative risk for cancer induction in the young child.

III. Methods and Materials

A neonatal chest simulation phantom was developed. It consisted of plastics and gels that were radiologically equivalent to real neonatal bone, muscle, healthy or inflated lung and collapsed, sick or deflated lung. Radiological equivalence was obtained by matching the density, elemental composition, attenuation, scatter and absorption characteristics of different possible substitute materials to that of real neonatal tissues. For anatomical equivalence a computed tomography (CT) scan was done on a 7 month old preterm neonatal cadaver and software measuring tools available at the scanner were used to measure the dimensions of different organs and structures using different window and level settings. These measurements were combined with simplifying assumptions, due to machining limitations, to manufacture posterior ribs, a vertebral column, a sick and a healthy lung, anterior ribs and sternal blocks from the radiologically equivalent plastics. A central line was included in the phantom for image quality evaluation. The phantom was validated with region of interest (ROI) analyses as described by Duggan et al. [13]. This anatomical and radiological simulation phantom of a real neonatal chest was used to evaluate the obtained image quality for different exposure protocols.

Images were acquired using a Shimadzu Mobile Art Evolution mobile x-ray unit exposing 18 cm x 24 cm Fujifilm FCR Fuji IP CC cassettes and processing the images in a Philips PCR Eleva Corado reader. The ESD associated with each exposure was measured using a PTW Conny II dosimeter (PTW, Freiburg), with a calibration traceable to a standards laboratory. The detector was placed on top of the phantom, which was 53 mm thick, to measure ESD. The standard exposure used routinely for AP imaging of neonatal chests in our department was 50 kV, 2 mAs, 100 cm FFD, fine focus, inherent filtration and processed image readout.

The optimal combination of kV, mAs, FFD, focus, collimation, filtration and raw or processed image readout was determined experimentally. The recommendations in literature, as in Table 1, were used in four preliminary exposure sets. The phantom was placed on the x-ray bed and an AP image was acquired. The dosimeter was then placed on top of the phantom and another exposure at the same setting was made to measure the ESD. Incubators were not considered. The results, measured ESD and image quality, from each of these sets were used to derive a final set of exposures, which consisted of the standard exposure and eight other possible optimised options. In the first set, 12 images investigated the effect of changing FFD and filtration at a constant kV and mAs setting. With all other parameters constant, the effect of changing kV was assessed. In the second set, consisting of 20 images, a wider kV range and different filtration options were considered at a constant mAs setting. It was decided to use 100 cm FFD and this was constant in the third set. Different kV, mAs and filtration options were assessed in 38 images. In the fourth set, consisting of 56 images, a finer kV and mAs range was used and the effect of 0.1 mm Cu and 1 mm Al additional filtration, compared to inherent filtration of 1.5 mm Al only, was evaluated. The final set of exposures was derived from these preliminary exposure results. These preliminary exposure sets are shown in Table 2.

Table 2 : Preliminary exposure sets

Exposure set	kV	mAs	FFD	Filtration	Focus	Mode
1	Change Constant	Constant	Constant Change Constant	Constant Change	Constant	Processed
2	Change Constant	Constant	Constant	Constant Change Constant	Constant Change	Raw and processed
3	Constant Change	Change Constant Change	Constant	Constant Change Constant	Constant	Raw and processed
4	Constant	Change	Constant	Change	Constant	Raw and processed

Image quality was evaluated visually with image quality scoring. This analysis was a blind process in which 11 observers, medical physicists and radiographers, scored the images according to the criteria in Fig. 1 and Table 3. Observers were not aware of the exposure parameters used with each of the images. The scoring system was a simple one, where a mark was assigned to a criterion based on the visibility of that criterion in each image. This was also done for the overall impression of the image. The marks were added for a total score. The average score for each image from the 11 observers was calculated.

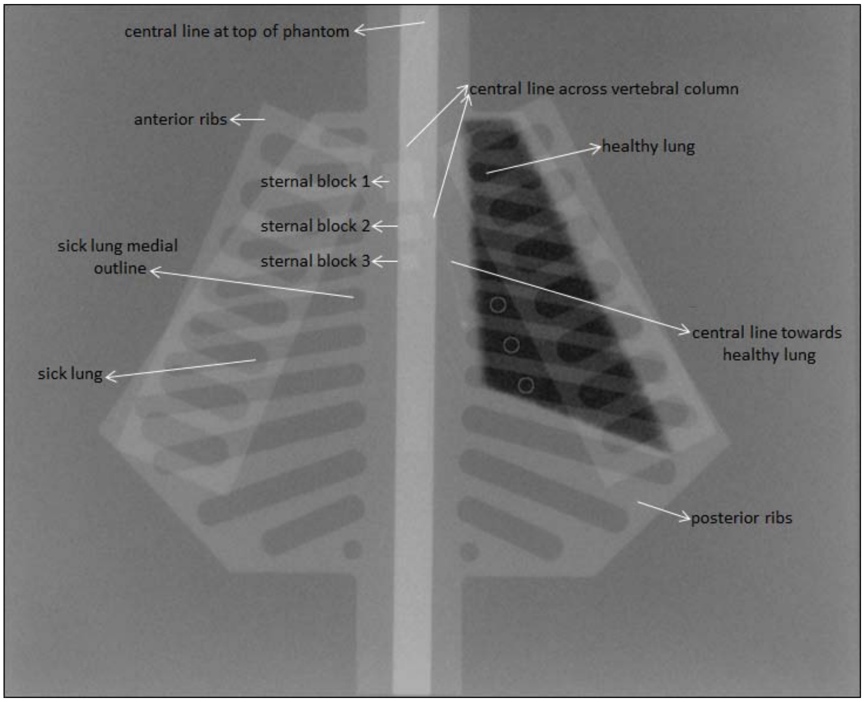

Figure 1 : Location of visual image quality scoring criteria in the simulation phantom

Table 3 : Visual image scoring criteria.

Criteria		Scoring Scale
Sternum	All 3 blocks are clearly visible	5
	2 blocks are clearly visible	4
	1 block is clearly visible	3
	1 block is partially visible	2
	1 block is not clear	1
	No blocks are visible	0
Central line	Seen completely, from top of phantom across spinal column to healthy lung	3
	Seen at top of phantom and towards healthy lung only	2
	Seen towards healthy lung only	1
	Not seen	0
Healthy lung	Posterior ribs are clearly visible behind the lung	3
	Posterior ribs are partially visible behind the lung	2
	Posterior ribs are not clear behind the lung	1
	Posterior ribs are not seen / black lung	0
Sick lung	Sick lung is completely seen	3
	Medial outline of lung is clearly visible	2
	Medial outline of lung is partially visible	1
	Lung is not seen	0
Overall impression	Very good	5
	Good	4
	Acceptable	3
	Not good	2
	Poor	1
	Unusable	0

Cancer induction risk is the product of the effective dose and an International Commission on Radiological Protection (ICRP) risk factor.[7] These were 2.8-13 x 10^{-2} Sv^{-1} for foetal or prenatal exposures to radiation. [9]Effective doses were obtained from the measured ESDs by using conversion coefficients published by the National Radiological Protection Board (NRPB). [17]These effective doses were used as relative dose indicators for quantitative comparison of the different images and were not absolute dose values. An average of 15 x-rays per patient was assumed.

IV. Results

The developed neonatal chest simulation phantom is shown schematically in Fig 2. The phantom was used to assess visual image quality and ESD measurements for the final set of exposures as shown in Table 4.

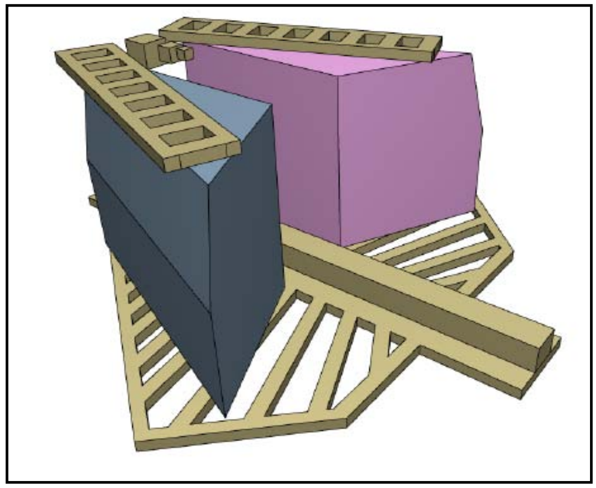

Figure 2 : Schematic representation of the neonatal chest simulation phantom

Table 4 : Standard and derived optimised exposure protocols

Image number	Acquisition mode	Focus	FFD (cm)	kV	mAs	Filtration
1	Processed	Fine	100	50	2.0	Inherent
2	Raw	Fine	100	60	2.0	Inherent and 0.1 mm Cu + 1 mm Al
3	Raw	Fine	100	64	2.0	Inherent and 0.1 mm Cu + 1 mm Al
4	Raw	Fine	100	61	0.8	Inherent
5	Raw	Fine	100	62	0.8	Inherent
6	Processed	Fine	100	57	2.0	Inherent and 0.1 mm Cu + 1 mm Al
7	Processed	Fine	100	57	3.2	Inherent and 0.1 mm Cu + 1 mm Al
8	Processed	Fine	100	60	2.0	Inherent and 0.1 mm Cu + 1 mm Al
9	Processed	Fine	100	61	0.8	Inherent

Table 5 shows the measured ESDs. The images were ranked from high to low quality according to the ESDs. Relative cancer induction risks were then considered for derivation of optimised exposure protocols that decreased delivered ESD and relative cancer induction risks, whilst maintaining acceptable visual image quality. Calculated relative cancer induction risks were noted in Table 5 for an average of 15 chest AP x-rays per neonate. The risks in Table 5 are relative risks only, and should not be interpreted as absolute risk values.

The images used for the evaluation are shown in Fig. 3. Image 1 was the standard exposure image of 50 kV, 2 mAs, 100 cm FFD, inherent filtration and processed readout. Images 2 – 9 were derived optimised images, with exposure technique factors as recorded in Table 4.

Table 5 : ESD and image quality evaluation and relative cancer induction risk results

Image number	ESD (μGy)	ESD ranking	Average total visual image quality score	Visual image quality ranking	Minimum relative cancer induction risk	Maximum relative cancer induction risk	Overall ranking with relative cancer induction risk
1	44.0±2.2	6	11	8	$1.8x10^{-6}$	$8.3x10^{-6}$	Standard
2	19.1±1.0	2	13	3	$1.4x10^{-6}$	$6.3x10^{-6}$	4
3	22.8±1.1	3	14	2	$1.7x10^{-6}$	$7.9x10^{-6}$	Not optimal option
4	25.8±1.3	4	12	7	$1.3x10^{-6}$	$5.9x10^{-6}$	6
5	26.4±1.3	5	13	4	$1.3x10^{-6}$	$6.1x10^{-6}$	2
6	16.2±0.8	1	12	6	$1.1x10^{-6}$	$5.0x10^{-6}$	1
7	26.3±1.3	5	14	1	$1.8x10^{-6}$	$8.1x10^{-6}$	Not optimaloption
8	19.1±1.0	2	13	5	$1.4x10^{-6}$	$6.3x10^{-6}$	3
9	25.8±1.3	4	11	9	$1.3x10^{-6}$	$5.9x10^{-6}$	5

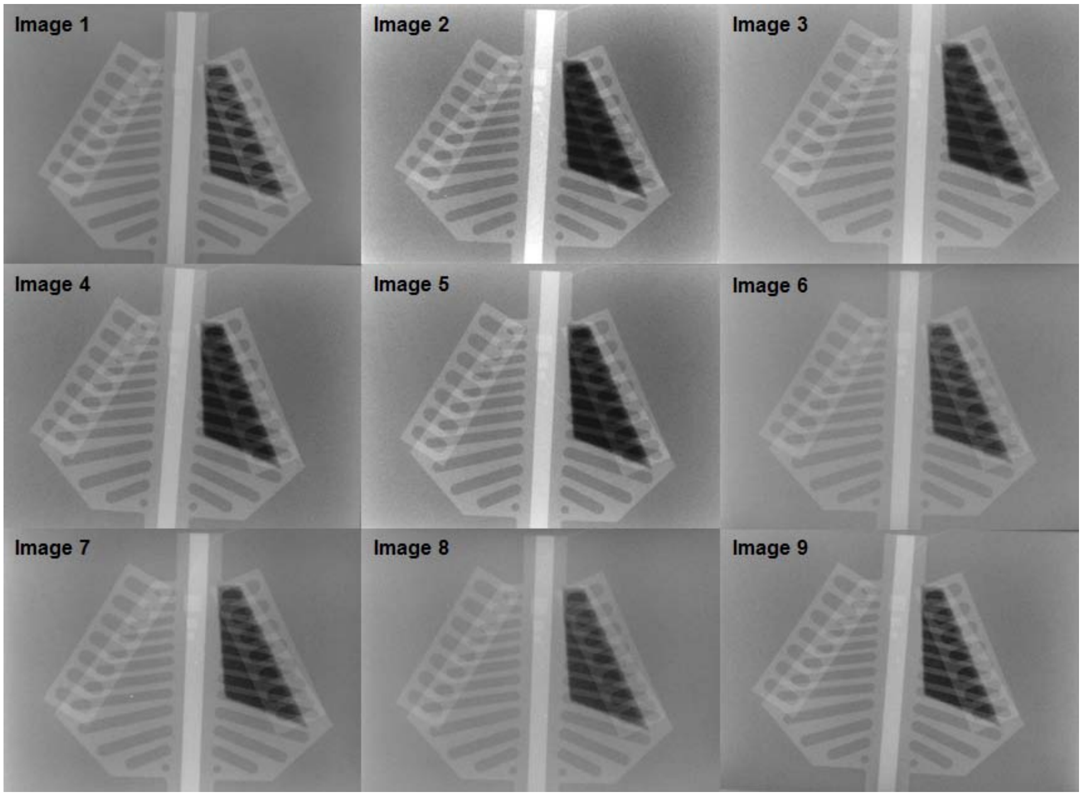

Figure 3 : Images obtained for evaluation. Image numbers correspond to those in Tables 3 and 4

V. Discussion

Exposure technique would influence the ESD and image quality. These factors thus had to be altered in combination with one another to achieve a decrease in ESD whilst image quality was maintained. Cancer induction is a stochastic risk, with no threshold dose, thus the smallest exposure to radiation has a chance of inducing cancer, e.g. leukaemia [1], in the young child. This emphasizes the importance of the ALARA principle. The risks with neonates are higher due to increased radiosensitivity and longer life expectancy. [7] Calculated relative cancer induction risks represent the risk up to the age of 15 years, but life time risks can be two to four times higher than this[18]. These risks cannot be ignored and must be reduced. [1,18]

Image 1 in Table 5 is the standard exposure image currently used for neonatal chest AP x-rays in Tygerberg Academic Hospital. Its image quality should be maintained and its ESD and relative cancer induction risk decreased in order to answer the aim of the study. The visual image quality of images 6 and 8 was comparable, image 6 was better than image 8 as it had the largest ESD reduction of about 63%. Image 7 was the best visually and had a significant ESD reduction of about 40%. The visual image quality of image 7 was about 27% better than that of the standard exposure image, image 1, as was that of image 3. Although image 3 had a slightly higher ESD than image 2, this was justified by its improved visual image quality. Image 9 was visually of lowest quality, a visual image quality that was comparable to that of image 1. However image 9 was registered a lower ESD than image 1, providing a higher overall ranking, and still answering the aim of the study. This was also the case with image 4. Image 5 performed average in the ESD and visual image quality criteria. Images 2-9 all had visual image quality comparable to or better than that of image 1, the standard exposure image, and all were obtained at reduced ESDs. Thus, all of these imaging options satisfied the aim of ESD reduction with image quality maintenance.

The relative cancer induction risk for image 1, the standard exposure image, was 1.8 – 8.3 per million for an average of 15 chest AP exposures. This risk had to be reduced to answer the aim of the study. The risk for image 3 was 1.7 – 7.9 and for image 7 it was 1.8 – 8.1 per million for 15 exposures. This was very comparable to the risk for image 1, although these images were obtained at ESDs 48% and 40% less than that of image 1. The risks for the remaining exposures in Table 5 were lower than that of image 1. It was decided that images 2, 4, 5, 6, 8 and 9 were more optimal options, with a greater relative cancer induction risk reductions than images 3 and 7. The ESD and relative cancer induction risk could be reduced, with maintenance or improvement of visual image quality, compared to the standard exposure.

This method of cancer induction risk calculation, although suggested in literature [7], did have limitations. The NRPB tables did not make provision for the actual inherent, i.e. 1.5 mm Al, and total filtration with additional filtration of 0.1 mm Cu and 1 mm Al, i.e. 6 mm Al equivalent, filtrations used, thus the closest available values were used in approximation, i.e. the values for 2 mm and 5 mm Al filtrations. The coefficient for 1.5 mm Al filtration was expected to be lower than the one at 2 mm Al filtration, therefore the risk with such an exposure was also expected to be lower. Similarly, the coefficient for 6 mm Al filtration was anticipated to be larger than that of 5 mm Al filtration, which would result in a higher risk. The tables considered a narrow range of kV values only, so linear interpolation was used to derive the coefficients at the experimentally used kV settings. The coefficients were based on ICRP 60, quoting data applicable to adults, and not ICRP 103, which would have been more ideal. The science committee of International Organization for Medical Physics (IOMP) has expressed caution in the use of effective dose for estimation of cancer induction risks. [19] These considerations introduced uncertainties in the calculated risks. The risks in Table 5 are thus not absolute risks, but were used for quantitative relative comparison of the images in Table 5. As the results in Table 5 were used to relatively compare different exposures obtained in the same dose range this method was deemed acceptable for this study. Other options for cancer induction risk calculation include programs like Child Dose. [20]

Recommended images 6, 8 and 2 required additional filtration of 0.1 mm Cu and 1 mm Al, or a total filtration of 0.1 mm Cu and 2.5 mm Al. This was equivalent to 6 mm Al filtration. Additional filtration was not available on the mobile units used for neonatal chest x-rays. Additional filtration plates thus had to be stuck to the exit window of the tube after set-up, as these plates obstruct the light field. This can lead to retakes. Current mobile units can be fitted with commercially available filter assemblies that do not obstruct the light beam. Alternatively new mobile units, with additional filtration on a selection dial, could be acquired.

Images could be obtained as raw or processed. Raw images are more grainy. Raw mode can be selected at image readout. Images 5, 2 and 4 were obtained with raw image readout. In raw mode no inherent image processing occurred with the readout process. Processed images are the standard with the equipment used. Inherent image processing occurs with readout, making the images smoother and easier to look at.Images 6, 8 and 9 were processed images. All six of these images were recommendable options.

VI. Conclusion

Use of a self-developed phantom allowed derivation of optimised exposure protocols that decreased the ESD and relative cancer induction risk, while maintaining or even improving visual image quality. A total of six optimised exposure protocols were derived as images 6, 5, 8, 2, 9 and 4 in Table 4 and Fig 3. The most optimal protocol, giving the best relationship between ESD and image quality maintenance, was image 6 obtained as a processed image at 57 kV, 2 mAs, 100 cm FFD, fine focus and with additional filtration of 0.1 mm Cu and 1 mm Al (or total filtration equivalent to 6 mm Al). These protocols were recommended to the radiology department for implementation on real neonatal patients, which would clinically evaluate its acceptability and usability. Neonates are more sensitive to radiation, experience rapid cell division and growth, have a smaller body size and longer life expectancies. The ALARA principle must be honoured in order to minimise the stochastic risk of cancer induction in the young child, due to the care given to him or her as a neonate.

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Combined Richtmyer-Meshkov and Kelvin-Helmholtz Instability with Surface Tension

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Abstract- A nonlinear theoretical model of the combined Richtmyer-Meshkov and Kelvin-Helmholtz instability between two different density fluids with surface tension is proposed. The model is based on the extended Layzer's potential flow model. It is observed that, the surface tension decreases the velocity but does not affect the curvature of the bubble tip, provided surface tension is greater than a critical value. Under a certain condition it is also observed that surface tension stabilized the motion with nonlinear oscillations. The nonlinear oscillations depend on surface tension and relative velocity shear of two fluids. All results are obtained theoretically and supported by numerical technique.

Keywords: *shear flow; shock wave; surface tension; bubbles.*

GJSFR-A Classification : *FOR Code: 240201*

COMBINEDRICHTMYER-MESHKOVANDKELVIN-HELMHOLTZINSTABILITYWITHSURFACETENSION

Strictly as per the compliance and regulations of :

Combined Richtmyer-Meshkov and Kelvin-Helmholtz Instability with Surface Tension

Rahul Banerjee [α] & S. Kanjilal [σ]

Abstract- A nonlinear theoretical model of the combined Richtmyer-Meshkov and Kelvin-Helmholtz instability between two different density fluids with surface tension is proposed. The model is based on the extended Layzer's potential flow model. It is observed that, the surface tension decreases the velocity but does not affect the curvature of the bubble tip, provided surface tension is greater than a critical value. Under a certain condition it is also observed that surface tension stabilized the motion with nonlinear oscillations. The nonlinear oscillations depend on surface tension and relative velocity shear of two fluids. All results are obtained theoretically and supported by numerical technique.

Keywords: shear flow; shock wave; surface tension; bubbles.

I. Introduction

The instability of two fluid interface under an acceleration by an incident shock was predicted theoretically by Richtmyer[1] and then Meshkov[2] confirmed experimentally Richtmyer's prediction. Since then, this interfacial instability has been referred to as the Richtmyer-Meshkov instability. Such instability is observed in supernova explosions, inertial confinement fusion, shock tube experiment etc.[3, 4]. On the other hand, the Kelvin-Helmholtz instability[5] arises when two fluids are separated by an interface across which the tangential velocity is discontinuous. Such a flow is unstable under a sinusoidal perturbation of the interface. The Kelvin- Helmholtz instability plays an important role in many astrophysical and experimental situations[6,7,8]. The Kelvin- Helmholtz instability and shear flow effects in general are also of practical importance in a number of high energy density systems. They should be considered in multi shock experiments for direct drive capsule for inertial confinement fusion, since Kelvin- Helmholtz instability may accelerate the growth of turbulent mixing layer at the interface between the ablator and solid deuterium-tritium nuclear fuel. In high energy density and astrophysical system, it has been seen that structures driven by shear flow appear on the high density spikes produced by Richtmyer-Meshkov instability.

In the linear theory, Richtmyer-Meshkov and kelvin-Helmholtz instabilities are well understood. In the nonlinear stage, the interface becomes finger like structure. The structure is called a bubble if the lighter fluid pushes across the unperturbed surface into the heavier fluid and a spike if the opposite takes place. The dynamics of such Richtmyer-Meshkov and kelvin-Helmholtz instabilities generated nonlinear structures have been studied under different physical situation using an expression near the tip of the bubble second order in the transverse coordinate to unperturbed surface following Layzers[9, 11] approach. In the domain of linear theory, Chandrasekhar[12] has investigated the problem of Kelvin-Helmholtz instability taking the effect of surface tension and Mikaelian[13] has studied the same effect on Richtmyer-Meshkov instability.

The present article deals with the problem of the time development of the nonlinear interfacial structure caused by combined Richtmyer-Meshkov and Kelvin-Helmholtz instability in presence of surface tension. The dynamics of the bubble tip is investigated under the nonlinear potential flow

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model and obtained a condition for oscillatory stabilization of the interface between two fluids. A analytic expression of the velocity of the bubble tip is also obtained for asymptotic stage.

II. Basic Hydrodynamic Model

To describe the nature of the bubble tip in presences of velocity shear and surface tension, we consider two incompressible, inviscid fluids separated by an initial horizontal interface situated at $y = 0$ in a two dimensional $x - y$ plane. The classical combined RM and KH instability refers to the following density and velocity profile:

$$\rho = \begin{cases} \rho_h & : y > 0 \\ \rho_l & : y < 0 \end{cases} \tag{1}$$

$$U = \begin{cases} U_h & : y > 0 \\ U_l & : y < 0 \end{cases} \tag{2}$$

Initially, the system is subjected to a sudden and very brief acceleration $g(t)$, and the evolution of the fluid flow and of the interface deformation is studied. As is customary in impulsive models, the time-dependent acceleration is represented by a Dirac function, under the form:

$$g(t) = \Delta U \ \delta(t) \tag{3}$$

whereΔU is the speed change imparted to the fluids by the shock. The equation of the interface is defined by function η, under the parabolic form:

$$y = \eta(x,t) = \eta_0(t) + \eta_2(t)(x - \eta_1(t))^2 \tag{4}$$

The nonlinear perturbed interface forms a bubble or spike according to $\eta_0(t) > 0$, $\eta_2(t) < 0$ or $\eta_0(t) < 0$, $\eta_2(t) > 0$. Here, at time t, the position of the bubble tip is given by $(\eta_1(t), \eta_0(t))$ and $\eta_2(t)$ gives the curvature of the tip of the bubble. In presence of streaming motion of the fluids, the tip of the bubble moves parallel to unperturbed interface with velocity $\dot{\eta_1}(t)$.

Each fluid is inviscid and incompressible and so flows irrotationally. As a result, velocity potentials ϕ_h and ϕ_l may be constructed in upper and lower fluids, respectively Each velocity potential must satisfy Laplace's equation, so that

$$\nabla^2\phi_h = 0 \text{ in } y > \eta(x,t) \tag{5}$$

$$\nabla^2\phi_l = 0 \text{ in } y < \eta(x,t) \tag{6}$$

According to the extended Layzer model [9, 11, 14, 17, 16], the velocity potentials describing the motion for the upper and lower fluids are given by,

$$\phi_h(x,y,t) = a_1(t)\cos(k(x-\eta_1(t))e^{-k(y-\eta_0(t))} + a_2(t)\sin(k(x-\eta_1(t))e^{-k(y-\eta_0(t))} - xU_h \tag{7}$$

$$\phi_l(x,y,t) = b_0(t)y + b_1(t)\cos\left(k(x-\eta_1(t)\right)e^{k(y-\eta_0(t))} + b_2(t)\sin\left(k(x-\eta_1(t)\right)e^{k(y-\eta_0(t))} - xU_l \qquad (8)$$

where k is the perturbed wave number.

The boundary condition that the normal velocity is continuous at the interface $y = \eta(x,t)$ can be written as

$$\frac{\partial \eta}{\partial t} - \frac{\partial \eta}{\partial x}\frac{\partial \phi_h}{\partial x} = -\frac{\partial \phi_h}{\partial y} \qquad (9)$$

$$\frac{\partial \eta}{\partial x}\left(\frac{\partial \phi_h}{\partial x} - \frac{\partial \phi_l}{\partial x}\right) = \frac{\partial \phi_h}{\partial y} - \frac{\partial \phi_l}{\partial y} \qquad (10)$$

The dynamical boundary condition (Bernoulli's equation) at the interface $y = \eta(x,t)$ is of the form,

$$-\rho_{h(l)}\tfrac{\partial \phi_{h(l)}}{\partial t} + \tfrac{1}{2}\rho_{h(l)}(\vec{\nabla}\phi_{h(l)})^2 + \rho_{h(l)}gy = -p_{h(l)} + f_{h(l)}(t) \qquad (11)$$

The pressure boundary condition at two fluid interface including surface tension[15] is

$$p_h - p_l = \frac{T}{R} \qquad (12)$$

where T is surface tension and R is the radius of curvature.

Plugging the boundary condition (12) at the interface $y = \eta(x,t)$ in Eq.(11), we obtain the following equation,

$$\rho_h[-\frac{\partial \phi_h}{\partial t} + \frac{1}{2}(\vec{\nabla}\phi_h)^2] - \rho_l[-\frac{\partial \phi_l}{\partial t} + \frac{1}{2}(\vec{\nabla}\phi_l)^2] + \Delta U\ \delta(t)(\rho_h - \rho_l)y = -\frac{T}{R} + f_h - f_l \qquad (13)$$

Here we have studied the dynamics of the peak of the perturbed structure where $|k(x-\eta_1(t))| \ll 1$. Thus we can neglect the terms of $O(|x-\eta_1|^i)$ $(i \geq 3)$ [14] – [17]. With this point of view,

$$\frac{1}{R} = 2\eta_2\left(1 + 4\eta_2^2(x-\eta_1)^2\right)^{-\frac{3}{2}} \approx 2\eta_2\left(1 - 6\eta_2^2(x-\eta_1)^2\right) \qquad (14)$$

Substituting all the fluid parameters η, ϕ_h and ϕ_l in the boundary conditions (9),(10) and (13), and equating the coefficients of $(x-\eta_1)^i$,$(i = 0,1,2)$, we obtain the flowing nonlinear equations

$$\frac{d\xi_1}{d\tau} = \xi_4 \qquad (15)$$

$$\frac{d\xi_2}{d\tau} = V_h - \frac{\xi_5(2\xi_3+1)}{2\xi_3} \qquad (16)$$

$$\frac{d\xi_3}{d\tau} = -\frac{1}{2}(6\xi_3+1)\xi_4 \qquad (17)$$

$$\frac{kb_0}{\sqrt{k\Delta U}} = -\frac{12\xi_3\xi_4}{6\xi_3 - 1} \tag{18}$$

$$\frac{k^2 b_1}{\sqrt{k\Delta U}} = \frac{6\xi_3 + 1}{6\xi_3 - 1}\xi_4 \tag{19}$$

$$\frac{k^2 b_2}{\sqrt{k\Delta U}} = \frac{(2\xi_3 + 1)\xi_5 - 2\xi_3(V_h - V_l)}{2\xi_3 - 1} \tag{20}$$

$$\frac{d\xi_4}{d\tau} = \frac{N_1(\xi_3, r)}{D_1(\xi_3, r)}\frac{\xi_4^2}{(6\xi_3 - 1)} + \frac{24(1+r)\xi_3^3(6\xi_3 - 1)\sigma}{D_1(\xi_3, r)} + \frac{N_2(\xi_3, r)}{D_1(\xi_3, r)}\frac{(6\xi_2 - 1)\xi_5^2}{2\xi_3(2\xi_3 - 1)^2}$$
$$+\frac{2(4\xi_3 - 1)(6\xi_3 - 1)}{D_1(\xi_3, r)(2\xi_3 - 1)^2}[(V_h - V_l)^2\xi_3 - (V_h - V_l)(2\xi_3 + 1)\xi_5 \tag{21}$$

and

$$\frac{d\xi_5}{d\tau} = -\frac{(2\xi_3 - 1)r\xi_4\xi_5}{2\xi_3 D_2(\xi_3, r)} + \frac{\xi_4(6\xi_3 + 1)}{2D_2(\xi_3, r)(6\xi_3 - 1)(2\xi_3 - 1)}[4(V_h - V_l)(4\xi_3 - 1) - \frac{\xi_5}{\xi_3}(28\xi_3^2 - 4\xi_3 - 1)] \tag{22}$$

where $r = \frac{\rho_h}{\rho_l}$; $\xi_1 = k\eta_0$; $\xi_2 = k\eta_1$; $\xi_3 = \frac{\eta_2}{k}$; $\xi_4 = \frac{ka_1}{\Delta U}$; $\xi_5 = \frac{ka_2}{\Delta U}$; $\tau = t(k\Delta U)$; $\sigma = \frac{Tk}{(\rho_h+\rho_l)(\Delta U)^2}$ and $V_{h(l)} = \frac{U_{h(l)}}{\Delta U}$ are corresponding dimensionless quantities. The functions $N_1(\xi_3, r)$, $N_2(\xi_3, r)$, $D_1(\xi_3, r)$ and $D_2(\xi_3, r)$ are given by

$$N_1(\xi_3, r) = 36(1-r)\xi_3^2 + 12(4+r)\xi_3 + (7-r);$$
$$D_1(\xi_3, r) = 12(r-1)\xi_3^2 + 4(r-1)\xi_3 - (r+1) \tag{23}$$

and

$$N_2(\xi_3, r) = 16(1-r)\xi_3^3 + 12(1+r)\xi_3^2 - (1+r);$$
$$D_2(\xi_3, r) = 2(1-r)\xi_3 + (r+1) \tag{24}$$

The above set of five equations (15)(17), (21) and (22) together with Eqs. (23) and(24) which define the different functions describe the combined effect of RM and KH instability.

III. Linear Approximation

In this section, we establish that the usual KH instability growth rate (without surface tension and shock) is recovered on linearization of Eqs. (15)-(17),(20) and (22). Let us consider

$$\frac{d\eta_1}{dt} = \alpha_h U_h + \alpha_l U_l \tag{25}$$

where

$$\alpha_{h(l)} = \frac{\rho_{h(l)}}{\rho_h + \rho_l} \tag{26}$$

Then Eq. (16) gives, after linearization,

$$k^2 a_2 = 2\alpha_l (U_h - U_l)\eta_2 \tag{27}$$

Linearizing Eqs. (17), (21) and (22) we get

$$\frac{d\eta_2}{dt} = -\frac{1}{2}k^3 a_1 \tag{28}$$

$$k\frac{da_1}{dt} = -2\alpha_h\alpha_l(U_h - U_l)^2\eta_2 \tag{29}$$

$$\frac{da_2}{dt} = -\rho_h(U_h - U_l)ka_1 \tag{30}$$

Eliminating η_2 from Eqs. (28) and (29)

$$\frac{d^2 a_1}{dt^2} = k^2\alpha_h\alpha_l(U_h - U_l)^2 a_1 \tag{31}$$

Thus the growth rate is given by

$$\gamma(k) = k\sqrt{\alpha_h\alpha_l(U_h - U_l)^2} \tag{32}$$

This result agrees with the result obtained by Chandrasekhar [12] and Mikaelian [18]. Note that Eq.(27) connecting η_2 and a_2 provides the consistency condition.

IV. Result and Discussion

The growth, curvature and growth rate of the peak height of the bubble is obtained by numerical integration of Eqs. (15), (16), (17), (21) and (22). The initial perturbed interface is assumed to be $y = \eta_0(t = 0)cos(kx)$. The expansion of the cosine function gives $(\xi_2)_{initial} = 0$, $(\xi_3)_{initial} = -\frac{1}{2}(\xi_1)_{initial}$ and $(\xi_1)_{initial}$ is the arbitrary initial amplitude. If the shock incidence is oblique then the normal component generates velocity shear and causes KH instability [18]. The shock generated initial values of ξ_4 and ξ_5 are obtained from the impulsive accelerations. From the linear formula $\xi_1(\tau) = \xi_1(0)A\tau$, we set $(\xi_4)_{initial} = (\xi_1)_{initial}A$ and $(\xi_5)_{initial} = 0$, where $A = \frac{\rho_h - \rho_l}{\rho_h + \rho_l}$ is the Atwood number. The obtained numerical results are shown in figures.

The growth rate contributed in absence of velocity shear and surface tension,i.e; by normally incident shock induced Richtmyer-Meshkov instability varies as $\frac{1}{t}$[15]. However in presence of velocity shear the growth rate due to combined influence of Richtmyer-Meshkov and Kelvin-Helmholtz instability approaches finite saturation value asymptotically.

$$[(\xi_3)_{asymp}]_{bubble} = -\frac{1}{6} \tag{33}$$

$$[(\xi_4)_{asymp}]_{bubble} = \sqrt{\frac{5}{16}\left(\frac{1-A}{1+A}\right)(V_h - V_l)^2 - \frac{2}{9}\left(\frac{\sigma}{1+A}\right)} \tag{34}$$

and

$$[(\xi_5)_{asymp}]_{bubble} = 0 \tag{35}$$

These asymptotic values are obtained by setting $\frac{d\xi_3}{d\tau} = 0$, $\frac{d\xi_4}{d\tau} = 0$ and $\frac{d\xi_5}{d\tau} = 0$. Note that the above asymptotic values exist if the surface tension is less than a critical value T_c, given by

$$T_c = \frac{45}{16}\frac{\rho_l}{k}(V_h - V_l)^2(\Delta U)^2 \tag{36}$$

Here the critical value is depended on the magnitude of relative velocity shear of two fluids, and the density of the lower fluid only. The growth (ξ_1) and velocity (ξ_4) of the tip is reduced if $T \to T_c - 0$. This feature exhibit in figure 1. Moreover, the asymptotic velocity of the bubble tip becomes large if there is a large velocity shear or large shock strength, which produce a large velocity jump after the shock impedance.

Figure (2) and (3) describe the nonlinear oscillation behavior of the perturbed interface. The nonlinear oscillation occurs if $T > T_c$. It is clear from the figure (2) that,the amplitude and period of oscillation of the interface decreases for large surface tension. Under this condition the self generated transverse velocity (ξ_5) also becomes oscillatory. On the other hand, $\xi_5 \to 0$ asymptotically when $T < T_c$. The oscillatory behavior also depends upon the magnitude of the relative velocity shear. Figure (3) shows that the amplitude and period of oscillation increases with magnitude of the relative velocity.

Further, the equilibrium is attained when $T = T_c$, i.e,

$$\dot{\xi}_3 = \dot{\xi}_4 = \dot{\xi}_5 = 0 \text{ when } \xi_3 = -\frac{1}{6} \text{ and } \xi_4 = \xi_5 = 0 \tag{37}$$

This feature shows by solid line in figure (2). Thus the combined Richtmyer-Meshkov and Kelvin-Helmholtz instability is stabilized when $T \geq T_c$.

V. Conclusion

In this article, we have studied the effect of surface tension on the interfacial structure of two fluids interface induced by combined action of Richtmyer-Meshkov and Kelvin-Helmholtz instability under nonlinear potential flow model. The analytic expressions for bubble tip growth rate at asymptotic stage are obtained for arbitrary Atwood number and velocity shear. In absence of surface tension the growth rate is reduced for small velocity shear and initial velocity induced by shock. Surface tension becomes a stabilizing factor of the instability, provided it is larger than a critical value. In this case, oscillatory behavior of motion is described by numerical integration of governing equations. The nature of oscillations depends on both surface tension and relative velocity shear of two fluids. On the other hand, below the critical value, surface tension dominates the growth and growth rate of the instability. This is a theoretical work and may be helpful for experiential study of the two fluid instability in future.

VI. Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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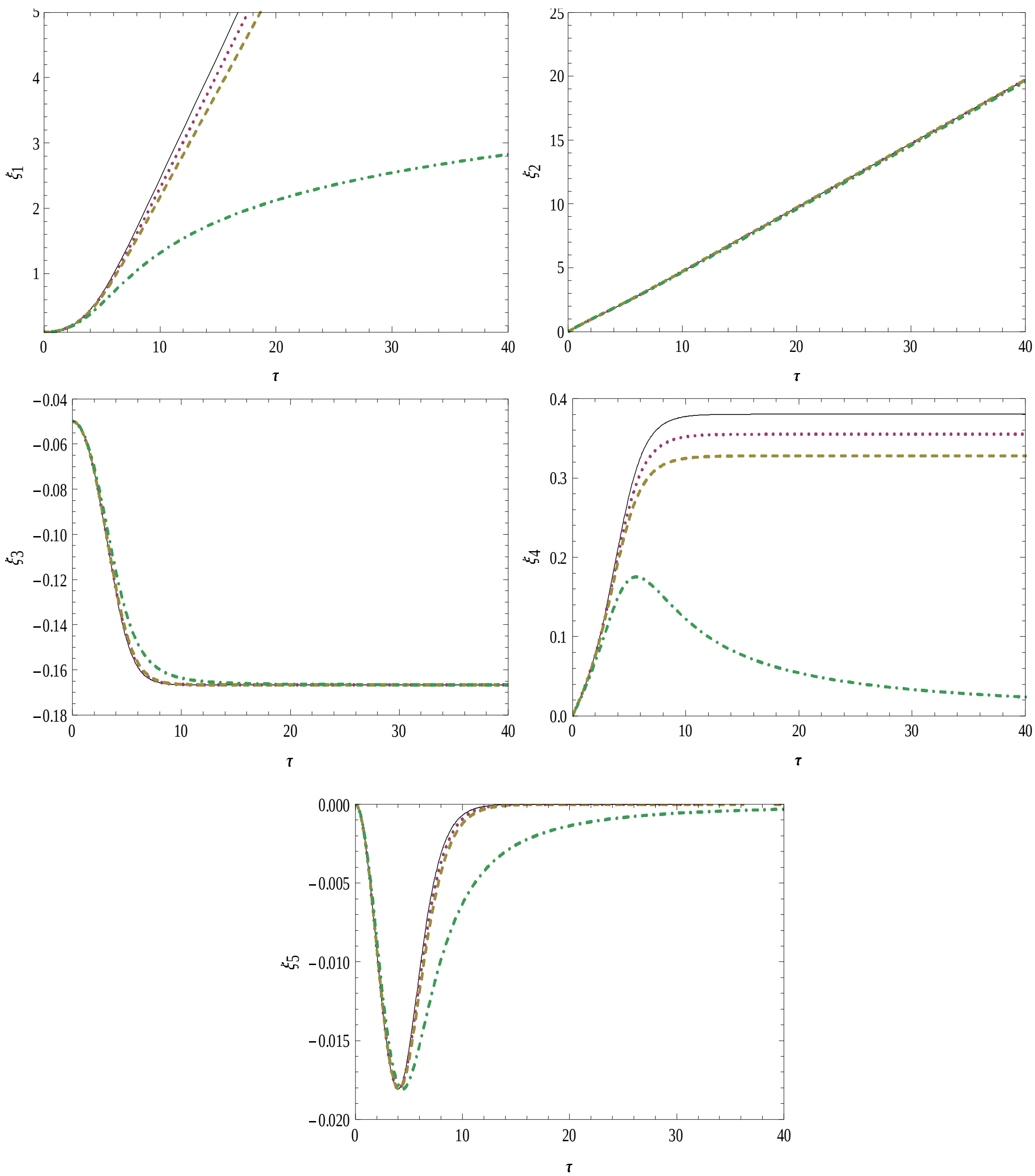

Figure 1 : Variation of ξ_1, ξ_2, ξ_3, ξ_4 and ξ_5 with τ. Initial value ξ_1 =0.1, ξ_2 =0, ξ_3 =-0.05, $\xi_4 = 0.02$, and $\xi_5 = 0$ with $r = 1.5$, V_h=0.6,$V_l = 0.1$, σ=0 (line),0.1 (Dot), 0.2 (Dash), 0.25 (Dash-Dot).

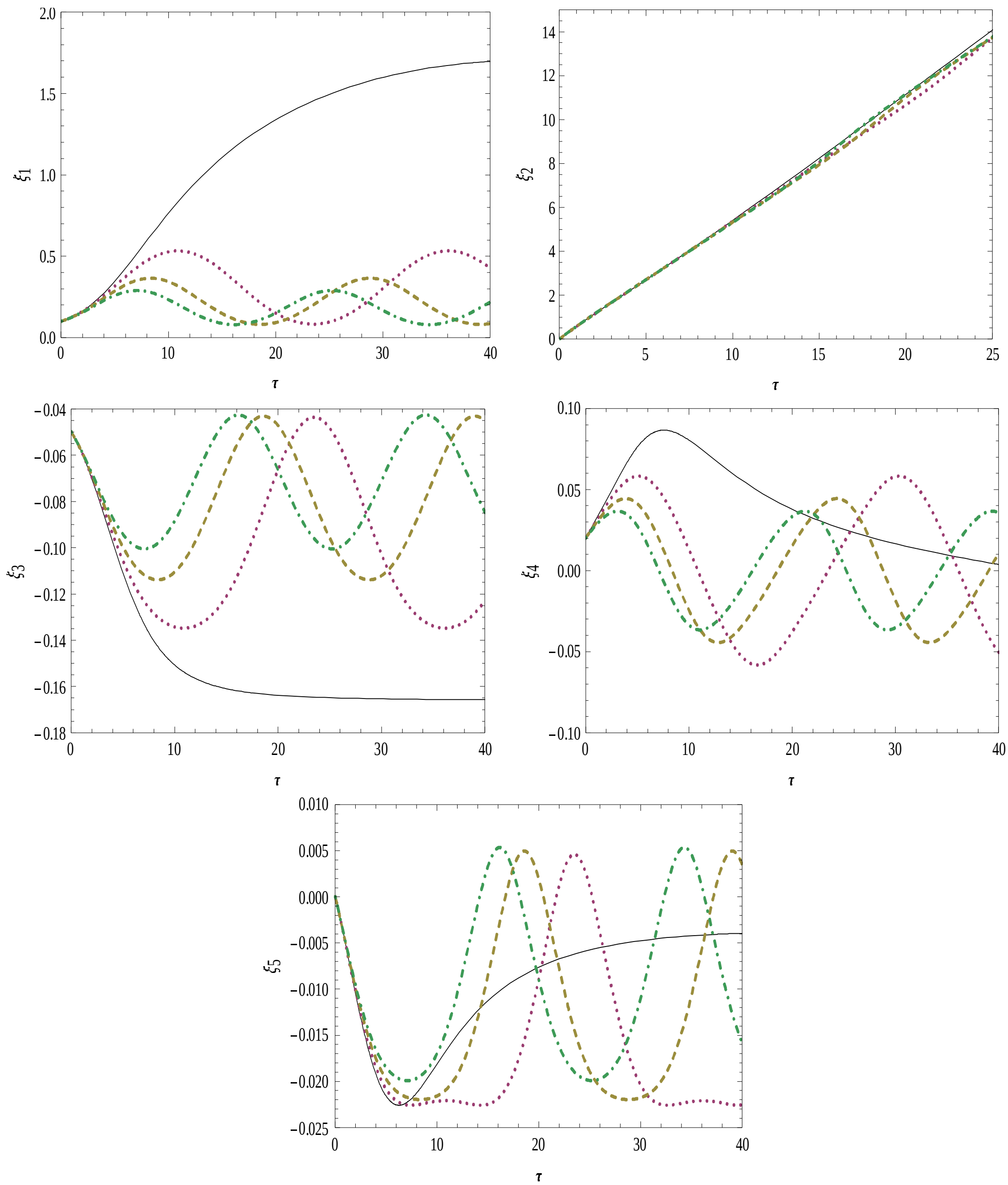

Figure 2 : Variation of ξ_1, ξ_2, ξ_3, ξ_4 and ξ_5 with τ. Initial value ξ_1 =0.1, ξ_2 =0, ξ_3 =-0.05, $\xi_4 = 0.02$, and $\xi_5 = 0$ with $r = 1.5$, V_h=0.6,$V_l = 0.1$, σ=9/32 (line),0.5 (Dot), 0.75 (Dash), 1 (Dash-Dot).

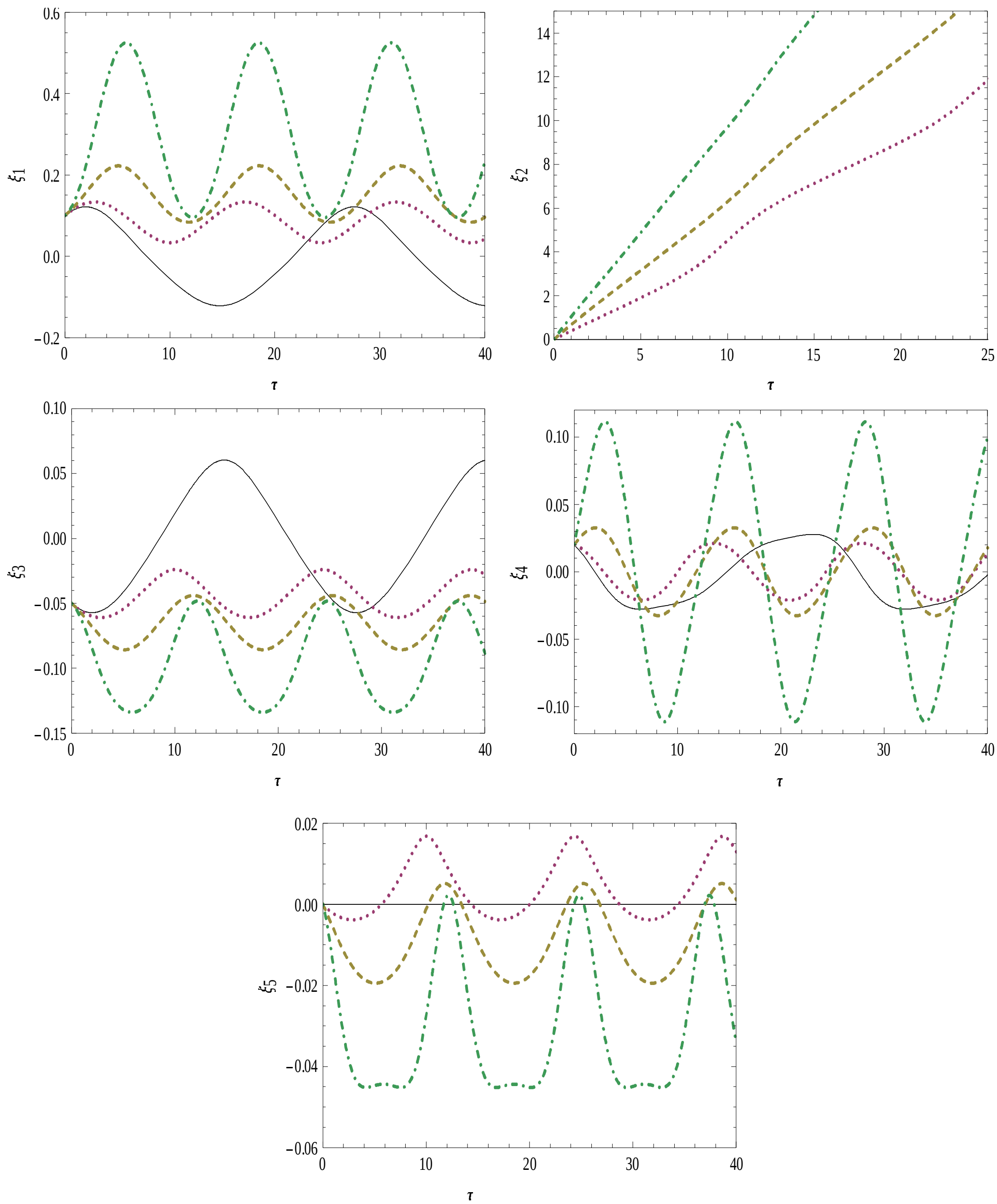

Figure 3 : Variation of ξ_1, ξ_2, ξ_3, ξ_4 and ξ_5 with τ. Initial value ξ_1 =0.1, ξ_2 =0, ξ_3 =-0.05, ξ_4 = 0.02, and ξ_5 = 0 with r = 1.5, σ=2, V_h=0,V_l = 0 (line),V_h=0.4,V_l = 0.1(Dot), V_h=0.7,V_l = 0.1 (Dash),V_h=1.1,V_l = 0.1 (Dash-Dot).

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Verification of the Second Postulate of the Special Relativity Theory

By Alexander A. Antonov
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GJSFR-A Classification : *FOR Code: 010504*

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Strictly as per the compliance and regulations of :

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I. Introduction

Any scientific theory is based on certain principles that are accepted for granted, on faith. In mathematics, these principles are referred to as axioms; in other sciences, as postulates or dogmata. However, contrary to mathematics, in other sciences these principles eventually become obsolete and are substituted with new principles.

In this respect, Karl Raimund Popper (1902–1994), the author of the 'open society' concept, wrote [1] that due to the short lifetime of all scientific theories, struggle and the replacement of scientific truths are inevitable and are an essential condition for the advancement of science. Thus, even such a universally recognized scientific theory as the special theory of relativity (STR) cannot be regarded as a truth, tout court.

Naturally, since the time the theory was developed by Joseph Larmor [2], Nobel Prize winner Hendrik Antoon Lorentz [3], Jules Henri Poincaré [4], and Nobel Prize winner Albert Einstein [5], as well as other prominent scientists, the battle of opinions has continued. It was criticized from the very beginning by Nickolay Y. Zhuckovskiy, Oliver Heaviside, Nikola Tesla, Nobel Prize winner Joseph John Thomson, Nobel Prize winner Svante August Arrhenius, Nobel Prize winner Walther Hermann Nernst, Nobel Prize winner Ernest Rutherford, Nobel Prize winner Frederick, Nobel Prize winner Percy Williams Bridgman, Léon Nicolas Brillouin, and many other outstanding scientists.

So far, over 500 scientific works [6] criticizing the STR have been published. Among the latest, publications [6 – 9] can be cited. There could have been more if influential pseudoscientific circles had not interfered in the scientific research process. For instance, in the USSR alone, three decisions banning criticism of the STR were taken:

- In 1934 by the Central Committee of the All-Union Communist Party (of Bolsheviks) resolution on discussion of relativism;
- In 1942 by the Presidium of the Academy of Sciences of the USSR resolution on the theory of relativity;
- In 1964 by the classified resolution of the Presidium of the Academy of Sciences of the USSR, which prohibited any scientific councils, journals, or departments from accepting, considering, discussing, or publishing any research criticizing the STR.

II. The Current Interpretation of the Second Postulate of the Special Relativity Theory

In the twenty-first century, the scientific critical thought even went beyond the theoretical scope: MINOS [10] and OPERA [11] experiments were performed. In order to refute the second postulate of the special theory of relativity, these experiments attempted to prove that a neutrino could move at a superluminal speed. However, the physical scientific community considered these experiments insufficiently valid, and their results were ignored. Moreover, the ICARUS [12] experiment was disproved the results of the OPERA experiment.

However, if we recall that the second postulate of the STR deals with the velocity of light, and not a neutrino, it is not quite clear how these experiments could have proved or disproved it. It turned out that there are three different wordings (see Fig.1) of the second postulate of the STR, which are assumed to be equivalent (but, as will be demonstrated below, are not):

1. The above-mentioned official wording, referred to as the principle of light speed invariance. According to

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it, the velocity of light in vacuum is independent of the state of motion of the emitting body and/or an observer and is constant in all inertial systems;

2. Another frequently used phrasing, referred to as the principle of unbreakable light speed barrier. It states that any material object moving in free space cannot exceed the velocity of light;
3. The third formulation, widely used not only in the STR, but also in physics in general, which states that imaginary (and, therefore, complex) numbers have no physical meaning.

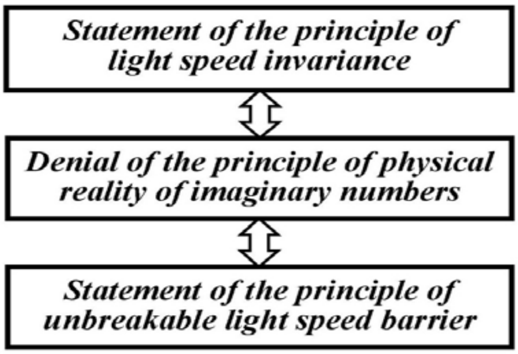

Figure 1 : The essence of the second postulate of the special relativity theory.

Consequently, the MINOS and OPERA experiments, in fact, aimed at disproving not the principle of light speed invariance but the principle of the unbreakable light speed barrier.

It is noteworthy that in the list of formulations of the second postulate of the STR, the third phrasing is compulsory, because, contrary to the principle of light speed invariance, which was proved experimentally, the principle of the unbreakable light speed barrier was proved theoretically, based, moreover, on denial of the principle of physical reality of imaginary numbers. The reasoning was approximately as follows: "The velocity of any physical body cannot break the light speed limit because at superluminal speed, in accordance with the relativistic formulae, their parameters would be measured with imaginary numbers. However, both the former (superluminal speed of physical bodies) and the latter (physical parameters of these bodies measured with imaginary numbers) are physical nonsense." Therefore, it was assumed that all three phrasings of the second STR postulate define it from different angles and are consistent.

Moreover, these three wordings of the second STR postulate seem to agree with the contemporary knowledge level. Indeed, imaginary and complex numbers have been used in mathematics for over 500 years [13] and in electric circuit theory for almost 200 years [14]; however, over these centuries, understanding of their physical essence has not improved. Therefore, it was acceptable to assume that this question in science would remain unanswered forever. This assumption, eventually, developed into a statement, which took the form of the third formulation of the second STR postulate.

Finally, the STR maintains that the principle of the unbreakable light speed barrier is true because in order to exceed the velocity of light, physical bodies with non-zero rest mass require infinitely large energy; however, there are no such energy sources in nature. The impossibility of breaking the light speed barrier follows from other formulae describing relativistic effects, as well.

Thus, there may be the impression that the second STR postulate in the interpretation discussed above is convincingly substantiated and agrees with common sense.

III. Verification of the Third Formulation of the Second STR Postulate in its Current Interpretation

However, this is not so, because there is experimental evidence that convincingly disproves the third phrasing of the second STR postulate. These experiments do not involve elementary particle physics, where it is difficult to verify them as they require unique and very expensive equipment; they concern oscillation process physics within electric circuit theory and can be verified using the equipment of any radio electronic laboratory. Therefore, experiments involving electric circuit theory can be easily validated and understood (thus enabling further new experiments) by any electronic engineer.

Let us prove it.

It is well-known that processes in linear electric circuits are described with linear differential equations (or systems of linear differential equations)

$$a_n \frac{d^n y}{dt^n} + a_{n-1} \frac{d^{n-1} y}{dt^{n-1}} + \dots + a_0 y = \\ = b_m \frac{d^m x}{dt^m} + b_{m-1} \frac{d^{m-1} x}{dt^{m-1}} + \dots + b_0 x \qquad (1)$$

where $x(t)$ is the input action (or the input signal);
$y(t)$ is the response to the action (or the output signal);
$a_n, a_{n-1}, \dots a_0, b_m, b_{m-1}, \dots b_0$ are constant coefficients;
$n, n-1, \dots 0, m, m-1, \dots 0$ is the order of derivatives.

The solution of equation (1), as is known, is the sum of two components

$$y(t) = y(t)_{forc} + y(t)_{free} \qquad (2)$$

where $y(t)_{forc}$ is the forced component of response $x(t)$;

$y(t)_{free}$ is the free (or transient) component of response $x(t)$.

Investigation of both components, as shown below, allows the principle of physical reality of imaginary and complex numbers to be proven, that is, refuting the third formulation of the second STR postulate.

a) Verification using resonant oscillation processes

For the task of verifying the third formulation of the second STR postulate using the forced component of response $y(t)_{forc}$, let us resort to precise (contrary to the conventional approximate) analysis of its parametric variations in resonant processes and demonstrate that the theory of this commonly known phenomenon still has certain unexplained peculiarities relevant to the solution of the problem.

Here, let us recall that resonance in electric circuits is commonly understood as a physical phenomenon, with the result that, as the frequency of harmonic action $x(t)$ approaches the resonance frequency of the electric circuit under investigation:

1. The amplitude of the forced component of response $y(t)_{forc}$ takes an extreme value;
2. The phase shift between the action $x(t)$ and the forced component of response $y(t)_{forc}$ vanishes;
3. The resonance frequency of the forced component of the response $y(t)_{forc}$ is equal to the frequency of free oscillations $y(t)_{free}$.

However, a phenomenon with these characteristics turned out to exist only in electric LC-circuits; in electric LCR-circuits, resonance has different behaviour.

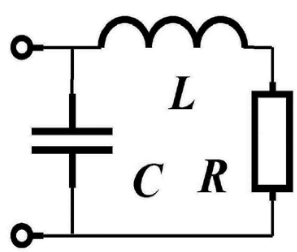

Figure 2 : Electric LCR-circuit where resonance at real frequencies is investigated

Indeed, since the complex admittance of, for instance, the series LCR-circuit plotted in Fig. 2 is

$$Y(j\omega) = C\frac{\omega R/L + j(\omega^2 - 1/LC)}{\omega - jR/L} = C\frac{\omega 2\sigma_0 + j(\omega^2 - \omega_0^2)}{\omega - j2\sigma_0} \qquad (3)$$

investigation of this function in terms of its compliance with the above listed attributes of resonance makes it possible to find a set of two (not one!) first resonance frequencies,

$$\left[\begin{array}{l} \omega'_{res1} = 0 \\ \omega''_{res1} = \sqrt{\omega_0\sqrt{\omega_0^2 + 8\sigma_0^2} - 4\sigma_0^2} = , \\ = \omega_0 \dfrac{\sqrt{Q\sqrt{Q^2+2} - 1}}{Q} \neq \omega_0 \end{array}\right. \qquad (4a)$$

as well as another set of two (once again, not one!) second resonance frequencies

$$\left[\begin{array}{l} \omega'_{res2} = 0 \\ \omega''_{res2} = \sqrt{\omega_0^2 - 4\sigma_0^2} = , \\ = \omega_0 \dfrac{\sqrt{Q^2 - 1}}{Q} \neq \omega_0 \end{array}\right. \qquad (4b)$$

and one frequency of free oscillations

$$\omega_{free} = \sqrt{\omega_0^2 - \sigma_0^2} = \omega_0 \frac{\sqrt{4Q^2 - 1}}{2Q} \neq \omega_0 , \qquad (4c)$$

where $j = \sqrt{-1}$; $\omega_0 = 1/\sqrt{LC}$;

$$2\sigma_0 = 1/RC;\quad Q = \frac{\omega_0}{2\sigma_0} .$$

As can be seen, in this case the frequency of free oscillations ω_{free} turned out to be equal to none of the computed resonance frequencies ω'_{res1}, ω''_{res1}, ω'_{res2}, and ω''_{res2}. Although, based on common sense, free oscillations must seemingly exist at the most energy-efficient frequency, that is at the resonance (but one and only) frequency. In the early twentieth century, Leonid Isaacovych Mandelstam [15] made huge efforts to find the reasons for the inequality $\omega_{free} \neq \omega_{res}$, but in vain. It is even less clear why resonance frequencies corresponding to different attributes of resonance (and different electric LCR-circuits) turned out to be different.

Similar results can be obtained after precise investigation of any other electric LCR-circuits.

As can be seen, the expressions (4a) and (4b) differ noticeably from the formula usually given in textbooks $\omega_{res} = 1/\sqrt{LC}$. This circumstance, naturally, requires an explanation. However, in order to avoid explanations, textbooks always give approximate formulae that disguise the problem.

Moreover, the approach is explained quite persuasively: the difference between the results of calculations using precise and approximate formulae is insignificant and does not exceed the experimental error. Besides, practical radio electronics does not require calculations that are more precise.

However, in MINOS, OPERA and ICARUS experiments, the speed of a neutrino differed from the velocity of light just as insignificantly, and the difference was comparable to an experimental error, as well. Nevertheless, these experiments were analysed in dozens of scientific publications within less than six months. At the same time, both situations – the experiments on establishing the precise speed of a neutrino and the experiments on defining the precise resonant frequencies in electric circuit theory – as a matter of fact, concern one and the same problem, namely, the problem of disproving or, on the contrary, confirming the third formulation of the second STR postulate.

Refs. [16-22] demonstrate that the above singularities of resonant processes in electric LCR-circuits at real frequencies are accounted for by the fact that, actually, resonance is observed not at real, but at complex frequencies. If the real resonance frequency and real frequency of free oscillations in the above-mentioned definition of resonance were substituted for the complex resonance frequency and complex frequency of free oscillations, all inconsistencies of the current interpretation of resonance would be dismissed.

However, the new theory of resonance has its pitfalls, as well. Thus, according to the theory of resonance at complex frequencies, resonance can be observed not only in the well-known situation under harmonic action on electric LC-circuits but under the impact of exponential radio pulses on electric LCR-circuits, and even under the impact of exponential video pulses on electric RL- and RC-circuits. These statements are quite extraordinary, and, therefore, require additional explanation and experimental verification.

Before describing and explaining these experiments, let us explain why they have not been performed earlier, or, even if they have been performed accidentally, no signs of resonance were detected.

The reason is that resonance is a regularity that defines the characteristic of parameters of the only forced component of response $y(t)_{forc}$ as the complex action frequency $x(t)$ changes. However, due to actual processes in electric circuits, the response $y(t)$ usually contains, along with the forced component $y(t)_{forc}$, the free (or transient) component $y(t)_{free}$, as well.

At the same time, in passive linear electric circuits the transient process is always a damped one. Therefore, during investigation of resonance in an electric circuit under harmonic action, separation of forced $y(t)_{forc}$ and transient $y(t)_{free}$ components of response occurs by itself in the course of time. However, in other cases both the free $y(t)_{free}$ and the forced $y(t)_{forc}$ components (comparable in terms of their duration) are observed simultaneously, which prevents resonance from being detected.

Therefore, it is obvious that in order for the corresponding experiments to be convincing enough, special measures to reduce the interference of the free component of response $y(t)_{free}$ must be taken. This can be achieved, for example, by using certain initial conditions or by choosing such signal source parameters that make the duration of the transient process much shorter or, on the contrary, much longer than the duration of the forced component of response $y(t)_{forc}$.

Now, it is time to explain one of the experiments published in [17 – 22], which proves the existence of resonance at complex frequencies.

As can be seen (see Fig. 3a), in a wellknown implementation of resonance in the electric LC-circuit under the impact of input sustained sinusoidal oscillations U_{inp}, in accordance with its immittance function

$$Z(0,\omega) = j\omega L + \frac{1}{j\omega C} = jL\frac{\omega^2 - \omega_0^2}{\omega} \qquad (5)$$

the forced component of output voltage $U_{outforc}$ at the resonance frequency $\omega_{res} = \omega_0$ is zero. The voltage drop of the forced component of response $U_{outforc}$ in the electric LC-circuit is zero because non-zero voltage drops of the forced component of response at the capacitor U_{Cforc} and at the inductance coil U_{Lforc} are equal in magnitude but opposite in sign. Therefore, the output voltage U_{out} has only the transient component of response $U_{outfree}$.

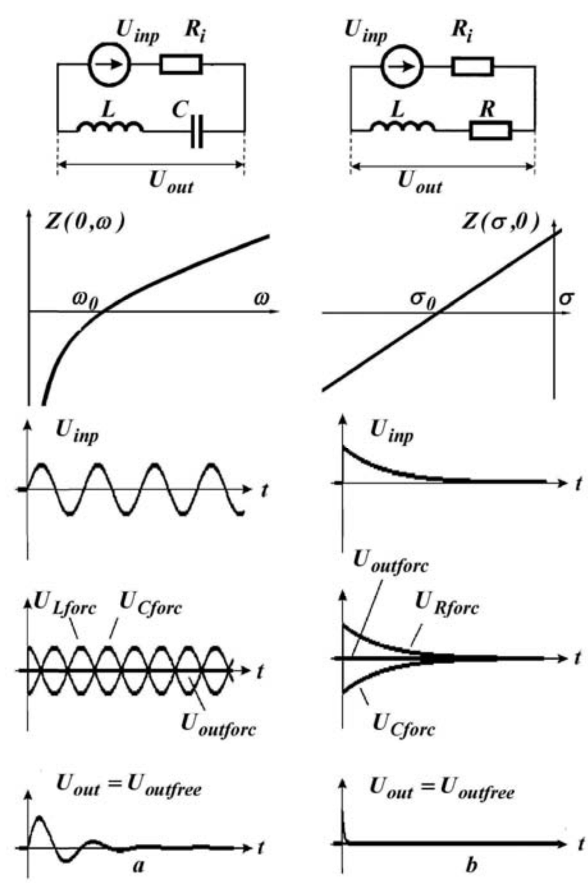

Figure 3 : Signalograms in LC- and RL-twoterminals at resonance at complex frequencies.

This is a well-known experiment. It is described only for comparison with a yet unknown experiment that proves the existence of resonance in an electric RL-circuit (see Fig. 3b). In the latter, as can be seen (note that the following paragraph reproduces the text of the

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previous paragraph almost word-for-word), under the impact of input exponential pulses U_{inp}, in accordance with its immittance function

$$Z(\sigma,0) = R + \sigma L = L(\sigma_0 + \sigma) \quad (6)$$

the forced component of output voltage $U_{outforc}$ at the complex resonance frequency $\sigma_{res} = \sigma_0$ is zero. The voltage drop of the forced component of response $U_{outforc}$ in the electric RL-circuit is zero because non-zero voltage drops of the forced component of response at the resistor U_{Rforc} and at the inductance coil U_{Lforc} are equal in magnitude but opposite in sign. Therefore, the output voltage U_{out} has only the transient component of response $U_{outfree}$.

A similar explanation of resonance can be provided for an electric RC-circuit under the impact of exponential video pulses, as well as for an electric LCR-circuit under the influence of exponential radio pulses (i.e., damped sinusoidal oscillations). Here, note, this will be true resonance, when voltage drop in the electric LCR-circuit is zero, and which is achieved only under the impact of damped sinusoidal oscillations. If sustained sinusoidal oscillations are applied to the electric LCR-circuit under consideration, zero voltage drop is impossible, which is well known.

Experimental evidence of the physical reality of resonance at complex frequencies can also include the patent [16], which gives an example of practical application of resonance.

All these experiments prove the physical reality of resonance particularly at complex frequencies and the physical reality of complex frequencies themselves as well as that of other complex physical quantities and thus refute the third formulation of the second STR postulate.

b) Verification using transient oscillation processes

To prove the principle of the physical reality of imaginary and complex numbers, it is also possible to resort to investigation of oscillation transient processes [23].

The particular types of transient processes is found, if not by operational method, by solving the characteristic algebraic equation

$$a_n p^n + a_{n-1} p^{n-1} + \ldots + a_0 = 0 \quad (7)$$

where a_n, $a_{n-1}, \ldots$ a_0 are the same constant coefficients as in equation (1);

$n, n-1, n-2, \ldots 1, 0$ are the exponents that are equal to the order of respective derivatives in the differential equation (1);

p is a variable that, in case it takes values in the form of complex numbers $-\sigma \pm j\omega$, is often referred to as the complex frequency.

However, contrary to algebraic equations in mathematics, which are solved using both real and complex numbers, characteristic algebraic equations in the electric circuit theory are always solved only on the set of complex numbers.

Why?

The reason is that, as engineers know, transient processes in electric LCR-circuits always exist, that is, at any combination of electric elements L, C, R. When the solution of a second-degree characteristic equation is found in the form of two different real numbers, the transient process is an aperiodic one. When the solution of the seconddegree characteristic equation is two equal real numbers, the transient process is a critical one (it would be better to refer to it as borderline). When the solution of the second-degree characteristic equations is two different complex numbers (i.e., a pair of complex-conjugate numbers), the transient process is an oscillation one. For a characteristic equation of a higher degree, the transient process will be described with a certain combination of aperiodic and/or critical and/or oscillation components.

If characteristic equations were to be solved using real numbers, oscillation processes would be non-existent in nature (i.e., not only in electric circuits), because transient oscillation processes have no corresponding solutions in the form of a combination of real numbers.

However, transient processes have always existed, and they are well known. These are, for instance, shock oscillations in the form of the sound of piano strings and the tolling of church bells, tsunamis, or Indian summers, as well as numerous other types of transient processes in nature, science, and technology.

Consequently, transient oscillation processes prove the physical reality of complex frequencies and, therefore, complex numbers of any physical nature.

The principle of the physical reality of imaginary and complex numbers is a general scientific principle; thus, it is true not only for the electric circuit theory [16 – 23], but also for the STR [24 – 27], quantum mechanics [28], [29], and other sciences.

Therefore, it has been proved indisputably that the third formulation of the second STR postulate in its current interpretation is incorrect.

Therefore, it has been proved indisputably that the third formulation of the second STR postulate in its current interpretation is incorrect.

IV. Verification of the Second Formulation of the Second STR Postulate in its Current Interpretation

Now, let us analyse the second formulation of the second STR postulate. On the one hand, it follows from the third (just refuted) formulation, which raises some doubts regarding its validity. However, on the other hand, the second formulation of the second STR postulate seemingly follows from the impossibility of using infinitely large energy sources to break the light speed barrier, and, thus, on the contrary, evokes some trust.

Therefore, verification of the second formulation of the second STR postulate in its current interpretation also appears to be necessary.

a) Physical nature of imaginary and complex numbers, hidden dimensions

Before moving on to the second formulation of the second STR postulate, it is necessary to complete the discussion on its third formulation and to find out the nature of physically real imaginary and complex numbers. In other words, how can these numbers be counted, seen, touched or felt?

Unfortunately, they cannot, because people do not have such senses. However, people do not feel either the magnetic fields or X-rays, do not see UV-rays, do not hear infra-low-frequency sounds, and cannot touch a black hole. Nevertheless, all these phenomena can be registered with respective devices.

Thus, it can be assumed that in the future people will also learn to register a yet unknown physical reality measured with imaginary numbers. So far, we can only note that since there are numbers that correspond to this physical reality, it can be measured somehow. In other words, it corresponds to some hidden dimensions [30] – [34], which got their name by analogy to the hidden dimensions described in [35].

The possibility that this unknown physical reality is in another parallel Universe (or Universes), which, however, somehow coexists with our parallel Universe, cannot be ruled out.

b) Parallel Universes

Despite the fact that we have no reliable information about these parallel Universes, we can assume that they actually exist and that their inhabitants have been visiting the Earth. Therefore, the similarity principle can be applied to parallel Universes. According to it, the same physical, chemical, biological, and other laws of nature govern both our Universe and other parallel Universes, although some divergence is possible (for instance – see below – time in them flows in different directions and/or with different speeds).

Parallel Universes (including our Universe) that correspond to dimensions in the form of real numbers will be hereinafter referred to as tardyon Universes (using the name of subluminal elementary particles), and parallel Universes that correspond to dimensions in the form of imaginary numbers will be referred to as tachyon Universes (using the names of superluminal elementary particles).

However, in this case relativistic formulae turn to be incorrect. Indeed, it follows from the principle of the physical reality of imaginary and complex numbers proved above that relativistic formulae, for instance,

$$m = \frac{m_0}{\sqrt{1-(v/c)^2}} \qquad (8)$$

where $m0$ is the rest mass;

m is the relativistic mass of a moving body;

v is the velocity of a body (e.g., a neutrino);

c is the speed of light;

have different formulations at subluminal (for a parallel tardyon Universe) and superluminal (for a parallel tachyon Universe) speeds (see Fig. 4a). Consequently, formula (8) and other relativistic formulae do not comply with the similarity principle.

In order for these formulae to comply with the similarity principle, they must be adjusted, similarly to formula (8), as follows:

$$m = \frac{(i)^k m_0}{\sqrt{1-(v/c-k)^2}} = \frac{(i)^k m_0}{\sqrt{1-(w/c)^2}} \qquad (9)$$

where $k = \lfloor v/c \rfloor$ is the discrete 'floor' function of argument v/c;

$w = v - kc$ is the local, for each Universe, velocity which can take values in the range $0 \le w < c$;

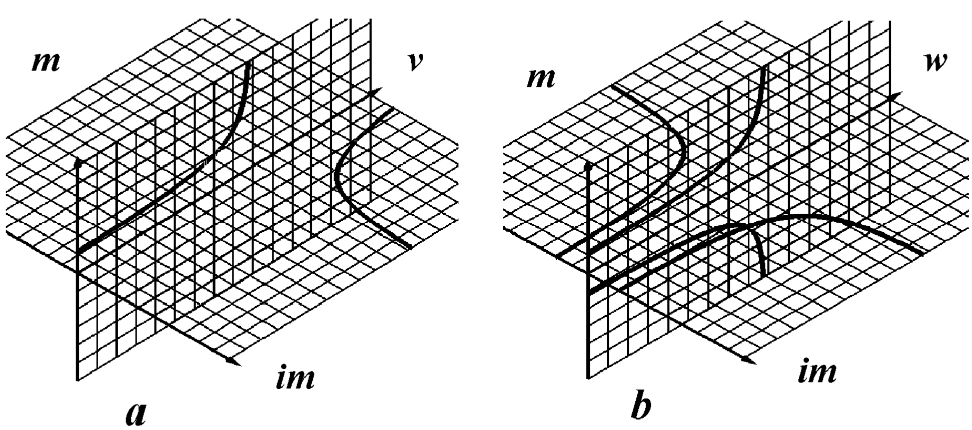

Figure 4 : Graphs of relativistic mass corresponding to formulae (8) and (9)

v is the velocity measured from our tardyon Universe, which, hence, can be referred to as the tardyon velocity.

Then, as can be seen (Fig. 4b), our tardyon Universe corresponds to the case $k = 1$, and the tachyon Universe to the case $k = 2$. However, Fig. 4b indicates that there must be at least two more parallel Universes, which correspond to $k = 3$ and $k = 4$. It is reasonable to refer to them as the tardyon Antiverse and the tachyon Antiverse, because they correspond to dimensions in the form of negative real numbers (or measurements) and negative imaginary numbers (or measurements). Moreover, according to the principle of physical reality of complex (not only imaginary) numbers proved above, there must be numerous other parallel Universes corresponding to non-integer values of the parameter k : the tardyon–tachyon, tachyon–anti-tardyon and others.

c) *Correction of the second formulation of the second STR postulate*

The adjusted relativistic formula (9) allows it to be noticed that the second formulation of the second STR postulate in its current interpretation is incorrect. Moreover, it prompts the possible corrections.

The second formulation of the second STR postulate is incorrect if the current formula (8) is used or if in formula (9) the term 'speed' is understood as the tardyon velocity v, which can actually exceed light speed.

However, it will be correct if formula (9) is used instead of formula (8) and if the term 'speed' in the latter is understood as the local, for each particular parallel Universe, velocity w.

Therefore, it can be stated that the second formulation of the second STR postulate in its current interpretation is conditionally correct (only with the above adjustments).

d) *The Multiverse structure*

However, the explanation suggested above raises some questions and appears incomplete until they are answered. The first question that needs clarification is whether physical objects with nonzero rest mass (including people) can move from one parallel Universe into another, and if they can, how these transitions (including those by people) can be made.

However, before answering these questions, it is reasonable to explain the possible structure of the Multiverse [36-40], which includes the abovementioned parallel Universes.

Obviously, it is determined by factors, many of which are unknown to us. However, we can assume that it also depends on the range of the parameter k in formula (9). If the range is $-\infty \le k \le +\infty$, the Multiverse has an unclosed helical structure. If $1 \le k \le 4$ and the corresponding tardyon Universe at $k = 4$ coincides with the tachyon Universe at $k = 1$, the corresponding Multiverse structure can be characterized as ringed. And, finally, if e.g. $1 \le k \le 12$ and the corresponding tardyon Universe at $k = 12$ coincides with the tardyon Universe at $k = 1$, the corresponding Multiverse structure can be referred to as spiralringed.

However, in any structure, any tardyon Universe will be adjacent only to a tachyon Universe and a tachyon Antiverse; any tachyon Universe will be adjacent only to a tardyon Universe and a tardyon Antiverse; any tardyon Antiverse will be adjacent only to a tachyon Universe and a tachyon Antiverse, and so on. This structure of the Multiverse makes it possible to prevent situations in which a tardyon Universe and a tardyon Antiverse, or a tachyon Universe and a tachyon Antiverse, are adjacent, thus making their annihilation impossible.

It is also noteworthy that when a transition from any parallel Universe to an adjacent parallel Universe is made, according to the respective adjusted formula for relativistic time (similar to formula (9)), the time flow direction (for an external observer) changes to $+\pi/2$ or $-\pi/2$; when a transition to the corresponding Antiverse is made, the time flow direction (once again, with respect to an external observer) changes to π. However, in each parallel Universe the local time flows only in one direction – from the past to the future. In addition, the possibility that time can flow at different velocities in different parallel Universes cannot be ruled out.

e) *Portals*

Finally, let us answer how elementary particles, living beings, and any other physical bodies can make transitions from one parallel Universe into adjacent parallel Universes. It turns out that nature provided another means for this, different from that mentioned in the STR, which does not require the light speed barrier to be broken. It is the use of portals.

This is similar to the way in which we do not have to break through the wall to move from one room of a house into another; it is more convenient to use the doors that were designed for the purpose.

This explanation leaves no doubt that the second formulation of the second STR postulate in its current interpretation is incorrect.

We just have to understand the nature of portals and the mechanism of their formation. Portals are passages between adjacent parallel Universes. They appear spontaneously because adjacent parallel Universes are not locked relative to each other but sort of float in the fourth spatial dimension. Therefore, adjacent parallel Universes sometimes contact each other and even penetrate each other. In this case, quite large territorial formations appear at the points of their mutual penetration, and there the abovementioned parameter k gradually changes per unit from the value corresponding to one parallel Universe to the value corresponding to another parallel Universe.

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Therefore, transition through a portal is similar to, for instance, transition from air into water and backwards during sea bathing. However, people who accidentally get into portals (e.g., when walking in the woods), having found themselves in an unfamiliar location, usually think they are lost, and instead of hurrying back to the portal exit, start wandering around. The portal, meanwhile, may close, and then the unfortunate traveller may have to stay in an alien parallel Universe forever.

V. Conclusion

The second STR postulate has not one but three different formulations, which are assumed to be equivalent:

- The official wording, referred to as the principle of light speed invariance;
- Another phrasing, referred to as the principle of the unbreakable light speed barrier;
- The third formulation, widely used not only in the STR but also in physics in general, which holds that imaginary (and, therefore, complex) numbers have no physical meaning.

The manuscript demonstrates that, in fact, these formulations are not identical. Moreover, the second STR postulate:

- Is incorrect in its third formulation;
- Is conditionally correct is its second formulation; that is, it is incorrect in its current interpretation and correct in its adjusted interpretation;
- Is correct in its first formulation, because it has been verified experimentally.

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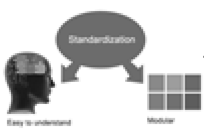

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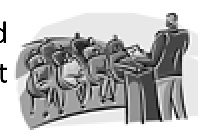

The Global Journals Incorporation (USA) at its discretion can also refer double blind peer reviewed paper at their end to the board for the verification and to get recommendation for final stage of acceptance of publication.

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The Board can also play vital role by exploring and giving valuable suggestions regarding the Standards of “Open Association of Research Society, U.S.A (OARS)” so that proper amendment can take place for the benefit of entire research community. We shall provide details of particular standard only on receipt of request from the Board.

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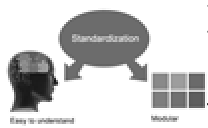

After nomination of your institution as "Institutional Fellow" and constantly functioning successfully for one year, we can consider giving recognition to your institute to function as Regional/Zonal office on our behalf.
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Note :

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- In future, if the board feels the necessity to change any board member, the same can be done with the consent of the chairperson along with anyone board member without our approval.
- In case, the chairperson needs to be replaced then consent of 2/3rd board members are required and they are also required to jointly pass the resolution copy of which should be sent to us. In such case, it will be compulsory to obtain our approval before replacement.
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1. General,

2. Ethical Guidelines,

3. Submission of Manuscripts,

4. Manuscript's Category,

5. Structure and Format of Manuscript,

6. After Acceptance.

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34. After conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print to the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects in your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form, which is presented in the guidelines using the template.
- Please note the criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of prior workings.

Writing a research paper is not an easy job no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record keeping are the only means to make straightforward the progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page
- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

Title Page:

Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.

- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

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	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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