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Bi-Directional EPR Correlation in Cosmology and Planckeon Origin of Dark Energy

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Abstract- A quantum paradox of nonlocal Einstein-Podolsky-Rosen correlation between counter-propagating pair of polarization-entangled photons emitted from a common source S and detected at points P and Q is solved outside the EPR's reality criterion of local causality but within the framework of time-symmetric quantum electrodynamics allowing the bi-directional signal transmission P ↔ S ↔ Q on the double-light cone where the future and the past cones share common light paths connecting the photon source S and the detection points P and Q. A cosmological implication of the bi-directional signal transmission P ↔ Q without common source S in cosmology and possible Planckeon origin of dark energy in the upper hemisphere of semiclosed Friedman universe, joined on to an asymptotically flat outer space, are also discussed.

Keywords: quantum theory, relativity, causality, locality, correlation, cosmology, dark energy.

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Bi-Directional EPR Correlation in Cosmology and Planckeon Origin of Dark Energy

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I. Introduction

Since the advent of quantum mechanics in the mid-1920s there have been continued interpretational controversies surrounding its counter-intuitive nature such as the wave-particle duality and the instantaneous collapse of the particle wave function at the detection point. But the paradox of nonlocal EPR correlation between distant events without nonlocal interactions has been more problematic in recent times by Bell's experimental non locality test proposed in 1964, though the paradox was first noticed by Schrödinger and discussed in the dialogue between Einstein and Bohr at 1935 Solvay Council. In emphasis of the signal transmission in EPR correlation Cavaicanti and Wiseman asked: “What Bohr could have told Einstein at Solvay had he known about Bell experiments?” In his recollection in 1990 Bell wrote: “Suppose quantum mechanics were found to resist precise formulation. Suppose that when formulation beyond FAPP (For All Practical Purposes) is attempted, we find an unmoving finger obstinately pointing outside the subject...to the Mind of the Observer... , or only Gravitation?” We here show that the solution of quantum paradoxes can be found outside the EPR's reality criterion of local causality but within the framework of time-symmetric quantum electrodynamics for finite spacetime. A cosmological implication of the bi-directional signal transmission P→Q without common source S in the inflationary cosmology and a possible origin of dark energy are also discussed.

II. EPR Correlation in EPR Loophole

At the Solvay council EPR asked: “Are there spooky actions at a distance in quantum mechanics?” Recently, Yin et al. led by Q. Zhang measured a superruminal speed of spooky actions between counter-propagating pair of photons emitted from an optically pumped atom in spin 0 state. During the measurement the locality and the freedom-of-choice loopholes of previous experiments were maximally closed by observing a 12-hour continuous violation of Bell's numerical expression (inequality) to EPR's reality criterion of local causality between P and Q. The experiments verified the quantum expectations of the correlation function of EPR's reality criterion of local causality and separability of distant events. Let the spacetime positions of the photon source and the detection points be S(x₀, t₀), P(x, t₀) and Q(x₀, t₀). Then the lower bound of the speed cₛ of the spooky actions

\[ cₛ = \frac{|x₀ - x|}{|t₀ - t₀|} \]  

can be superluminal as |t₀ − t₀| → 0. Here we can see a local and causal link P→S→Q (t₀ < t₀ = t₀) and the nonlocal and a causal (spooky) link P→Q (t₀ < t₀). Let εₑ and ε₀ be the unit polarization vectors of photons measured at P and Q. The experiments confirmed the insensitivity of Cₓₓ to observer's delayed decision as to which direction to measure each photon's polarization at P and Q after the photon left the source at S→Q improbable and the bi-directional link P→S improbable in the loophole of EPR's reality criterion of local causality between P and Q.

III. EPR Correlation on Double-Light Cone

Dirac defined the two-point correlation function or propagator Δ(x,t) between S(0,0) and P(x,t), and visualized the signal transmission S→P on the light cone with the origin S as vertex:

\[ (\partial^2/c^2)(\partial t)^2 - \partial x^2)Δ(x,t) = 0, \]  

\[ Δ(x,t) = α(t)\delta(c^2t^2 - x^2) \]  

\[ = [\delta(ct - x) - \delta(ct - x)] \]

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\[ \Delta_{\text{future}} - \Delta_{\text{past}} = \Delta_{\text{ret}} - \Delta_{\text{advt}}. \]  

(3)

where \( \alpha(t) = t/|t| = 1 \) (t > 0); \( -1 \) (t < 0). There an electron at S(0, 0) moves under the retarded (causal) action \( \Delta_{\text{ret}} \) of a charged particle at P on the past light cone \( \delta(c|t + x) \) of S as well as the advanced (retrocausal) action \( \Delta_{\text{advt}} \) of a charged particle at Q on the future light cone \( \delta(c|t - x) \) of S, giving a divergence-free radiation damping of the electron at S. The bi-directional EPR link, \( P(x_0, t_0) \leftrightarrow S(x_S, t_S) \rightarrow Q(x_Q, t_Q) \), can be visualized on the future light cone of the optically pumped metastable atom at S(0, 0) by replacing the step function \( \delta(c|t + x) \) of S with \( \delta(c|t - x) \) of S, that is, the electron is not at \( S(0, 0) \) but scatters the photon at P. The bi-directional EPR correlation in cosmology and Planckian origin of dark energy is undertaken by Zeldovich and others.

In an attempt to resolve EPR problem Dirac\(^{17,18}\) revived early ideas of aether transmitting light signal between distant points separated by spacelike distance, but was rejected by Einstein as it could not be fitted in his 4-dimensional formulation of relativity. Dirac\(^{18}\) further proposed a bi-directional EPR connection between points P and Q located on the 4-dimensional hyperboloid \( (ct)^2 - r^2 = l_0^2 \) crossing the light cone at \( ct = l_0 \) at \( r = 0 \) with spacelike velocity:

\[ \frac{dr}{dt} = ct/r = c(1 + l_0^2/r^2)^{1/2}, \]

(7)

defining 3-dimensional Lorenz sphere \( r^2 = l_0^2 \). We can likewise embed the Lorenz sphere into the radial line element ds of de Sitter universe in Reissner-Nordstroem form:\(^{20}\)

\[ ds^2 = c^2g_\mu\nu dt^2 - g_\nu dr^2, \]

(8)

where \( \Lambda \) is the cosmological constant. Putting \( ds^2 = 0 \), we get light velocity:

\[ \frac{dr}{dt} = cgg_\mu\nu = c(1 - \Lambda r^2/c^2 + l_0^2/r^2)^{1/2}. \]

(9)

We find that \( dr/dt \) is space like at \( r \sim l_0 \) but decreases towards \( dr/dt = c \) at \( r = (cl_0^2/\Lambda)^{1/4} \sim 10^{-12} \Lambda^{1/4} \) cm. From there \( dr/dt \) continues to decrease towards \( dr/dt = c \), but rises again to space like velocity at the cosmological horizon \( r = c\Lambda^{1/2} \) after a brief interlude of subluminal period.

Hawking\(^{19}\) proposed a cyclic Lorenz-de Sitter model where an expanding and contracting universe starts and ends on the 4-dimensional Lorenz sphere \( \tau^2 + r^2 = I_0^2 \) with imaginary time \( \tau \) = i. There the Hubble expansion \( \sim \exp Ht \) is replaced by a cosmological wave function of radius \( \sim \exp Ht \sim \exp i\tau \), determining the temperature \( T \sim H \), entropy \( S \sim \Lambda^{-2} \) and the energy of radiation \( E \sim h cR \) created by the de Sitter black hole capturing negative energy components of Zittering electrons\(^{20}\) at temperature T.

In high dimensional string theory,\(^{21}\) the parallel orbifold branes collide periodically in cycle, expanding and contracting with dark energy \( \Lambda \).

VI. Mass Defect of Semiclosed Friedman Universe

The idea of semiclosed Friedman universe was proposed by Zel'dovich and others\(^{21}\) in 1970s as a possible model of quasistellar radio sources evolving from and joined-on to preexisting asymptotically flat space. The expansion history of the semiclosed universe is dictated by the Hubble constant \( H = 8\pi G/\rho_0 \) and the dimensionless density parameter \( \Omega_0 = \rho_0/\rho_\Lambda \) where \( \rho_0 \) is the energy density and \( \rho_\Lambda \) the critical density.
For $0 < \Omega_\Lambda < 0.5$ the expanding universe in lower hemisphere is joined onto asymptotically flat outer space through Schwarzschild throat; for $0.5 < \Omega_\Lambda < 1$ the contracting upper hemisphere is joined onto outer space through double-valued Schwarzschild bottleneck; for $\Omega_\Lambda \sim 1$ the almost closed universe is joined onto asymptotically flat space extending to infinity through Planck scale throat. For an observer comoving with cosmological expansion and contraction history of semiclosed Friedman universe can be described by the radial line element $ds^2$ of the universe in Reissner-Nordstroem form:

$$ds^2 = c^2g_{tt}dt^2 - g_{rr}dr^2,$$

where $g_{tt} = g_{rr}^{-1} = (1 - r^2/r_g^2)^2/r^2 - 1/2$, (10)

where $r_g = 3c^2/8\pi G\rho_\Lambda$. The light velocity $dr/dt = c(1 - \Delta r^2/c^2 + l_p^2/r^2)$ is space like at $r \sim l_p$. As $r$ increases from $r = l_p$, $dr/dt$ decreases towards $c$ at $r = (r_g/l_p^2)^{1/2} \sim 10^8$cm for $r_g \sim 10^{26}$cm, to be compared with the radius of causally related small region $\sim 10$cm in inflationary model. With further increase of $r$ towards horizon $r = r_g$, $dr/dt$ reaches spacelike velocity $r = r_g$ after a long interlude of subluminal period: $l_{pl} \ll r < r_g$. In this period a detailed description of the semiclosed Friedman universe can be given by using the integral $\int dx/(1 - r^2/r_g^2)^{1/2} = \sin^{-1}x$ to calculate the proper mass $M_p$ and volume $V_p$ of the universe:

$$M_p = \rho_\Lambda V_p = 2\pi\rho_\Lambda r_g^3g_{rr}dr = (3/2)(R/r_g)^3[\sin^{-1}(R/r_g) - (R/r_g)(1 - (R/r_g)^2)^{1/2}]M,$$

(11)

where $M = (4\pi R^3)/3\rho_\Lambda = \rho_\Lambda V$ is the Newtonian mass and volume $V$ Eq. (11) tells that the proper radius $R_p = \int_0^{\infty}g_{rr}dr$ and volume $V_p = (4\pi R_p^3)/3$ increases with the increase of the world radius from $r \sim 0$, where $\sin^{-1}(R/r_g) \sim 0$, until $V_p$ fills the half of the closed universe (lower hemisphere) of the closed Friedman universe, where $\sin^{-1}(l_p/r_g) = \pi/2$. With further increase of $r$, $R_p$ decreases towards $R_p \sim l_p$, where $\sin^{-1}(l_p/r_g) \sim \pi$, forming a gravitational semicslosure with $V_p \sim M_p \sim 0$ (with upper hemisphere) having Planck surface $l_p^2$ and mass $m_p$, creating Planck scale black holes liberating dark energy $E \sim \hbar c/l_p$ or recreating a black Lorenz sphere outside the gravitational radius $R = r_g$, liberating dark energy $E \sim \hbar c/R$ with information content $(R/l_p)^2$ in asymptotically flat outer space.\(^{22}\)

VII. Source of Dark Energy

We note that the negative equation of state $\rho_\Lambda + p_\Lambda c^2 < 0$ required by the dark energy is satisfied in the upper hemisphere of the semiclosed Friedman universe. There the density of gravitationally bound pairs of quantized metric fluctuations, or gravitational Bohr atoms, dominate by creating negative attractive potential $Gm_p^2l_{pl}^2 = \hbar c/l_{pl} = m_pc^2$ capturing positive rest mass energy $m_pc^2$ of single metric fluctuation, or Planckeons. In the lower hemisphere, where the positive equation of state $\rho_\Lambda + p_\Lambda c^2 > 0$ is satisfied, the free Planckeons prevails. The evolutionarily earlier upper hemishere is characterized by the density parameter $0.5 < \Omega_\Lambda = (R/l_g)^2 = 1$ and the less earlier lower hemisphere by $0 < \Omega_\Lambda < 0.5$. The recently updated density parameters\(^{23}\) fall into these ranges: $\Omega_\Lambda \sim 0.685$ and $\Omega_m \sim 0.266$. Adding the evolutionarily recent atomic matter $\Omega_{atomic} \sim 0.049$, we have $\Omega_{tot} = \Omega_\Lambda + \Omega_m + \Omega_{atomic} = 0.965 \sim 1$ indicating the asymptotic flatness of the extragalactic space required for the asymptotic solutions of Einstein equations to be found useful.

VIII. Conclusion

We have shown that the quantum paradox of EPR correlation between distant points $P$ and $Q$ sharing a common source $S$ arises outside EPR's reality criterion of local causality, and can be solved within the framework of time-symmetric and relativistic quantum electrodynamics for finite spacetime\(^{10}\) with singular boundary conditions allowing the bi-directional signal transmission $P \leftrightarrow S \leftrightarrow Q$ on the double-light cone where the future and the past cones share a common light path connecting $S$ and $P/Q$. A cosmological implication of the bi-directional and superluminal signal transmission $P \leftrightarrow Q$ without a common source $S$ in explaining the observed homogeneity of the universe and the possible Planckon origin of dark energy in the upper hemisphere of the semiclosed Friedman universe, joined onto an asymptotically flat space, are also discussed to explain the asymptotic flatness of the extragalactic space. In conclusion Planckon origin of dark energy in the upper hemisphere of the semiclosed Friedman universe is proposed.

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High Energy K X-Ray Hypersatellites

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Abstract- This study focus on the weak lines that appear on high energy side of the diagram lines which is called High Energy K X-ray hypersatellites i.e., a particular category of characteristic X-ray due to splitting of fine structure levels. It’s resulted from the interaction of spin of an electron with the spin of the nucleus. They are emitted when an atom that has undergone a spontaneous transitions from the higher hyperfine level to the lower one to a radiation of $\approx 1.42 \times 10^9$ Hz frequency and $\approx 21 \text{ cm}$ wavelength. Simultaneous double ionization in the K-shell and multiple ionization in the L-shell gives rise to K$_\alpha$ X-ray hypersatellites. These can be studied only by high energy resolution instruments like WDXRF spectrometry. Fundamental experimental procedures were outlined in this field by several workers due to different excitation modes. The theoretical models to predict their energies and intensities were developed. And also this review can show a clear discrepancy between theoretical and experimental results in the case of hyper satellites formation from different shells. In case of experimental instrumentation, WDXRF is the most accurate for determining the energy and intensity of X-ray hypersatellites. All sources of data was literature done by different scholars.

Keywords: X-ray hyper satellites, energy ratio, intensity ratio.

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I. INTRODUCTION

X-ray satellites emitted in the radioactive decay of double-vacancy states when the two initial vacancies are located in the same shell say K shell are of particular interest. Such satellites were named by Briand et al[1] as the hyper satellites. The denotation of the spectra as $K_{\alpha_1, \alpha_2}$ and $K_{\beta_1, \beta_2}$ originate in the single electron K-spectator-hole transitions $1s^2 \rightarrow 1s^1 2p^1$ and $1s^2 \rightarrow 1s^1 3p^1$, respectively. They were first investigated by ion excitation and later by photon excitation using X-ray tubes. High-resolution measurements of heavy-ion-induced K hyper satellites were found to represent a sensitive tool for studying the relativistic and QED effects in atoms[2].

More recently, it has become possible to investigate the double-K-shell photo ionization process by measuring the K hyper satellite X-ray emission of light and mid-heavy elements irradiated with intense synchrotron radiation beams[3]. In double photo ionization despite of the electron shake-off process, the electron knock-out process appears, in which the first ionized electron can kick out a second bound electron leading to formation of a double-K-vacancy state. As a consequence, double K-shell photo ionization can only result from electron-electron correlation effects[4,5].

An atom with one of its shells empty is called a hollow atom. These satellites can give information on the energy level structure of the electron shell of the hollow atom. They can be produced using target bombardment by high energy heavy ions. But when electrons are ejected, the resulting hollow atom is very difficult to control so that using photo excitation by monochromatic synchrotron radiation is preferable. But photo excitation method produces small probability for the creation of a double K-vacancy and is a disadvantage.

Well resolved photo excitation studies of the hyper satellite lines are very rare because the creation probability of hollow atom via photo excitation is very small. For example, for a $Z=30$ atoms, the cross-section for the production of hyper satellite lines is $\approx 10^{-4}$ of that of the $K_{\alpha_1, \alpha_2}$ and $K_{\beta_1, \beta_2}$ diagram fluorescence lines. However, study of hyper satellites using photo ionization is also reported by Raju et al[6] for elements in the Z range 19-25. Studies of the formation mechanism and the electronic structure of hollow atoms give important new insight in to fundamental issues like inter and intra shell electron correlations, the effects of relativity, and the Breit interaction. In addition to their importance for basic atomic physics, hollow atoms have important applications for studies of e.g. the electronic structure of surface, or systems far from equilibrium[7]. Hollow atoms have even been proposed as a way of achieving population inversion and lasing in the hard X-ray range of wavelengths[8,9].

Relativistic effects also play a major role in the above mentioned transitions, due to the involvement of the highly relativistic K shell. While the effect of Breit interaction on almost all atomic transitions is less than 1%, for the hyper satellite transitions this effect can be as large as 20% in heavy atoms[10]. Therefore the hyper satellite lines offer a very rare opportunity to study in detail the Breit interaction, one of the least studied of all atomic interactions. The experiment done for a formation of hollow atom by bombarding high energy heavy ion, the number of electrons ejected and the state of the resulting hollow atoms are very difficult to control[11,12,13]. In this experiment photon excitation by monochromatic synchrotron radiation, this allows the measurement of a clean and high resolution hyper satellite spectrum and gives the possibility to select the exciting photon energy accurately. The disadvantage of the photo ionization method is the small probability for the creation of a double K vacancy, rendering high intensity synchrotron
radiation sources vital for these experiments. A hollow atom can be producing either a single\textsuperscript{14} or a multiphoton\textsuperscript{15} process. Two photons are used to excite two K electrons nearly simultaneously. In a single photon excitation experiment, which was the method used in this work, both electrons are excited as a result of a single photon absorption.

The hyper satellites in these studies were very poor both in intensity and resolution. Richard et al\textsuperscript{16} were the first to study hyper satellites of Calcium by heavy ion bombardment using the crystal spectrometer. This was followed by the work of Yohkoawa\textsuperscript{17} who measured K\Lp/K\Lp intensity ratio of Nickel, Iron, Chromium and Titanium by ion bombardment. Briand et al\textsuperscript{18} observed hypersatellites in Copper, Nickel and Iron in a study by electron bombardment. Keski-Rahkonen et al\textsuperscript{19} studied hyper satellite spectra of Magnesium, Vanadium, Chromium, Manganese and Iron by photon excitation. Pure Copper K\alpha hyper satellite spectrum generated by photo excitation using Synchrotron radiation is reported by Diamant et al\textsuperscript{20}.

In general, experimental procedures, theoretical computations based on some models, and some investigations carried out in this field at various laboratories in the world are examined with special references to chemical effects and Z systematics.

II. Experimental Procedures

The procedure, for utilizing WDXRF, adopted in recording the spectra is to introduce the sample in the sample holder and to record the intensities in 20 steps of suitable angular intervals ranging from 0.01 to 0.05\textdegree. In general, good statistics are maintained in counting. In each case, the experiment is repeated at least four times, using fresh sample each time.

The collected data are first smoothed using sliding least square fitting and then the spectra are corrected for background using an appropriate computer programmer. The deconvolution of the peaks and estimation of areas under different peaks is carried out by one of the codes like ‘PEAK-FIT\textsuperscript{20}’ software version 4.11 of Systat Software Inc. Energy calibration of the crystal is done by taking spectra of some element standards and assuming the established values of the diagram lines and Calibration parameters are determined. Using these energies of the X-ray is determined.

The estimated intensities, however, do not represent the absolute intensities, as they have to be corrected for various effects. Since the present interest is on the relative intensities and the energy regions covered for each element for the satellites are very small, the final total correction on relative basis is small. Hence normally no corrections need be applied\textsuperscript{21}. However, corrections like Self-Absorption in the Sample, Crystal Reflectivity, Window Absorption, and Efficiency of the Detector are applied, even though small, in the present investigations.

III. Theoretical Computations based on some Models

Different theoretical models are developed for the computation of energy shifts of hyper satellites relative to their respective diagram lines. The theoretical explanation of hyper satellite energy shifts can be defined by using calculations like;

\textbf{D-H-S calculations:} - Chen et al\textsuperscript{22} estimated the energy shifts of the K\alpha hyper satellites K\alpha\textsuperscript{1} and K\alpha\textsuperscript{2} from the K\alpha diagram line. They have completed the energy shift of K\alpha hyper satellites relative to the diagram line in the intermediate coupling scheme using Dirac–Hartree-Slater wave functions and incorporating the full Breit interaction and the final state splitting produced by the Coulomb and Breit interactions in addition to the electrostatic interaction. The Breit interaction operator used was

\[ H_{Br} = -\frac{1}{r_{12}} \left[ \vec{a}_1 \cdot \vec{a}_2 \cos \omega r_{12} + (1 - \cos \omega r_{12}) \right] \]

\[ \vec{a}_1, \vec{a}_2 = \text{Dirac matrices} \]

Where \( r_{12} \) = distance between the two interacting electrons.

For atoms with double inner shell vacancies, the multiplet splitting can be found by evaluating the corresponding coupled two hole matrix elements of the electrostatic and Breit interaction operators. As closed shells do not contribute to the multiplet splitting\textsuperscript{23} the splitting of the double hole states is determined by the coupled -- two- hole states alone. The sum of the electrostatic and Breit operators is,

\[ H_{CBr} = 1 - \frac{\vec{a}_1 \cdot \vec{a}_2}{r_{12}} \cos \omega r_{12} \]

Hence, the energy matrix of the electrostatic and Breit operators between the anti-symmetrized \( j-j \) coupled two hole states, which can be separated in terms of direct and exchange matrix elements is,

\[ \langle j_1 j_2 | M | r_{12}^{-1} (1 - \vec{a}_1 \cdot \vec{a}_2) \cos \omega r_{12} | j_1 j_2 | M \rangle = D - E \]

Chen\textsuperscript{2} et al have calculated these shifts with some gaps in the \( Z \) range of present interest. Values are available for Calcium (\( Z=20 \)) and Manganese (\( Z=25 \)). The values for the other elements are interpolated from the values given in the Table 1. The theoretical hyper satellite energy shift varies smoothly with \( Z \) in this region.
Table 1: Theoretical Energy shifts (in eV) of the Kα^nL^0 hyper satellites with respect to the KαL^0 diagram line

<table>
<thead>
<tr>
<th>Atomic number</th>
<th>Kα_1^n — Kα_1</th>
<th>Kα_2^n — Kα_2</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>184.4</td>
<td>175.5</td>
</tr>
<tr>
<td>20</td>
<td>206.3</td>
<td>197.4</td>
</tr>
<tr>
<td>25</td>
<td>260.7</td>
<td>254.9</td>
</tr>
<tr>
<td>30</td>
<td>317.3</td>
<td>314.0</td>
</tr>
<tr>
<td>36</td>
<td>388.0</td>
<td>387.6</td>
</tr>
<tr>
<td>40</td>
<td>438.9</td>
<td>439.1</td>
</tr>
<tr>
<td>45</td>
<td>506.6</td>
<td>506.4</td>
</tr>
</tbody>
</table>

M.C.D.F. Calculations: - Multi Configuration Dirac Fock calculations made in the intermediate coupling scheme takes into consideration the relativistic effects. But Breit interaction is omitted from the final splitting calculations. The Breit operator is expressed as,

\[ H_{Br} = -\frac{1}{2r_{12}}[\bar{\alpha}_1\cdot\bar{\alpha}_2 + \frac{1}{r_{12}}(\bar{\alpha}_1\cdot\bar{r}_{12})(\bar{\alpha}_2\cdot\bar{r}_{12})] \]

Where \(\alpha_i\) Dirac matrices and \(r_{12}\) is the distance between the two interacting electrons. In the MCDF calculations only the average contribution of this Breit operator which is valid only in the long wave length limit is taken into account. According to Chen these calculations tend to overestimate the hyper satellite energy shifts.

IV. Dependence on Mode of Excitation, Chemical Effects and Z Systematics

A review of the literature shows that experimental investigations were carried out on hyper satellites on low and medium Z elements (mostly up to Z=32). In these studies attention was paid to the aspects of dependence on mode of excitation, chemical effect and Z systematics. Related to this for any element and chemical compounds regarding to their atomic number and projectiles has different energy shift and intensity ratio. When we see the oxidation number of any pure element is zero while the oxidation number of compounds are higher relative to one the other and also even if the oxidation number increase or decrease there is no variation in energy shift while the value of the intensity ratio increase or decrease.

**Dependence on Mode of Excitation:**
1) Projectile Dependence of Energy Shifts:

In the case of the Al satellites, no systematic variation of the peak energies with projectile atomic number could be discerned.

Table 2: K X-ray energies for Al, Cl, and K

<table>
<thead>
<tr>
<th>X-ray peak</th>
<th>Initial state vacancy configuration</th>
<th>Al X-ray energy</th>
<th>Cl X-ray energy</th>
<th>K X-ray energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1s⁻¹</td>
<td>1486.6</td>
<td>2621.9</td>
<td>3312.9</td>
</tr>
<tr>
<td>2</td>
<td>1s⁻¹ 2s⁻¹ 1s⁻¹ 2p⁻¹</td>
<td>1496.9±0.1</td>
<td>2640.2±1.4</td>
<td>3336.0±3.2</td>
</tr>
<tr>
<td>3</td>
<td>1s⁻¹ 2s⁻¹ 1s⁻¹ 2p⁻¹ 1s⁻¹ 2p⁻¹</td>
<td>1507.9±0.2</td>
<td>2658.8±1.8</td>
<td>3357.1±4.0</td>
</tr>
<tr>
<td>4</td>
<td>1s⁻¹ 2s⁻¹ 2p⁻¹ 1s⁻¹ 2s⁻¹ 2p⁻¹ 1s⁻¹ 2p⁻¹</td>
<td>1521.3±0.3</td>
<td>2678.5±2.2</td>
<td>3379.1±4.7</td>
</tr>
<tr>
<td>5</td>
<td>1s⁻¹ 2s⁻¹ 2p⁻¹ 1s⁻¹ 2s⁻¹ 2p⁻¹ 1s⁻¹ 2p⁻¹</td>
<td>1535.1±0.3</td>
<td>2699.1±2.0</td>
<td>3402.3±5.7</td>
</tr>
<tr>
<td>6</td>
<td>1s⁻¹ 2s⁻¹ 2p⁻¹ 1s⁻¹ 1s⁻¹ 2p⁻¹ 1s⁻¹ 2p⁻¹</td>
<td>1549.9±0.5</td>
<td>2720.3±2.8</td>
<td>3427.5±5.3</td>
</tr>
<tr>
<td>7</td>
<td>1s⁻¹ 2s⁻¹ 2p⁻¹ 1s⁻¹ 1s⁻¹ 2p⁻¹ 1s⁻¹ 2p⁻¹</td>
<td>_</td>
<td>2743.5±2.7</td>
<td>3452±5.6</td>
</tr>
<tr>
<td>8</td>
<td>1s⁻¹ 2s⁻¹ 2p⁻¹ 1s⁻¹ 1s⁻¹ 2p⁻¹ 1s⁻¹ 2p⁻¹</td>
<td>_</td>
<td>2769.8±3.6</td>
<td>3481.2±5.6</td>
</tr>
</tbody>
</table>
The listed energies are the averages obtained for all runs with all projectiles and the indicated errors are root mean square deviations. The absolute error in the satellite energies for Cl and K are essentially the same as those given for Al. 2) Projectile Dependence of Intensity Ratio: - Watson et al. studied how $K_{\alpha}L_{\alpha}$ relative intensity varies with different projectiles in Al, Cl and K.

<table>
<thead>
<tr>
<th>Target</th>
<th>Projectile</th>
<th>No. of L shell vacancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al</td>
<td>H</td>
<td>0 0.858 0.142</td>
</tr>
<tr>
<td></td>
<td>He</td>
<td>0 0.664 0.285 0.051</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>0 0.068 0.215 0.366 0.239 0.090 0.023</td>
</tr>
<tr>
<td></td>
<td>O</td>
<td>0 0.045 0.128 0.312 0.293 0.168 0.053</td>
</tr>
<tr>
<td>Cl</td>
<td>He</td>
<td>0 0.680 0.320</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>0 0.053 0.229 0.363 0.256 0.094 0.005</td>
</tr>
<tr>
<td></td>
<td>O</td>
<td>0 0.028 0.133 0.304 0.316 0.170 0.049</td>
</tr>
<tr>
<td>K</td>
<td>He</td>
<td>0 0.765 0.235</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>0 0.074 0.307 0.353 0.208 0.058</td>
</tr>
<tr>
<td></td>
<td>O</td>
<td>0 0.045 0.185 0.316 0.271 0.142 0.042</td>
</tr>
</tbody>
</table>

From the Table 3 in all Al, Cl and K targets the intensity under He projectile decrease as a number of vacancy increase; while directly correlated with atomic number. As we see under the Table 3 in the case of C and O projectile the value of intensity is not consistent when Z increases. 3) Chemical Effects: - A noticeable chemical effect was observed in the case fluorine K. Ram Narayana et al. 4) Z Systematics (Z Dependence of Relative intensities): - Raju et al. measured energies and intensities of $K_{\alpha}$ hyper satellites and $K_{\beta}$ satellites of the elements in the Z range 19-25 by photon excitation. The relative intensity of the $K_{\alpha}$ hyper satellite with respect to that of the $K_{\beta}$ diagram line is related to the ratio of double K-shell to single K-shell ionization. This intensity ratio was plotted as a function of Z. It decreases smoothly and exponentially with Z. The $K_{\beta}$ satellite relative intensity with respect to that of the $K_{\alpha}$ diagram line was plotted as a function of Z. This also was observed to vary exponentially and smoothly with Z. 5) Z Dependence of Energy Shift: -Raju et al. supplemented their data with those reported by other authors on $K_{\alpha}$ hyper satellite energy shift relative to the $K_{\beta}$ diagram line in the Z range 12-30 and studied the variation of this with respect to Z. They found the relationship to be linear. They obtained from the plot of this $\Delta(E)$ versus Z, the following empirical relationship

$$\Delta E(K_{\alpha}) = -3.0 + 10.048Z$$

V. Conclusions

WDXRF has an auxiliary collimator mounted in front of the detector helps in improving the resolution, analyzing crystal spectrometer is effected and data acquired by a personal computer making use of Philips super QMS windows based software, a suitable voltage and current to operate easily, sample changers for fast data collection etc. used to determining the energy shift and intensity of x-ray satellites. Due to this instrument the production of a satellites have been registered for a double-vacancy states existing in the K-shells is called X-ray hyper satellites.

When the atom is doubly ionized in K-shell and if one of these holes is filled by transitions from outer shell K X-ray hyper satellites (weak lines) are emitted. These lines appear on high energy side of the diagram lines. Study of K X-ray hyper satellites provides information on the; intra atomic relations, excitation dynamics, relaxation and other factors influencing X-ray emissions.

Energies and relative intensities of hyper satellites of high Z-elements were determined by various researchers using crystal spectrometer by applying photon, electron, and ion excitation modes. Investigations were carried out to examine chemical shifts, it was found that relative intensities are susceptible to the chemical environment but energies are not much affected by it.

Generally, from different literature, studies were not cover an energy from small Z-elements which have smaller wavelength of the satellites. So that the existing few studies about hyper satellites can be extended to cover all elements. Because a number of synchrotron facilities are being developed throughout the world; using these tunable hard X-ray sources, energy dependence of these processes can be studied more efficiently.

References Références Referencias


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On the New Solitary Wave Solution of the Generalized Hirota-Satsuma Couple KdV System

By Mostafa M. A. Khater
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Abstract- In this article, we employ \( \left( \frac{G'}{G} \right) \)-expansion method for the generalized Hirota-Satsuma couple KdV system to find the exact traveling wave solutions involving parameters with the aid of Maple 16. When these parameters are taken special values, the solitary wave solutions are derived from the exact traveling wave solutions. It is shown that the \( \left( \frac{G'}{G} \right) \)-expansion method provides an effective and a more powerful mathematical tool for solving nonlinear evolution equations in mathematical physics. Comparison between our results and the well-known results will be presented.

Keywords: the generalized hirota-satsuma couple KdV system, the \( \left( \frac{G'}{G} \right) \)-expansion method, traveling wave solutions, solitary wave solutions, bell singular soliton solutions.

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I. Introduction

No one can deny the important role which played by the nonlinear partial differential equations in the description of many and a wide variety of phenomena not only in physical phenomena, but also in plasma, fluid mechanics, optical fibers, solid state physics, chemical kinetics and geochemistry phenomena. So that, during the past five decades, a lot of method was discovered by a diverse group of scientists to solve the nonlinear partial differential equations. For examples tanh - sech method [12],[16] and [18], extended tanh - method [13], [6] and [20], sine – cosine method [19], [17] and [22], homogeneous balance method [4], the \( \exp \left( -\varphi (\xi) \right) \) expansion Method [11], Jacobi elliptic function method [3], [5], [14] and [24], F-expansion method [2], [21] and [9], exp-function method [8] and [7], trigonometric function series method [32], \( \left( \frac{G'}{G} \right) \) expansion method [10], [15], [29] and [26], the modified simple equation method [1], [27], [30], [28], [31] and [25] and so on.

The objective of this article is to apply the \( \left( \frac{G'}{G} \right) \) expansion method for finding the exact traveling wave solution of the generalized Hirota-Satsuma couple KdV system [23], which play an important role in mathematical physics.

The rest of this paper is organized as follows: In section 2, we give the description of the modified simple equation method. In section 3, we use this method to find the exact solutions of the nonlinear evolution equations pointed out above. In section 5, conclusions are given.

II. Description of Method

Consider the following nonlinear evolution equation

\[ F(u, u_t, u_x, u_{tt}, u_{xx}, ...) = 0, \quad (2.1) \]

where \( F \) is a polynomial in \( u(x; t) \) and its partial derivatives in which the highest order derivatives and nonlinear terms are involved. In the following, we give the main steps of this method:

Step 1. We use the wave transformation

\[ u(x, t) = u(\xi), \quad \xi = x - ct, \quad (2.2) \]

where \( c \) is a constant, to reduce Eq.(2.1) to the following ODE:

\[ P(u, u', u'', u''', ..., ...) = 0, \quad (2.3) \]

where \( P \) is a polynomial in \( u(\xi) \) and its total derivatives, while \( \left\{ u' = \frac{du}{d\xi} \right\} \).

Step 2. Suppose that the solution of Eq.(2.3) has the form:

\[ U(\xi) = a_0 + \sum_{j=1}^{m} a_j \left( \frac{G'}{G} \right)^j, \quad a_m \neq 0, \quad (2.4) \]

where \( a_0 \) and \( a_j \), for \( (j = 1, 2, 3, ..., m) \), are constants to be determined later, \( G(\xi) \) satisfies a second order linear ordinary differential equation (LODE):

\[ G'' + \lambda G' + \mu G = 0, \quad (2.5) \]

where \( \lambda \) and \( \mu \) are arbitrary constants. The positive integer \( M \) can be determined by considering the homogeneous balance between the highest order derivatives and nonlinear terms appearing in Eq.(2.3). Moreover precisely, we define the degree of \( u(\xi) \) as \( D(u(\xi)) = m \), which gives rise to degree of other expression as follows:
\[
D \left( \frac{d^3 u}{d \xi^3} \right) = m + q,
D \left( u^p \left( \frac{d^q u}{d \xi^q} \right)^s \right) = mp + s(m + q)
\]

Therefore, we can find the value of \( m \) in Eq.(2.4)

Step 3. Substitute Eq.(2.4) along Eq.(2.5) into Eq.(2.3) and collecting all the terms of the same power \( \left( \frac{G'}{G} \right)^j \) by Maple or Mathematica to get the values of \( a_j \), since \( a_m \neq 0 \). The solution of Eq.(2.5) depending on whether \( \lambda^2 - 4\mu > 0, \lambda^2 - 4\mu < 0, \lambda^2 - 4\mu = 0 \) are given as

Case 1. When \( \lambda^2 - 4\mu > 0 \)

\[
\left( \frac{G'}{G} \right) = \frac{\sqrt{\lambda^2 - 4\mu}}{2} \left( \frac{A_1 \sinh\left( \frac{\sqrt{\lambda^2 - 4\mu}}{2} \xi \right) + A_2 \cosh\left( \frac{\sqrt{\lambda^2 - 4\mu}}{2} \xi \right)}{A_1 \cosh\left( \frac{\sqrt{\lambda^2 - 4\mu}}{2} \xi \right) + A_2 \sinh\left( \frac{\sqrt{\lambda^2 - 4\mu}}{2} \xi \right)} \right) - \frac{\lambda}{2}.
\]  
(2.6)

Case 2. When \( \lambda^2 - 4\mu < 0 \)

\[
\left( \frac{G'}{G} \right) = \frac{-\sqrt{4\mu - \lambda^2}}{2} \left( \frac{-A_1 \sin\left( \frac{\sqrt{4\mu - \lambda^2}}{2} \xi \right) + A_2 \cos\left( \frac{\sqrt{4\mu - \lambda^2}}{2} \xi \right)}{A_1 \cos\left( \frac{\sqrt{4\mu - \lambda^2}}{2} \xi \right) + A_2 \sin\left( \frac{\sqrt{4\mu - \lambda^2}}{2} \xi \right)} \right) - \frac{\lambda}{2}.
\]  
(2.7)

Case 3. When \( \lambda^2 - 4\mu = 0 \)

\[
\left( \frac{G'}{G} \right) = \frac{A_2}{A_1 + A_2 \xi} - \frac{\lambda}{2}.
\]  
(2.8)

The above results can be written in simplified forms as

Case 1. When \( \lambda^2 - 4\mu > 0 \)

\[
\left( \frac{G'}{G} \right) = \frac{\sqrt{\lambda^2 - 4\mu}}{2} \tanh\left( \frac{\sqrt{\lambda^2 - 4\mu}}{2} \xi + \xi_0 \right) - \frac{\lambda}{2}, \quad \tanh \xi_0 = \frac{A_1}{A_2}, \quad \left| \frac{A_1}{A_2} \right| > 1.
\]  
(2.9)

Case 2. When \( \lambda^2 - 4\mu < 0 \)

\[
\left( \frac{G'}{G} \right) = \frac{\sqrt{4\mu - \lambda^2}}{2} \coth\left( \frac{\sqrt{4\mu - \lambda^2}}{2} \xi + \xi_0 \right) - \frac{\lambda}{2}, \quad \coth \xi_0 = \frac{A_1}{A_2}, \quad \left| \frac{A_1}{A_2} \right| < 1.
\]  
(2.10)

Case 3. When \( \lambda^2 - 4\mu = 0 \)

\[
\left( \frac{G'}{G} \right) = \frac{\sqrt{\lambda^2 - 4\mu}}{2} \cot\left( \frac{\sqrt{4\mu - \lambda^2}}{2} \xi + \xi_0 \right) - \frac{\lambda}{2}, \quad \cot \xi_0 = \frac{A_2}{A_1}.
\]  
(2.11)

Step 4. Substituting these values and the solutions of Eq.(2.5) into Eq.(2.3) we obtain the exact solutions of Eq.(2.1).

III. APPLICATION

Here, we will apply the \( (G'/G) \)-expansion method described in Sec.2 to find the exact traveling wave solutions and the solitary wave solutions of the generalized Hirota-Satsuma couple KdV system[23]. We consider the generalized Hirota-Satsuma couple KdV system

\[
\begin{align*}
\left\{ 
\begin{array}{l}
u_t &= \frac{1}{2} \bar{v}_{xxx} + 3u \bar{u}_x + 3\left(-v^2 + w \right)_x, \\
v_t &= -\frac{1}{2} v \bar{v}_{xxx} - 3u \bar{u}_x, \\
w_t &= -\frac{1}{2} \bar{w}_{xxx} - 3u \bar{w}_x.
\end{array}
\right\
\end{align*}
\]  
(3.1)

When \( w = 0 \), Eq.(3.1) reduce to be the well known Hirota-Satsuma couple KdV equation. Using the
wave transformation \( w(x, t) = u(\xi), v(x, t) = v(\xi), w(x, t) \) = \( w(\xi), \xi = k(x - \alpha t) \) carries the partial differential equation (3.1) into the ordinary differential equation (3.2).

\[
\begin{align*}
-\lambda_1 k u'' &= \frac{1}{4} k^3 u''' + 3 k u u' + 3 k (-v^2 + w)', \\
-\lambda_1 k v'' &= -\frac{1}{2} k^3 v''' - 3 k u v', \\
-\lambda_1 k w'' &= \frac{3}{2} k^3 w''' - 3 k u w'.
\end{align*}
\]

(3.2)

Suppose we have the relations between \( u \) and \( v \) and \( w \) as \( u = \alpha v^2 + \beta v + \gamma \) and \( w = \alpha v + B \) where \( \alpha, \beta, \gamma, A \) and \( B \) are arbitrary constants. Substituting this into the second and third equations of Eq.(3.2) and integrating them, we get the same equation and integrate it once again we obtain

\[
k^2 v'' = -2\alpha v^4 - 2\beta v^3 + 2 (\lambda_1 - 3\gamma) v^2 + 2c_1 v + c_2, \quad (3.3)
\]

where \( c_1 \) and \( c_2 \) is the arbitrary constants of integration, and hence, we obtain

\[
k^2 u'' = 2\alpha k^2 v'^2 + k^2 (2\alpha v + \beta) v'' = 2\alpha \left[ -\alpha v^4 - 2\beta v^3 + 2 (\lambda_1 - 3\gamma) v^2 + 2c_1 v + c_2 \right] + (2\alpha v + \beta) \left[ -2\alpha v^3 - 3\beta v^2 + 2 (\lambda_1 - 3\gamma) v + c_1 \right]. \quad (3.4)
\]

So that, we have

\[
P'' + lP - mP^3 = 0. \quad (3.5)
\]

Where

\[
c_1 = \frac{1}{2\alpha^2 (\beta^2 + 2\lambda_1 \alpha \beta - 6\alpha \beta \gamma)}, \quad v(\xi) = aP(\xi) - \beta \frac{\alpha}{2\alpha}, \quad \alpha = \frac{\beta^2 - 4}{4(\gamma - \lambda_1)}, \quad A = \frac{4\beta (\lambda_1 - \gamma)}{\beta^2 - 4},
\]

\[
B = \frac{1}{6 (-\gamma + \lambda_1)(\beta^2 - 4)^2} \left[ 16c_3 \lambda_1 \beta^2 - 2c_3 \lambda_1 \beta^4 - 16c_3 \gamma \beta^2 + 3c_3 \gamma \beta^4 + 56\lambda_1^2 \gamma \beta^2 - 48\gamma^2 \lambda_1 \beta^2 - 16c_2 + c_2 \beta^2 - 12c_2 \beta^4 + 12c_2 \beta^2 - 16\gamma \lambda_1 - 32\lambda_1^2 \gamma - 8\lambda_1^3 \beta^2 + \beta^4 \gamma^3 \right. \\
\left. - 2\beta^4 \lambda_1 + 32c_3 \gamma - 32c_3 \lambda_1 + 48\gamma^3 + \beta^4 \gamma^2 \lambda_1 \right],
\]

\[
l = \frac{-a}{k^2} \left( \frac{3\beta^2}{2\alpha} + 2\lambda_1 - 6\gamma \right), \quad m = \frac{-2\alpha a^3}{k^2}.
\]

Balancing between the highest order derivatives and nonlinear terms appearing in \( P'' \) and \( P^3 \Rightarrow (N + 2 = 3N) \Rightarrow (N = 1) \) So that, by using Eq.(2.4) we get the formal solution of Eq.(3.5)

\[
P(\xi) = a_0 + a_1 \left( \frac{G'}{G} \right). \quad (3.6)
\]

Substituting Eq.(3.6) and its derivative into Eq.(3.5) and collecting all term with the same power of \( \left( \frac{G'}{G} \right)^3, \left( \frac{G'}{G} \right)^2, \left( \frac{G'}{G} \right)^1, \left( \frac{G'}{G} \right)^0 \) we obtained:

\[
\left( \frac{G'}{G} \right)^3 : 2a_1 + ma_1^3 = 0, \quad (3.7)
\]

\[
\left( \frac{G'}{G} \right)^2 : 3a_1 \lambda + 3ma_0 a_1^2 = 0, \quad (3.8)
\]

\[
\left( \frac{G'}{G} \right)^1 : a_1 \lambda^2 + 2a_1 \mu + la_1 + 3ma_0 a_1 = 0, \quad (3.9)
\]

\[
\left( \frac{G'}{G} \right)^0 : a_1 \lambda \mu + la_0 + ma_0^3 = 0 \quad (3.10)
\]

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Solving above system of algebraic equations by using Maple program, we obtain

\[
l = \frac{1}{2} \lambda^2 - 2 \mu, \quad a_1 = \pm \sqrt{-\frac{2}{m}}, \quad a_0 = \pm \lambda \sqrt{-\frac{1}{2m}} \quad \text{since} \quad (m < 0).
\]

So that, the exact traveling wave solution

\[
P(\xi) = \pm \lambda \sqrt{-\frac{1}{2m}} \pm \sqrt{-\frac{2}{m}} \left( \sqrt{\frac{\lambda^2 - 4\mu}{2}} A_1 \sinh \left( \frac{1}{2} \sqrt{\lambda^2 - 4\mu} \xi \right) + A_2 \cosh \left( \frac{1}{2} \sqrt{\lambda^2 - 4\mu} \xi \right) \right) - \frac{\lambda}{2}.
\]

(3.11)

here, we discuss the three cases:

Case 1. When \( \lambda^2 - 4\mu > 0 \)

\[
P(\xi) = \pm \lambda \sqrt{-\frac{1}{2m}} \pm \sqrt{-\frac{2}{m}} \left[ \sqrt{\frac{\lambda^2 - 4\mu}{2}} A_1 \sinh \left( \frac{1}{2} \sqrt{\lambda^2 - 4\mu} \xi \right) + A_2 \cosh \left( \frac{1}{2} \sqrt{\lambda^2 - 4\mu} \xi \right) \right] - \frac{\lambda}{2}.
\]

(3.12)

Case 2. When \( \lambda^2 - 4\mu < 0 \)

\[
P(\xi) = \pm \lambda \sqrt{-\frac{1}{2m}} \pm \sqrt{-\frac{2}{m}} \left[ \sqrt{\frac{4\mu - \lambda^2}{2}} - A_1 \sin \left( \frac{1}{2} \sqrt{4\mu - \lambda^2} \xi \right) + A_2 \cos \left( \frac{1}{2} \sqrt{4\mu - \lambda^2} \xi \right) \right] - \frac{\lambda}{2}.
\]

(3.13)

Case 3. When \( \lambda^2 - 4\mu = 0 \)

\[
P(\xi) = \pm \lambda \sqrt{-\frac{1}{2m}} \pm \sqrt{-\frac{2}{m}} \frac{A_2}{A_1 + A_2 \xi} - \frac{\lambda}{2}.
\]

(3.14)

The above results can be written in simplified forms as

Case 1. When \( \lambda^2 - 4\mu > 0 \)

\[
P(\xi) = \pm \lambda \sqrt{-\frac{1}{2m}} \pm \sqrt{-\frac{2}{m}} \left[ \tanh \left( \frac{\sqrt{\lambda^2 - 4\mu} \xi + \xi_0}{2} \right) - \frac{\lambda}{2} \right].
\]

(3.15)

Case 2. When

\[
P(\xi) = \pm \lambda \sqrt{-\frac{1}{2m}} \pm \sqrt{-\frac{2}{m}} \left[ \coth \left( \frac{\sqrt{\lambda^2 - 4\mu} \xi + \xi_0}{2} \right) - \frac{\lambda}{2} \right].
\]

(3.16)

Case 3. When \( \lambda^2 - 4\mu = 0 \)

\[
P(\xi) = \pm \lambda \sqrt{-\frac{1}{2m}} \pm \sqrt{-\frac{2}{m}} \left[ \cot \left( \frac{\sqrt{4\mu - \lambda^2} \xi + \xi_0}{2} \right) - \frac{\lambda}{2} \right].
\]

(3.17)

Note that:

All the obtained results have been checked with Maple 16 by putting them back into the original equation and found correct.

IV. **Physical Interpretations of the Solutions**

In this section, we depict the graph and signify the obtained solutions to the generalized Hirota-Satsuma couple KdV system. Now, we will discuss all possible physical significances for parameter.
V. Conclusion

The \( \left( \frac{G'}{G} \right) \)-expansion method has been successfully used to find the exact traveling wave solutions of some nonlinear evolution equations. As an application, the traveling wave solutions for the generalized Hirota-Satsuma couple KdV system which have been constructed using the \( \left( \frac{G'}{G} \right) \)-expansion method. Let us compare between our results obtained in the present article with the well-known results obtained by other authors using different methods as follows: Our results of the generalized Hirota-Satsuma couple KdV system are new and different from those obtained in [23]. It can be concluded that this method is reliable and propose a variety of exact solutions NPDEs. The performance of this method is effective and can be applied to many other nonlinear evolution equations. The solutions represent the solitary traveling wave solution for the generalized Hirota-Satsuma couple KdV system.

Competing Interests

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors. The author did not have any competing interests in this research.

Author's Contributions

All parts contained in the research carried out by the researcher through hard work and a review of the various references and contributions in the field of mathematics and the physical Applied.

VIII. Acknowledgment

The author thanks the referees for their suggestions and comments.

![Figure 1](image-url): The Solitary wave solution of Eqs. (3.12), (3.13) and (3.14)
References Références Referencias


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Quintessential Nature of the Fine-Structure Constant

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Abstract- An introduction is given to the geometry and harmonics of the Golden Apex in the Great Pyramid, with the metaphysical and mathematical determination of the fine-structure constant of electromagnetic interactions. Newton's gravitational constant is also presented in harmonic form and other fundamental physical constants are then found related to the quintessential geometry of the Golden Apex in the Great Pyramid.

Keywords: quintessence, fine-structure constant, great pyramid, physical constants, electromagnetism.

GJSFR-A Classification : FOR Code: 240199p

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Quintessential Nature of the Fine-Structure Constant

Michael A. Sherbon

Abstract- An introduction is given to the geometry and harmonics of the Golden Apex in the Great Pyramid, with the metaphysical and mathematical determination of the fine-structure constant of electromagnetic interactions. Newton's gravitational constant is also presented in harmonic form and other fundamental physical constants are then found related to the quintessential geometry of the Golden Apex in the Great Pyramid.

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1. Introduction

The geometry of the Great Pyramid of Giza, as stated by Eckhart Schmitz in The Great Pyramid of Giza, "... demonstrates extraordinary precision in relaying highly accurate geodetic knowledge..." and "it is evident, with a very high degree of probability, that the design parameters were expressly intent on conveying this advanced knowledge." [1]. In The Essence of the Cabalah, William Eisen describes the fundamental geometry of what was known as the Golden Apex of the Great Pyramid and the ancient pre-pharaonic science of the Agashan Masters [2].

II. Golden Geometry of the Great Pyramid

The Golden Apex of the Great Pyramid is the side of a square in the upper part of the capstone resulting from four exponential curves at the base of the Great Pyramid [2]. Golden Apex of the Great Pyramid $A$:

$$A = e^a + 7\pi - 1 \approx 0.1495$$ (1)

The inverse of the Golden Apex $A^{-1}$ is a harmonic of Newton's gravitational constant $G$. $A^{-1} \approx \phi \sqrt{2\pi e} \approx \phi / \ln(4/\pi)$ and $4/\pi \approx \sqrt{11}$. $A + 1 \approx R \approx 1.152$, the approximate radius of the regular heptagon with the side equal to one. $A \equiv \pi / \sqrt{140} \approx \sqrt{\pi / 140}$, the base of the Great Pyramid is approximately 440 cubits, and the height is $2 \times 140 = 280$ cubits. $140/360 \equiv e/7 \equiv \sqrt{A}$ and $4 \times 440 = 2\pi x 280$. The height of the Golden Apex, $4A/2\pi \equiv S^{-2}$, the silver constant of the heptagon, see Eq. (4).

$$RA \equiv \sqrt{\phi / e^2} \equiv \ln(\pi / \sqrt{7})$$ (2)

The golden ratio approximates the squaring of the circle and is also closely related to the heptagon geometry. $2R = \csc(\pi/7)$ and $R \equiv \phi \sqrt{2} \approx 13 / 7 \phi \equiv \ln \pi \approx 2 / \sqrt{3} \approx 7 / \sqrt{37}$. The tangent is $1 / \sin \phi$. In the Timaeus, Plato "considered the golden section to be the most binding of all mathematical relationships and the key to the physics of the cosmos," quoted by Robert Schoch and Robert McNally in Pyramid Quest [3]. Quintessence is associated with the dynamic aether and also embraces the four known forces of nature.

$$Q = C / \sqrt{2} \equiv \sqrt{e} / \phi \equiv 1 + \alpha \phi^2,$$ (3)

where $\alpha \equiv 1/137$ is the fine-structure constant and quintessence $Q \equiv 377/370 \equiv \sqrt{11}/S \equiv 1.019$. $C^2$ is the approximate inner diameter of the regular heptagon with side equal to one. $C^2 \equiv \cot(\pi/7) \equiv 1 / \ln \phi$. Also, $CQ \equiv \sqrt{\phi} R \equiv \csc \alpha^2$. With the golden ratio $\phi \equiv A + CQ$ and $\phi^2 \equiv A + C + Q$. In elementary form, $22 = 1 + (3 \times 7) \equiv 7\pi$. Also, $C = \sqrt{2} Q \equiv 1.441$.

Aristotle coined the term quinta essentia for Plato's fifth element, often represented by the dodecahedron. The quintessence is described in Malcolm Macleod's geometry of angular momentum model as the harmonic $Q$ and also has units from the square root of Planck angular momentum [4]. The golden ratio is an approximate harmonic of the Planck length in meters and harmonics of fundamental units have a geometric basis in ancient metrology [5]. $R$ is a harmonic of half the Great Pyramid base length in meters, and $CQ$ is a harmonic of the height in meters. The $\ln A^{-1} \equiv \sec Q \equiv 6/\pi \equiv \pi / \sqrt{e}$, the cube-sphere ratio. With golden ratio overlay software, a golden spiral centered on the Eye of Ra in Robert Temple's plan of the Giza Plateau, is shown to pass through both the Golden Apex of the Great Pyramid and the Great Sphinx of Giza.
Ratio of the length of the sides of Temple’s Perfect Square of Giza/Shadow Square of Giza is approximately equal to \( Q \) \[6\]. \( Q \equiv \sqrt{7A} \equiv \ln(\sqrt{R/A}) \equiv A + R^{-1} \) and \( \ln(S/Q) \equiv \pi/e \). The tan \( Q \equiv \phi \).

\[
A \equiv \sqrt{11}/7 \pi \equiv \sqrt{11}/11 \equiv 2 \pi a S \tag{4}
\]

The silver constant \( S \) from the regular heptagon, \( S = 4 \cos^2(\pi/7) \equiv 2\sqrt{2R} \equiv 2 \tan \varphi \equiv \sqrt{528} \cong 2.3247 \). Also, \( CQ \equiv \sqrt{7S} \equiv 1.3 \). Half the face apex angle of the regular heptagon, \( \pi - \Theta/2 \equiv 11/7 = \pi/2 \) and \( \pi - \Theta \equiv A\tan \varphi \), with the regular pentagon angle. \( S \equiv \sqrt{3}\pi/C \) and \( C^2 \equiv R/S \equiv \cot(\pi/7) \).

Jean-Paul and Robert Bauval describe in the *Secret Chamber Revisited* how prime numbers 7 and 11 are significant keys to the Great Pyramid \[7\]. The number seven was “especially dedicated to Sirius,” \[1, 8, 9\]. Half the face apex angle of the Great Pyramid is approximately \( 32\degree \) \[10\]. Also, \( 11 \times 11 = 121 \) and \( 121/137 \equiv 1/\sqrt{2} \tan 32\degree \). \( G_a \equiv 1/\sqrt{A \phi} \equiv 2/\sqrt{C} \). In \( 11 \equiv 2 \), where \( G_a \) is the golden angle in radians. From the pyramid face apex angle, tan \( 64\degree \equiv \sqrt{11}/\phi \equiv 137/67 \).

The special number 528 translates as the Key to the Pyramid of Light \[11, 12\]. The harmonic 5.28 \( \equiv 37/7 \equiv \sqrt{7} \equiv \pi/e/\phi \). Also, \( 2\pi \equiv \ln(528) \) and \( 5.28 \equiv 2\pi/\sqrt{C} \equiv \pi/4 \cdot A \). Found in several places, \( 2.64 \) is the width and height of the Ark of the Covenant, the proportioned Golden Apex height and section lengths above the 5.28 rise in the Grand Gallery. \( 2.64 \equiv Q/\sqrt{A} \equiv \sqrt{7} \).

### III. Mathematics of the Fine-Structure Constant

The fine-structure constant was introduced by Arnold Sommerfeld with the addition of elliptic orbits to Bohr’s atomic model \[13\]. The fine-structure constant determines the strength of the electromagnetic interaction and being related to quintessence it is involved in all aetheric phenomena. The usual definition for alpha, the fine-structure constant is \( \alpha = e^2/\hbar c \) in cgs units. Mark Rothbard’s review of Nassim Haramein’s work motivated the question of recombining the classical electron radius \( r_e = e^2/m_e e \) with the formulation by Haramein for the proton charge radius, from the modified Eq. \(31\) \( r_p = 4 \hbar/m_p c \) \[14\].

\[
\alpha = 4/(m_p/m_e) (r_p/r_e) \tag{5}
\]

When substituting the reference value for alpha and using the latest reference values for the proton and electron mass with the classical radius of the electron, gives a value for the proton radius \( r_p \equiv 0.8412 \) fm. The proton/electron radius ratio: \( r_p/r_e \equiv 5\pi/7\sqrt{7} \). The inradius of the regular pentagon, \( \sqrt{25 + 10\sqrt{5}}/10 \), is approximately equal to \( e^\pi + 7\pi + \ln 2\pi \). Also, the heptagon diameter divided by the pentagon inradius is approximately equal to \( r_p/r_p \). The approximate value for the inverse fine-structure constant from Eqs. \(9-11\):

\[
\alpha^{-1} \equiv 137.035 999 168 \tag{6}
\]

The latest value by Aoyama et al. \( \alpha^{-1} \equiv 137.035 999 157 \) \[41\], determined from quantum electrodynamics and experiment \[15\]. M. Temple Richmond says that in the esoteric tradition 137 is a representation of the Law of One, the Three Cosmic Laws and the Seven Rays \[8\]. Given \( G_w \) is the Wilbraham-Gibbs constant and the sinc function \( \sin x = \sin x /x \), then:

\[
G_w = \int_0^\pi \sin x \ dx \equiv \pi \ln \pi \equiv e \sin^{\alpha-1} \tag{7}
\]

The Wilbraham-Gibbs constant \( G_w \equiv \sec(1) \equiv \frac{\phi^2}{\sqrt{5}} \equiv 1.852 \). The Wilbraham-Gibbs constant is related to the overshoot of Fourier sums in Gibbs phenomena \[16\]. In \( G_w \equiv 1/\phi \) and \( 137 \equiv 37 + 37G_w \). \( G_a/G_w = KA \equiv 3/2 \equiv \sqrt{5}/\phi \), where \( K \) is the polygon circumscribing constant. Again with \( K \), the Wilbraham-Gibbs constant \( G_w \equiv \pi/(K-1) \). The polygon circumscribing constant \( K \) \[13\]:

\[
K = \frac{\pi}{2} \sum_{n=1}^{\infty} \sin \left( \frac{2\pi}{2n+1} \right) = \prod_{n=3}^{\infty} \frac{\pi \sin \left( \frac{\pi}{n} \right)}{n} \tag{8}
\]

The polygon circumscribing constant \( K \equiv 2 + 3\sqrt{5} \equiv \sqrt{11} \phi^2 \equiv 8.7 \). \( KA \equiv R + A \equiv \sqrt{e/\phi} \equiv \phi^2/2 \). Also, \( 1 + \phi^{-2} \equiv K/2 \pi \equiv \sqrt{6/\pi} \equiv \sinh^2(1) \). \( KA + RA \equiv CQ \) and \( K \equiv 10/R \). A curious relationship between the Key harmonic 528 and the polygon circumscribing constant \( K \), \( 528/140 \equiv K/D \), where \( D = 2R \) is the heptagon diameter. The internal angle of the nonagon is \( 140\degree \) and is also the central angle in the ancient Egyptian hieroglyph for gold \[10\]. 

\[
D \equiv 85/37 \equiv \sqrt{\phi^2 + \phi^2} \equiv 85/111 \equiv R/A \text{ and } 528/85 \equiv 2\pi \equiv 440/85 \equiv \pi/\phi \equiv 137/85 \equiv \phi \text{ and } 12 \times 44 = 528. \quad 528/440 \equiv \pi/\phi^2,
\]
gravitational constant, equinoxes. 22/11. √SSR

with the same approximate value for the inverse fine-structure constant as Eq. (6). Plato’s favorite symbolic number 5040 = 7!. 504/396 ≈ 108/85 = √q. 7920 represents the canonical harmonic of the Earth’s diameter. 7920/5040 = 11/7 and 25920/7920 = (14 + 22)/11. 25920 represents the precession of the equinoxes. 2592/1370 ≈ 6/π. 792/528 = 3/2, 792/396 = 2 and 792/264 = 3. The harmonic of Newton’s gravitational constant, A−1 ≈ ln 792. 14 × 20 = 280 and 22 × 20 = 440. DK ≡ 20. 504 = 7 × 8 × 9 and √TI4 ≡ SR. Also, sin α−1 ≈ 2 sin (π/9). CQ is the approximate circumradius of the nonagon. Other relationships include csc α−1 − sin α−1 ≈ π/4 and tan−1(4/π) ≈ 51.85° ≈ 2 × 25.92°, the Great Pyramid base angle. 4/π ≈ 57/2 ≈ √q and RA ≡ 3/2K. 2.592 ≈ 1/√A ≈ 7/9. D√A ≈ 8/9 the proportion for “squaring the circle.” D = 2R ≡ csc(π/7) and R ≡ cot2 (α−1). In degrees, the modern golden angle, Ga = 360°/ϕ2 and the related 26.57° ≈ tan−1(1/2) is the ancient Golden Angle of Resurrection according to Robert Temple [6]. Along with the Golden Angle of Resurrection, Robert Temple states the Pythagorean Comma P4 was one of the greatest secrets of the ancient Egyptians [6], P4 = (√2ϕ/π) ≈ √3ϕ/ϕ2 ≈ 370/365. Q5 ≈ P6 and P7 = (3/2)12/27 ≈ 1.0136. Also, 27/12 ≈ 3/2 ≈ ARK. Another form of calculation involves the prime constant [13], described as a binary expansion corresponding to an indicator function for the set of prime numbers. The inverse fine-structure constant:

\[ \alpha^{-1} \approx 157 - 337P/7, \]  

with the same approximate value for the inverse fine-structure constant as determined in Eq. (6), having three prime numbers and the prime constant. The prime constant \( P \approx √KA \approx ϕ^2/2π \approx 220/528 \approx 0.4147. \) PQ ≈ 2√2A and PK ≈ 2√3. KA ≈ Pπ ≈ e ln ϕ. 852 + 1322 ≈ 1572. Grand Gallery length in the Great Pyramid is 157. 137 − 90 = 47 and 47 + 85 = 132. 132/90 = 528/360 ≈ CQ. 157/288 ≈ 288/528. 180/157 ≡ R and 337/180 ≈ ϕR. With the Key, 528/337 = π/2 and 157/528 ≈ 2A, approximate proton/electron radius ratio. With pyramid base, 440/337 = ϕ/2 and 440/157 = √3ϕ. The sin 140° = sin 40° = √P. 528/140 ≈ K/D ≈ 7/Gw and 140/360 ≈ e/7. The sec 40° = P/√3√ ≈ KA.

\[ ϕ^{-1} \approx 2867.2867 + 28672−η, \]  

which also gives the same approximate value for the inverse fine-structure constant as Eq. (6), where \( η \approx 365/365.24 \) and \( η^4 \approx -sin(14/3) \approx 286.7287 \approx (√2^1 - 1)/P, \) inverse of the proposed “pyramid inch” by Taylor and Smyth [17]. The Solar Year harmonic is 365.24. The proton/neutron mass ratio is approximately equal to \( m_p/m_n \approx η^2. \) From the pyramid capstone height, 8 × 286.7 = 2π × 365 [18]. 2.867/2.592 ≈ 111/3 and 25920/2867 = 2πC. The ascending and descending passages of the Great Pyramid are displaced 287° to the east [3]. 365/287 = 4/π ≈ √5/2 and 528/287 ≈ S/√π ≈ 111/5. (3 × 37)/287 ≈ √5. \( P^ϕ \) ≈ Q and \( P^ϕ \) Q ≈ (64/63)2 ≈ sec(1/4). The inverse of the Eye of Horus fractions is 64/63 [6]. With the polygon circumscribing constant, \( √π - K ≈ √2 + √5 \approx 3.65, \) again from the harmonic 365 of the capstone height [18]. 504/365 ≈ √5/ϕ and (286.7 × 8)2/π ≈ 365. 2.867 ≈ 3/7A ≈ 9/π ≈ ϕ/√π. Another expression with alpha, \( ϕ^{-1} \approx 3π223/35 \) having prime factors of 3, 5, 7 and 11 with a value approximately the same as Eq. (6). Also, \( ϕ^{-1} \approx (ϕ/A)^φ \) and again, 2.867 ≈ 2√2P ≈ Gw √Gw ≈ (4 + √3)/2. The Golden Apex A ≈ (1 + √5)/ϕ = 432/2867. With the Wilbraham-Gibbs constant, \( Gw \) ≈ 528/286.7 and 2867/528 = S/4A = 2e. The harmonic of the Solar Year again, 365.24 ≈ 2πK/A, 365.24/140 ≈ ϕ2 and 365.24/37 ≈ π2.

IV. Conclusion

The height of the gold pyramidion thought to be on the original Great Pyramid, as described by John Michell (with the metrology of Algeon Berriman) [19], is 0.152 ≈ AQ/(7 × 11), \( √137 \approx 11.7 \) and the tenth part of the Greek cubit of 1.52 = π − ϕ. The modern golden angle in radians, \( Ga \approx 365/152. \) This small pyramidion was supposed to be the final top and possibly made of something like transmuted gold, similar to the legendary Golden Sun Disc of Mu. Reports about stargates, resurrection and the replication of golden pyramids in the hyperdimensional aether suggest the ancient Egyptian initiates were well-informed by Thoth, “Architect of the Great Pyramid.” They knew about the mathematical constants, fundamental physical constants and advanced mathematical functions inherent in the analysis and applications of the golden ratio vortices of the quintessential dynamic aether [20]-[23]. According to Manly P. Hall, the capstone of the Great Pyramid was associated with the Eye of Horus. “The exact science of human regeneration is ... when the Spirit Fire is lifted up through the ... spinal column ... passes into the pituitary
body (Isis), where it invokes Ra (the pineal gland) and ... the Eye of Horus is opened." [24].

V. ACKNOWLEDGMENTS

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REFERENCES RÉFÉRENCES REFERENCIAS

Abstract- We analyze the CV bipartite entanglement of the light generated by a coherently pumped non degenerate three-level laser with a two-mode subharmonic generator coupled to a two-mode vacuum reservoir via a single-port mirror, whose open cavity contains N non-degenerate three-level cascade atoms. We carry out our analysis by putting the noise operators associated with a vacuum reservoir in normal order. It is found that the photon-state of the system is strongly entangled at steady state where as the atom state of the system is not entangled. We have also shown that as the stimulated decay constant increases, the degree of entanglement increases. In addition, we have established that the photons in the laser cavity are highly correlated and the photon correlation and entanglement increases as the amplitude of the coherent light driving the pump mode increases. Moreover, we have realized that the presence of the subharmonic generator leads to an increase in the degree of entanglement and correlations.

Keywords: continuous variables, bipartite, entanglement, quadrature squeezing, correlations, two-mode subharmonic generator.

GJSFR-A Classification : FOR Code: 020502
Cv Bipartite Entanglement of Non-Degenerate Three-Level Laser with Squeezed Modes Pumped by Coherent Light

Getachew A. Gebru & Solomon Getahun

Abstract—We analyze the CV bipartite entanglement of the light generated by a coherently pumped non-degenerate three-level laser with a two-mode subharmonic generator coupled to a two-mode vacuum reservoir via a single-port mirror, whose open cavity contains N non-degenerate three-level cascade atoms. We carry out our analysis by putting the noise operators associated with a vacuum reservoir in normal order. It is found that the photon-state of the system is strongly entangled at steady state where as the atom state of the system is not entangled. We have also shown that as the stimulated decay constant increases, the degree of entanglement increases. In addition, we have established that the photons in the laser cavity are highly correlated and the photon correlation and entanglement increases as the amplitude of the coherent light driving the pump mode increases. Moreover, we have realized that the presence of the subharmonic generator leads to an increase in the degree of entanglement and correlations.

Keywords: continuous variables, bipartite, entanglement, quadrature squeezing, correlations, two-mode subharmonic generator.

1. INTRODUCTION

One of the most fundamentally interesting and intriguing phenomena associated with the composite quantum system is entanglement. In recent years, the topic of continuous-variable entanglement has received a significant amount of attention as it plays an important role in all branches of quantum information processing [1]. The efficiency of quantum information schemes highly depends on the degree of entanglement. A two-mode subharmonic generator at and above threshold has been theoretically predicted to be a source of light in an entangled state [2,3]. Recently, the experimental realization of the entanglement in two-mode subharmonic generator has been demonstrated by Zhang et al [4]. On the other hand, Xiong et al [5] have recently proposed a scheme for an entanglement based on a non-degenerate three-level laser when the three-level atoms are injected at the lower level and the top and bottom levels are coupled by a strong coherent light. They have found that a non-degenerate three-level laser can generate light in an entangled state employing the entanglement criteria for Bipartite continuous-variable state [5].

Moreover, Tan et al [6] extended the work of xiong et al and examined the generation and evolution of the entangled light in the Wigner representation using the sufficient and necessary inseparability criteria for a two-mode Gaussian state proposed by Duan et al [5] and simon [7]. Tesfa [8] have considered a similar system when the atomic coherence is induced by superposition of atomic states and analyzed the entanglement at steady state. Furthermore, Ooi [9] has studied the steady-state entanglement in a two-mode laser.

More recently, Eyob [10] has studied continuous-variable entanglement in non-degenerate three-level laser with a parametric amplifier. In this model the injected atomic coherence introduced by initially preparing the atoms in a coherent superposition of the top and bottom levels. In addition, to exhibiting a two-mode squeezed light, this combined system produces light in an entangled state. In one model of such a laser, three-level atoms initially in the upper level are injected at a constant rate into the cavity and removed after they have decayed due to spontaneous emission. It appears to be quite difficult to prepare the atoms in a coherent superpositions of the top and bottom levels before they are injected into the laser cavity. Beside, it should certainly be hard to find out that the atoms have decayed spontaneously before they are removed from the cavity.

In order to avoid the aforementioned problems, Fesseha [11] have considered that N two-level atoms available in a closed cavity are pumped to the top level by means of electron bombardment. He has shown that the light generated by this laser operating well above threshold is coherent and the light generated by the same laser operating below threshold is chaotic. In addition, Fesseha [12,13] has studied the squeezing and the statistical properties of the light produced by a degenerate three-level laser with the atoms in a closed cavity and pumped by electron bombardment. He has shown that the maximum quadrature squeezing of the light generated by the laser, operating far below threshold, is 50% below the coherent-state level. Alternatively, the three-level atoms available in a closed cavity and pumped by coherent light also generated
squeezing light under certain conditions, with the maximum quadrature squeezing being 43% below the coherent-state level. In view of these results, better squeezing is found from the laser, in which the atoms are pumped by electron bombardment than by coherent light.

In this paper, we seek to study CV bipartite entanglement for the light generated by a coherently pumped non-degenerate three-level laser with a two-mode subharmonic generator coupled to a two-mode vacuum reservoir via a single-port mirror whose open cavity contains N non-degenerate three-level cascade atoms. In order to carry out our analysis, we put the noise operators associated with the vacuum reservoir in the normal order and by considering the interaction of the three-level atoms with a two-mode vacuum reservoir outside the cavity. We then drive the quantum Langevin equations for the cavity mode operators. We next determine the equations of evolution of the expectation values of atomic operators employing the pertinent master equation. Applying the steady-state solutions of the equations of evolution of atomic and cavity mode operators, we analyze the CV atomic and photon state entanglement as well as atom and photon state correlations.

II. MODEL AND DYNAMICS OF ATOMIC AND CAVITY MODE OPERATORS

We consider a coherently pumped non-degenerate three-level laser with two-mode subharmonic generator coupled to a two-mode vacuum reservoir whose cavity contains N non-degenerate three-level atoms in cascade configuration as depicted in Fig. 1. For the sake of convenience, we denote the top, middle, and bottom levels of these atoms by $|2⟩_{jj}, |1⟩_{j}$ and $|0⟩_{j}$, respectively. We seek to represent the light emitted from the top level by $a_2$ and the light emitted from the middle by $a_1$. In addition, in order to expedite the cascading process, it is assumed that the parity of energy levels $|2⟩_j$ and $|0⟩_j$ is the same, while that of $|1⟩_j$, is different. This entails that direct transition between energy level $|2⟩_j$ and $|0⟩_j$ is electric dipole forbidden but due to parity difference, the transition between $|2⟩_j → |1⟩_j$, and $|1⟩_j → |0⟩_j$ are allowed.

The interaction of one of the three-level atoms with light modes $a_1$ and $a_2$ can be described at resonance by the Hamiltonian

$$\hat{H}_1(t) = ig \left[ \hat{σ}^{ij}_1(t)\hat{a}_1(t) - \hat{a}_1^\dagger(t)\hat{σ}^{ij}_1(t) + \hat{σ}^{ij}_2(t)\hat{a}_2(t) - \hat{a}_2^\dagger(t)\hat{σ}^{ij}_2(t) \right],$$

where

$$\hat{σ}^{ij}_1 = |0⟩_{jj}\langle 1|$$

and

$$\hat{σ}^{ij}_2 = |1⟩_{jj}\langle 2|$$

are lowering atomic operators, $\hat{a}_1(t)$ and $\hat{a}_2(t)$ is the annihilation operators for light modes $a_1$ and $a_2$, and $g$ is the coupling constant between the atom and the cavity modes.

On the other hand, a pump mode photon of frequency $ω_3$ directly interacts with the nonlinear crystal (NLC) to produce the signal-idler photon pairs having different frequencies as the two cavity modes. Furthermore, we consider the case for which the pump mode emerging from the NLC (or two-mode subharmonic) does not couple the top and bottom levels. This could be realized by putting on the right-hand side of the NLC a screen which absorbs the pump mode. The top and bottom levels of the three-level atoms are coupled by a strong driving coherent light with the frequency $ω_1$. The coupling of the top and bottom levels of a three-level atom by coherent light can be described at resonance by the Hamiltonian

$$\hat{H}_2(t) = \frac{iΩ}{2} \left( \hat{σ}^{ij}_0(t) - \hat{σ}^{ij}_0(t) \right),$$

in which

$$\hat{σ}^{ij}_0 = |0⟩_{jj}\langle 2|$$

and

$$Ω = 2\mu_0\lambda_0.$$
The master equation for a pair of cavity modes coupled to a two-mode vacuum reservoir has the form \[ \frac{d}{dt} \hat{\rho}(t) = -i \left[ \hat{H}_s(t), \hat{\rho}(t) \right] + \frac{\beta}{2} \left[ 2 \hat{\sigma}^{ij}_1 \hat{\rho} \hat{\sigma}^{ij}_1 - \hat{\sigma}^{ij}_1 \hat{\rho} \hat{\sigma}^{ij}_1 - \hat{\rho} \hat{\sigma}^{ij}_1 \hat{\sigma}^{ij}_1 \right] + \frac{\beta}{2} \left[ 2 \hat{\sigma}^{ij}_0 \hat{\rho} \hat{\sigma}^{ij}_0 - \hat{\sigma}^{ij}_0 \hat{\rho} \hat{\sigma}^{ij}_0 - \hat{\rho} \hat{\sigma}^{ij}_0 \hat{\sigma}^{ij}_0 \right], \] (9)

where \( \gamma \) is the spontaneous emission decay constant. Now with the aid of Eq. (8), one can put Eq. (9) in the form

\[ \frac{d}{dt} \hat{\rho}(t) = g \left[ \hat{\sigma}^{ij}_1 \hat{a}_1 \hat{\rho} - \hat{\sigma}^{ij}_1 \hat{a}_2 \hat{\sigma}^{ij}_1 \hat{a}_2 \hat{\rho} + \hat{\sigma}^{ij}_2 \hat{a}_1 \hat{\rho} - \hat{\sigma}^{ij}_2 \hat{a}_2 \hat{\sigma}^{ij}_2 \hat{a}_2 \hat{\rho} \right] \]

\[ - g \left[ \hat{\rho} \hat{\sigma}^{ij}_1 \hat{a}_1 - \hat{\rho} \hat{\sigma}^{ij}_1 \hat{a}_2 + \hat{\rho} \hat{\sigma}^{ij}_2 \hat{a}_2 - \hat{\rho} \hat{\sigma}^{ij}_2 \hat{a}_2 \right] + \varepsilon \left[ \hat{\sigma}^{ij}_1 \hat{a}_2 + \hat{\sigma}^{ij}_1 \hat{a}_1 \right] + \frac{\Omega}{2} \left[ \hat{\sigma}^{ij}_0 \hat{\rho} - \hat{\sigma}^{ij}_0 \hat{\rho} + \hat{\rho} \hat{\sigma}^{ij}_0 - \hat{\rho} \hat{\sigma}^{ij}_0 \right] \]

\[ + \frac{\beta}{2} \left[ 2 \hat{\sigma}^{ij}_1 \hat{\rho} \hat{\sigma}^{ij}_1 - \hat{\sigma}^{ij}_1 \hat{\rho} \hat{\sigma}^{ij}_1 - \hat{\rho} \hat{\sigma}^{ij}_1 \hat{\sigma}^{ij}_1 \right] + \frac{\beta}{2} \left[ 2 \hat{\sigma}^{ij}_0 \hat{\rho} \hat{\sigma}^{ij}_0 - \hat{\sigma}^{ij}_0 \hat{\rho} \hat{\sigma}^{ij}_0 - \hat{\rho} \hat{\sigma}^{ij}_0 \hat{\sigma}^{ij}_0 \right] \] (10)

We recall that the laser cavity is coupled to a two-mode vacuum reservoir via a single-port mirror. In addition, we carry out our analysis by putting the noise operators associated with the vacuum reservoir in normal order. Thus the noise operators will not have any effect on the dynamics of the cavity mode operators \[13\]. In view of this, we can drop the noise operators and write the quantum Langevin equation for the operators \( \hat{a}_1 \) and \( \hat{a}_2 \) as

\[ \frac{d}{dt} \hat{a}_1(t) = -\frac{k}{2} \hat{a}_1(t) - i \left[ \hat{a}_1(t), \hat{H}_s(t) \right] \] (11)

and

\[ \frac{d}{dt} \hat{a}_2(t) = -\frac{k}{2} \hat{a}_2(t) - i \left[ \hat{a}_2(t), \hat{H}_s(t) \right], \] (12)

where \( k \) is the cavity damping constant for the light modes \( a_1 \) and \( a_2 \). Then with the aid of Eqs. (8), (11), and (12), we easily

\[ \frac{d}{dt} \hat{a}_2(t) = -\frac{k}{2} \hat{a}_2(t) + \varepsilon \hat{a}_2(t) - g \hat{\sigma}^{ij}_2 \] (14)

Making use of the pertinent master equation and the fact that \( \frac{d}{dt} \langle \hat{A} \rangle = Tr \left( \frac{d\hat{\rho}}{dt} \hat{A} \right) \) where \( \hat{A} \) is an operator, it is not difficult to verify that

\[ \frac{d}{dt} \langle \hat{\sigma}^{ij}_1 \rangle = g \left[ \langle \hat{n}^{ij}_0 \hat{a}_1 \rangle - \langle \hat{n}^{ij}_1 \hat{a}_1 \rangle \right] - \frac{\Omega}{2} \langle \hat{\sigma}^{ij}_2 \rangle \] (15)

\[ + \frac{\beta}{2} \langle \hat{\sigma}^{ij}_1 \rangle \] (15)

\[ \frac{d}{dt} \langle \hat{\sigma}^{ij}_2 \rangle = g \left[ \langle \hat{n}^{ij}_2 \hat{a}_2 \rangle - \langle \hat{n}^{ij}_2 \hat{a}_2 \rangle \right] + \frac{\Omega}{2} \langle \hat{\sigma}^{ij}_2 \rangle \] (16)
We intend to overcome this problem by applying the coupled differential equations. Therefore, it is not large-time approximation \[13\]. Then using this possible to obtain the exact time-dependent solutions.

Evidently, these turn out to be exact relations at steady state. Solving these equation simultaneously, one easily verify that

\[
\dot{\sigma}_1^j = -\frac{2g_k}{(k^2 - 4\varepsilon^2)} \sigma_2^j - \frac{2g_k}{(k^2 - 4\varepsilon^2)} \sigma_1^j
\]  
(26)

and

\[
\dot{\sigma}_2^j = -\frac{2g_k}{(k^2 - 4\varepsilon^2)} \sigma_1^j - \frac{2g_k}{(k^2 - 4\varepsilon^2)} \sigma_2^j.
\]  
(27)

Now introducing (26) and (27), into Eqs. (15)-(20), we get

\[
\frac{d}{dt} \langle \sigma_1^j \rangle = -\frac{1}{2} \left[ \beta + \frac{\gamma e k^2}{k^2 - 4\varepsilon^2} \right] \langle \sigma_1^j \rangle
\]  
(28)

\[
\frac{d}{dt} \langle \sigma_2^j \rangle = -\frac{1}{2} \left[ \beta + \frac{\gamma e k^2}{k^2 - 4\varepsilon^2} \right] \langle \sigma_2^j \rangle
\]  
(29)

\[
\frac{d}{dt} \langle \sigma_0^j \rangle = -\frac{1}{2} \left[ \beta + \frac{\gamma e k^2}{k^2 - 4\varepsilon^2} \right] \langle \sigma_0^j \rangle
\]  
(30)

\[
\frac{d}{dt} \langle \sigma_1^j \rangle = -\left[ \beta + \frac{\gamma e k^2}{k^2 - 4\varepsilon^2} \right] \langle \sigma_1^j \rangle
\]  
(31)

\[
\frac{d}{dt} \langle \sigma_2^j \rangle = -\left[ \beta + \frac{\gamma e k^2}{k^2 - 4\varepsilon^2} \right] \langle \sigma_2^j \rangle
\]  
(32)

where

\[
\tilde{n}_0^j = |0\rangle_j \langle 0|,
\]  
(21)

\[
\tilde{n}_1^j = |1\rangle_j \langle 1|,
\]  
(22)

\[
\tilde{n}_2^j = |2\rangle_j \langle 2|.
\]  
(23)

We see that Eqs. (15)-(20) are nonlinear and coupled differential equations. Therefore, it is not possible to obtain the exact time-dependent solutions. We intend to overcome this problem by applying the large-time approximation \[13\]. Then using this approximation scheme, we get from Eqs. (13) and (14) the approximately valid relations

\[
\dot{a}_1 = \frac{2\varepsilon}{k} \hat{a}_2^\dagger - \frac{2g}{k} \hat{\sigma}_1^j
\]  
(24)

and

\[
\dot{a}_2 = \frac{2\varepsilon}{k} \hat{a}_1^\dagger - \frac{2g}{k} \hat{\sigma}_2^j.
\]  
(25)
where
\[ \gamma_c = \frac{4g^2}{k} \]  \hspace{1cm} (34)

is the stimulated emission decay constant.

We next sum Eqs. (29)-(33) over the \( N \) three-level atoms, so that
\[
\frac{d}{dt} \langle \hat{\Sigma}_1 \rangle = -\frac{1}{2} \left[ \beta + \frac{\gamma_c k^2}{k^2 - 4 \varepsilon^2} \right] \langle \hat{\Sigma}_1 \rangle + \frac{\Omega}{2} \langle \hat{\Sigma}_1 \rangle, \tag{35}
\]

\[
\frac{d}{dt} \langle \hat{\Sigma}_2 \rangle = -\frac{1}{2} \left[ \beta + \frac{\gamma_c k^2}{k^2 - 4 \varepsilon^2} \right] \langle \hat{\Sigma}_2 \rangle + \frac{\Omega}{2} \langle \hat{\Sigma}_1 \rangle, \tag{36}
\]

\[
\frac{d}{dt} \langle \hat{\Sigma}_0 \rangle = -\frac{1}{2} \left[ \beta + \frac{\gamma_c k^2}{k^2 - 4 \varepsilon^2} \right] \langle \hat{\Sigma}_0 \rangle + \gamma_c \varepsilon k \left[ \langle \hat{N}_1 \rangle - \langle \hat{N}_0 \rangle \right] + \frac{\Omega}{2} \left[ \langle \hat{N}_0 \rangle - \langle \hat{N}_2 \rangle \right], \tag{37}
\]

\[
\frac{d}{dt} \langle \hat{N}_1 \rangle = -\left[ \beta + \frac{\gamma_c k^2}{k^2 - 4 \varepsilon^2} \right] \times \left[ \langle \hat{N}_1 \rangle - \langle \hat{N}_2 \rangle \right] + \gamma_c \varepsilon k \left[ \langle \hat{\Sigma}_1 \rangle + \langle \hat{\Sigma}_0 \rangle \right], \tag{38}
\]

\[
\frac{d}{dt} \langle \hat{N}_2 \rangle = -\left[ \beta + \frac{\gamma_c k^2}{k^2 - 4 \varepsilon^2} \right] \langle \hat{N}_2 \rangle + \gamma_c \varepsilon k \left[ \langle \hat{\Sigma}_1 \rangle + \langle \hat{\Sigma}_0 \rangle \right] - \frac{\Omega}{2} \left[ \langle \hat{\Sigma}_0 \rangle + \langle \hat{\Sigma}_0 \rangle \right], \tag{39}
\]

\[
\frac{d}{dt} \langle \hat{N}_0 \rangle = \left[ \beta + \frac{\gamma_c k^2}{k^2 - 4 \varepsilon^2} \right] \langle \hat{N}_1 \rangle - \frac{\Omega}{2} \left[ \langle \hat{\Sigma}_0 \rangle + \langle \hat{\Sigma}_0 \rangle \right] + \beta \langle \hat{N}_2 \rangle, \tag{40}
\]

in which
\[
\hat{\Sigma}_1 = \sum_{j=1}^{N} \hat{\sigma}_1^j, \tag{41}
\]

\[
\hat{\Sigma}_2 = \sum_{j=1}^{N} \hat{\sigma}_2^j, \tag{42}
\]

\[
\hat{\Sigma}_0 = \sum_{j=1}^{N} \hat{\sigma}_0^j, \tag{43}
\]

\[
\hat{N}_0 = \sum_{j=1}^{N} \hat{n}_0^j, \tag{44}
\]

\[
\hat{N}_1 = \sum_{j=1}^{N} \hat{n}_1^j, \tag{45}
\]

\[
\hat{N}_2 = \sum_{j=1}^{N} \hat{n}_2^j, \tag{46}
\]

with the operators \( \hat{N}_2, \hat{N}_1, \) and \( \hat{N}_0 \) representing the number of atoms in the top, middle, and bottom levels. In addition, employing the completeness relation
\[
\hat{n}_0^j + \hat{n}_1^j + \hat{n}_2^j = \hat{I}, \tag{47}
\]

we easily arrive at
\[
\langle \hat{N}_0 \rangle + \langle \hat{N}_1 \rangle + \langle \hat{N}_2 \rangle = N. \tag{48}
\]

Furthermore, applying the definition given by Eq. (2) and setting for any \( j \)
\[
\hat{\sigma}_1^j = |0\rangle \langle 1|, \tag{49}
\]

we have
\[
\hat{\Sigma}_1 = N|0\rangle \langle 1|. \tag{50}
\]

Following the same procedure, one can easily find
\[
\hat{\Sigma}_2 = N|1\rangle \langle 2|, \tag{51}
\]

\[
\hat{\Sigma}_0 = N|0\rangle \langle 2|, \tag{52}
\]

\[
\hat{N}_0 = N|0\rangle \langle 0|, \tag{53}
\]

\[
\hat{N}_1 = N|1\rangle \langle 1|, \tag{54}
\]

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Moreover, using the definition
\[ \hat{\Sigma} = \hat{\Sigma}_1 + \hat{\Sigma}_2 \]  
(56)
and taking into account Eqs. (50)-(55), it can be readily established that
\[ \hat{\Sigma} \dagger \hat{\Sigma} = N(\hat{N}_1 + \hat{N}_2), \]  
(57)
\[ \hat{\Sigma} \hat{\Sigma} \dagger = N(\hat{N}_0 + \hat{N}_1), \]  
(58)
\[ \hat{\Sigma}^2 = N \hat{\Sigma}_0. \]  
(59)

We next seek to calculate the expectation value of the atomic operators \( \hat{\Sigma}_0, \hat{\Sigma}_1, \) and \( \hat{\Sigma}_2 \). To this end, applying the large time approximation scheme to Eqs. (36) and (37), we easily get
\[ \langle \hat{\Sigma}_0 \rangle = \frac{1}{(\gamma_e \kappa^2 + \beta \kappa^2 - 4 \beta \varepsilon^2)} \left\{ \Omega \left[ k^2 - 4 \varepsilon^2 \right] \times \left[ N - \langle \hat{N}_1 \rangle - 2 \langle \hat{N}_2 \rangle \right] - 2 \gamma_e \varepsilon \kappa \left[ N - \langle \hat{N}_1 \rangle - 2 \langle \hat{N}_2 \rangle \right] \right\}, \]  
(60)
\[ \langle \hat{\Sigma}_2 \rangle = \frac{1}{2} \left\{ \frac{\Omega k^2 - 4 \Omega \varepsilon^2 - 2 \gamma_e \varepsilon \kappa^2}{\gamma_e \kappa^2 + \beta \kappa^2 - 4 \beta \varepsilon^2} \times \langle \hat{\Sigma}_1 \rangle \right\}, \]  
(61)
and in view of the adjoint of (61), Eq. (35) takes the form
\[ \frac{d}{dt} \langle \hat{\Sigma}_1 (t) \rangle = - \frac{1}{2} \eta \langle \hat{\Sigma}_1 (t) \rangle, \]  
(62)
where
\[ \eta = \beta + \frac{\gamma_e \kappa^2}{k^2 - 4 \varepsilon^2} \]
\[ + \frac{\Omega}{2} \left[ \frac{\Omega k^2 - 4 \Omega \varepsilon^2 - 2 \gamma_e \varepsilon \kappa^2}{\gamma_e \kappa^2 + \beta \kappa^2 - 4 \beta \varepsilon^2} \right]. \]  
(63)

We notice that the steady-state solution of Eq. (62) for \( \eta \) different from zero is
\[ \langle \hat{\Sigma}_1 (t) \rangle = 0. \]  
(64)
Now on account of (64), one can write (61) in the form
\[ \langle \hat{\Sigma}_2 (t) \rangle = 0. \]  
(65)

### III. Correlations

In this section we seek to analyze the degree of photon number and atomic-number correlation. In addition, we wish to study the entanglement of photon-state and atomic states in the laser cavity. In the cascading transition from energy level \( |2\rangle_j \) to \( |0\rangle_j \) via \( |1\rangle_j \), a correlation between the two emitted photons \( a_1 \) and \( a_2 \) can readily be established. Hence the photon number correlation for the cavity modes can be defined as
\[ g(n_1, n_2) = \frac{\langle \hat{a}_1^\dagger (t) \hat{a}_1 (t) \hat{a}_2^\dagger (t) \hat{a}_2 (t) \rangle}{\langle \hat{a}_1^\dagger (t) \hat{a}_1 (t) \rangle \langle \hat{a}_2^\dagger (t) \hat{a}_2 (t) \rangle}. \]  
(66)

On the other hand, using Eqs. (13) and (14) together with (26) and (27), the equation of evolution of cavity mode operators \( \hat{a}_1 \) and \( \hat{a}_2 \) can be rewritten as
\[ \frac{d}{dt} \hat{a}_1 (t) = - \frac{1}{2} \left[ \frac{k^2 - 4 \varepsilon^2}{k} \right] \hat{a}_1 (t) - g \hat{a}_1^\dagger \hat{a}_2 - 2 g \varepsilon \frac{k}{k} \hat{a}_2^\dagger, \]  
(67)
\[ \frac{d}{dt} \hat{a}_2 (t) = - \frac{1}{2} \left[ \frac{k^2 - 4 \varepsilon^2}{k} \right] \hat{a}_2 (t) - g \hat{a}_1 \hat{a}_2^\dagger \hat{a}_1^\dagger - 2 g \varepsilon \frac{k}{k} \hat{a}_2^\dagger \hat{a}_1^\dagger. \]  
(68)

Applying the steady state solution of Eqs. (67) and (68), one readily established the commutation relation of the cavity mode operators \( \hat{a}_1 \) and \( \hat{a}_2^\dagger \) as well as \( \hat{a}_2 \) and \( \hat{a}^\dagger_2 \).

Hence, we notice that
\[ \left[ \hat{a}_1, \hat{a}_1^\dagger \right]_j = \frac{\gamma_e \kappa}{(k^2 - 4 \varepsilon^2)^2} \left[ k^2 (\hat{n}_0^j - \hat{n}_1^j) + 4 \varepsilon^2 (\hat{n}_2^j - \hat{n}_0^j) + 2 \varepsilon k (\hat{\sigma}_0^j + \hat{\sigma}_0^\dagger) \right], \]  
(69)
\[ \left[ \hat{a}_2, \hat{a}_2^\dagger \right]_j = \frac{\gamma_e \kappa}{(k^2 - 4 \varepsilon^2)^2} \left[ k^2 (\hat{n}_1^j - \hat{n}_2^j) + 4 \varepsilon^2 (\hat{n}_0^j - \hat{n}_1^j) - 2 \varepsilon k (\hat{\sigma}_0^j + \hat{\sigma}_0^\dagger) \right], \]  
(70)
and summing over all atoms, we obtain...
The commutation relation for the cavity mode operators is

\[ [\hat{a}, \hat{a}^\dagger] = \frac{\gamma_c k}{(k^2 - 4\varepsilon^2)^2} \left[ k^2 (\hat{N}_0 - \hat{N}_1) + 4\varepsilon^2 (\hat{N}_2 - \hat{N}_1) + 2\varepsilon k \left( \hat{\Sigma}_0^\dagger + \hat{\Sigma}_0 \right) \right], \quad (71) \]

\[ [\hat{a}_2, \hat{a}_2^\dagger] = \frac{\gamma_c k}{(k^2 - 4\varepsilon^2)^2} \left[ k^2 (\hat{N}_1 - \hat{N}_2) + 4\varepsilon^2 (\hat{N}_1 - \hat{N}_0) - 2\varepsilon k \left( \hat{\Sigma}_0^\dagger + \hat{\Sigma}_0 \right) \right], \quad (72) \]

where

\[ [\hat{a}_i, \hat{a}_k^\dagger] = \delta_{ik} \sum_{j=1}^N [\hat{a}_i, \hat{a}_j^\dagger]_j \quad (73) \]

stands for the commutators of \((\hat{a}_1, \hat{a}_1^\dagger)\) and \((\hat{a}_2, \hat{a}_2^\dagger)\) when the cavity light modes \(\alpha_c\) is interacting with all the \(N\) three-level atoms.

In the presence of \(N\) three-level atoms, we rewrite Eqs. (67) and (68) as

\[ \frac{d}{dt} \hat{a}_1(t) = -\frac{1}{2} \left[ \frac{k^2 - 4\varepsilon^2}{k} \right] \hat{a}_1(t) + \lambda_1^\prime \hat{\Sigma}_1 + \lambda_1'' \hat{\Sigma}_1^\dagger, \quad (74) \]

\[ \frac{d}{dt} \hat{a}_2(t) = -\frac{1}{2} \left[ \frac{k^2 - 4\varepsilon^2}{k} \right] \hat{a}_2(t) + \lambda_2' \hat{\Sigma}_2 + \lambda_2'' \hat{\Sigma}_2^\dagger, \quad (75) \]

in which \(\lambda_1', \lambda_1'', \lambda_2'\) and \(\lambda_2''\) are a constant whose values remains to be fixed. The steady-state solution of Eqs. (74) and (75) is

\[ \hat{a}_1 = \frac{2\lambda_1' k}{(k^2 - 4\varepsilon^2)} \hat{\Sigma}_1 + \frac{2\lambda_1'' k}{(k^2 - 4\varepsilon^2)} \hat{\Sigma}_1^\dagger, \quad (76) \]

\[ \hat{a}_2 = \frac{2\lambda_2' k}{(k^2 - 4\varepsilon^2)} \hat{\Sigma}_2 + \frac{2\lambda_2'' k}{(k^2 - 4\varepsilon^2)} \hat{\Sigma}_2^\dagger. \quad (77) \]

On account of Eq. (76) and (77), the commutation relation for the cavity mode operators is

\[ [\hat{a}_1, \hat{a}_1^\dagger] = \frac{4N k^2}{(k^2 - 4\varepsilon^2)^2} \left[ \lambda_1'^2 (\hat{N}_0 - \hat{N}_1) + \lambda_1'' \hat{\Sigma}_0 \right], \quad (78) \]

\[ [\hat{a}_2, \hat{a}_2^\dagger] = \frac{4N k^2}{(k^2 - 4\varepsilon^2)^2} \left[ \lambda_2'^2 (\hat{N}_1 - \hat{N}_2) + \lambda_2'' \hat{\Sigma}_0 \right], \quad (79) \]

On comparing Eqs. (71) and (78) together with (72) and (79), shows that

\[ \lambda_1' = \lambda_2' = \frac{g}{\sqrt{N}} \quad (80) \]

and

\[ \lambda_1'' = \lambda_2'' = \frac{2g\varepsilon}{k\sqrt{N}}. \quad (81) \]

Then Eqs. (76) and (77) can be written as

\[ \hat{a}_1 = \frac{2kg}{\sqrt{N} (k^2 - 4\varepsilon^2)} \hat{\Sigma}_1 + \frac{4g\varepsilon}{\sqrt{N} (k^2 - 4\varepsilon^2)} \hat{\Sigma}_1^\dagger \quad (82) \]

and

\[ \hat{a}_2 = \frac{2kg}{\sqrt{N} (k^2 - 4\varepsilon^2)} \hat{\Sigma}_2 + \frac{4g\varepsilon}{\sqrt{N} (k^2 - 4\varepsilon^2)} \hat{\Sigma}_2^\dagger. \quad (83) \]

Furthermore, the expectation value of the solution of Eqs. (74) and (75) together with (80) and (81) is expressible as

\[ \langle \hat{a}_1(t) \rangle = \langle \hat{a}_1(0) \rangle e^{-\frac{1}{2} \eta_t} + \frac{g}{\sqrt{N}} e^{-\frac{1}{2} \eta_t} \times \int_0^t e^{\frac{1}{2} \eta_t} \langle \hat{\Sigma}_1(t') \rangle dt' \]

\[ + \frac{2g\varepsilon}{k\sqrt{N}} e^{-\frac{1}{2} \eta_t} \int_0^t e^{\frac{1}{2} \eta_t} \langle \hat{\Sigma}_1^\dagger(t') \rangle dt' \quad (84) \]
and
\[
\langle \hat{a}_2(t) \rangle = \langle \hat{a}_2(0) \rangle e^{-\frac{1}{2} n_0 t} + \frac{g}{\sqrt{N}} e^{-\frac{1}{2} n_0 t} \int_0^t e^{\frac{1}{2} n_0 t'} \langle \hat{S}_2(t') \rangle \\
+ \frac{2g\varepsilon}{k\sqrt{N}} e^{-\frac{1}{2} n_0 t} \int_0^t e^{\frac{1}{2} n_0 t'} \langle \hat{\Sigma}_1(t') \rangle, \tag{85}
\]
where
\[
\eta_0 = \frac{k^2 - 4\varepsilon^2}{k}. \tag{86}
\]
Now in view of Eqs. (64) and (65) with the assumption that the cavity light is initially in a vacuum state, Eqs. (84) and (85) goes over into
\[
\langle \hat{a}_1(t) \rangle = \langle \hat{a}_2(t) \rangle = 0. \tag{87}
\]
On account of this result as well as Eqs. (74) and (75) that \( \hat{a}_1(t) \) and \( \hat{a}_2(t) \) are Gaussian variables with zero mean. Then Eq. (66) can be rewritten as
\[
g(\hat{n}_1, \hat{n}_2)_p = 1 + \frac{\langle \hat{a}_1^\dagger(t)\hat{a}_1^\dagger(t) \rangle \langle \hat{a}_1(t)\hat{a}_2(t) \rangle \langle \hat{a}_1^\dagger(t)\hat{a}_2(t) \rangle}{\langle \hat{a}_1^\dagger(t)\hat{a}_1(t) \rangle \langle \hat{a}_1^\dagger(t)\hat{a}_1(t) \rangle} + \frac{\langle \hat{a}_1^\dagger(t)\hat{a}_2(t) \rangle \langle \hat{a}_2^\dagger(t)\hat{a}_1(t) \rangle}{\langle \hat{a}_1(t)\hat{a}_1(t) \rangle \langle \hat{a}_2(t)\hat{a}_2(t) \rangle}. \tag{88}
\]
Thus employing Eqs. (82) and (83) together with (50) and (51) along with (88), the photon-number correlation turns out to be
\[
g(\hat{n}_1, \hat{n}_2)_p = 1 + \frac{W_1}{W_2}, \tag{89}
\]
where
\[
W_1 = 4\varepsilon k \left[ \frac{k^2 + 4\varepsilon^2}{\langle \hat{\Sigma}_0 \rangle} \langle \hat{\Sigma}_0 \rangle + 2\varepsilon k \langle \hat{\Sigma}_0 \rangle \right], \tag{90}
\]
\[
W_2 = \left[ k^2 + 4\varepsilon^2 \right] \left[ k^2 \langle \hat{\Sigma}_0 \rangle + 4\varepsilon^2 \langle \hat{\Sigma}_0 \rangle \right] + 4\varepsilon \langle \hat{\Sigma}_0 \rangle, \tag{91}
\]
in which \( \langle \hat{\Sigma}_0 \rangle \) is given by Eq. (60). Moreover, the atom-number correlation is defined by
\[
g(\hat{n}_1, \hat{n}_2)_a = \frac{\langle \hat{\Sigma}_1^\dagger \hat{\Sigma}_1^\dagger \hat{\Sigma}_2 \rangle}{\langle \hat{\Sigma}_1^\dagger \hat{\Sigma}_1 \rangle \langle \hat{\Sigma}_2^\dagger \hat{\Sigma}_2 \rangle}. \tag{92}
\]
We recall that the atomic operators \( \hat{\Sigma}_1 \) and \( \hat{\Sigma}_2 \) are Gaussian variables with zero mean. Hence Eq. (92) can be rewritten as
\[
g(\hat{n}_1, \hat{n}_2)_a = 1 + \frac{\langle \hat{\Sigma}_1^\dagger \hat{\Sigma}_1^\dagger \hat{\Sigma}_2 \rangle}{\langle \hat{\Sigma}_1^\dagger \hat{\Sigma}_1 \rangle \langle \hat{\Sigma}_2^\dagger \hat{\Sigma}_2 \rangle} + \frac{\langle \hat{\Sigma}_1^\dagger \hat{\Sigma}_2 \rangle}{\langle \hat{\Sigma}_1^\dagger \hat{\Sigma}_1 \rangle \langle \hat{\Sigma}_2^\dagger \hat{\Sigma}_2 \rangle} + \frac{\langle \hat{\Sigma}_1^\dagger \hat{\Sigma}_1 \hat{\Sigma}_2^\dagger \hat{\Sigma}_2 \rangle}{\langle \hat{\Sigma}_1^\dagger \hat{\Sigma}_1 \rangle \langle \hat{\Sigma}_2^\dagger \hat{\Sigma}_2 \rangle}. \tag{93}
\]
Thus in view of Eqs. (50) and (51), we obtain
\[
g(\hat{n}_1, \hat{n}_2)_a = 1. \tag{94}
\]
We immediately see that the maximum degree of photon number correlation observed when more atoms in the lower energy level than on the upper level. This occurs when the three-level laser is operating below threshold. On the other hand, we note that Eq. (94) that unlike the photon-number correlation, the atoms in the laser cavity are not correlated. Moreover, we point out that in the absence of subharmonic generator, one can never realize correlated photons in the laser cavity.

IV. Entanglement Quantification

Here, we seek to analyze the entanglement of photon-states and atomic states in the laser cavity. Quantum entanglement is a physical phenomenon that occurs when pairs or groups of particles cannot be described independently instead, a quantum state may be given for the system as a whole. Measurements of physical properties such as position, momentum, spin polarization, etc performed on entangled particles are found to be appropriately correlated.

A pair of particles is taken to be entangled in quantum theory, if its states cannot be expressed as a product of the states of its individual constituents. The preparation and manipulation of these entangled states that have non-classical and non-local properties lead to better understanding of the basic quantum principles. It is in this spirit that this section is devoted to the analysis of the entanglement of the two modes (photon-states). In other words, it is a well-known fact that a quantum system is said to be entangled, if it is not separable. That is, if the density operator for the combined state cannot be described as a combination of the product density operators of the constituents,
\[
\rho \neq \sum_k P_k \rho_k^{(1)} \otimes \rho_k^{(2)}, \tag{95}
\]
in which $P_k \gg 0$ and $\sum_k P_k = 1$ to verify the normalization of the combined density states. On the other hand, on entangled continuous variable (CV) states can be expressed as a common eigenstate of a pair of EPR-type operators [14] such as $\hat{x}_2 - \hat{x}_1$ and $\hat{p}_2 + \hat{p}_1$. The total variance of these two operators reduces to zero for maximally entangled CV states. According to the inseparable criteria given by Duan et al [5], cavity photon-states of a system are entangled, if the sum of the variance of a pair of EPR-like operators,

$$\hat{s} = \hat{x}_2 - \hat{x}_1$$

and

$$\hat{t} = \hat{p}_2 + \hat{p}_1,$$

where

$$\hat{x}_1 = \frac{1}{\sqrt{2}} (\hat{a}_1 + \hat{a}_1^\dagger),$$

$$\hat{x}_2 = \frac{1}{\sqrt{2}} (\hat{a}_2 + \hat{a}_2^\dagger),$$

$$\hat{p}_1 = \frac{i}{\sqrt{2}} (\hat{a}_1^\dagger - \hat{a}_1),$$

$$\hat{p}_2 = \frac{i}{\sqrt{2}} (\hat{a}_2^\dagger - \hat{a}_2),$$

are quadrature operators for modes $\alpha_1$ and $\alpha_2$, satisfy

$$(\Delta s)^2 + (\Delta t)^2 < 2N$$

and recalling the cavity mode operators $\hat{a}_1$ and $\hat{a}_2$ are Gaussian variables with zero mean, we readily get

$$(\Delta s)^2 + (\Delta t)^2 = \left[ \langle \hat{a}_1^\dagger \hat{a}_1 \rangle + \langle \hat{a}_1 \hat{a}_1^\dagger \rangle \right]$$

$$+ \left[ \langle \hat{a}_1^\dagger \hat{a}_2 \rangle + \langle \hat{a}_2 \hat{a}_1^\dagger \rangle \right]$$

$$- \left[ \langle \hat{a}_1 \hat{a}_2 \rangle + \langle \hat{a}_2^\dagger \hat{a}_1^\dagger \rangle \right] + \left[ \langle \hat{a}_1^\dagger \hat{a}_2 \rangle + \langle \hat{a}_2 \hat{a}_1^\dagger \rangle \right].$$

Thus with the aid of Eqs. (82) and (83) along with (50) and (51), we arrive at

$$(\Delta s)^2 + (\Delta t)^2 = \frac{\gamma_c k}{(k^2 - 4\varepsilon^2)^2}$$

$$\times \left[ k^2 + 4\varepsilon^2 - 4\varepsilon k \right]$$

$$\times \left[ 2N - \langle \hat{N}_0 \rangle - \langle \hat{N}_2 \rangle - 2\langle \hat{\Sigma}_0 \rangle \right].$$

Upon setting $\varepsilon = 0$, we see that

$$(\Delta s)^2 + (\Delta t)^2 = \frac{\gamma_c k}{k^2 - 4\varepsilon^2}$$

$$\times \left[ 2N - \langle \hat{N}_0 \rangle - 2\langle \hat{\Sigma}_0 \rangle \right].$$

where

$$\langle \hat{\Sigma}_0 \rangle = \frac{\Omega}{\gamma_c + \beta} \left[ N - \langle \hat{N}_1 \rangle - 2\langle \hat{N}_2 \rangle \right].$$

On the other hand, cavity atomic-states of a system are entangled, if the sum of the variance of a pair of EPR-like operators,

$$\hat{u} = \hat{x}_2 - \hat{x}_1$$

and

$$\hat{v} = \hat{p}_2 + \hat{p}_1,$$

where

$$\hat{x}_1' = \frac{1}{\sqrt{2}} (\hat{\Sigma}_1 + \hat{\Sigma}_1^\dagger),$$

$$\hat{x}_2' = \frac{1}{\sqrt{2}} (\hat{\Sigma}_2 + \hat{\Sigma}_2^\dagger),$$

$$\hat{p}_1' = \frac{i}{\sqrt{2}} (\hat{\Sigma}_1^\dagger - \hat{\Sigma}_1),$$

$$\hat{p}_2' = \frac{i}{\sqrt{2}} (\hat{\Sigma}_2^\dagger - \hat{\Sigma}_2),$$

are quadrature operators for the cavity atoms, satisfy

$$(\Delta u)^2 + (\Delta v)^2 < 2N^2.$$
V. Conclusion

In this paper we have studied a coherently driven non-degenerate three-level laser with two-mode subharmonic generator, coupled to a two-mode vacuum reservoir via a single-port mirror whose open cavity contains N non-degenerate three-level atoms. We carried out our analysis by putting the noise operators associated with the vacuum reservoir in normal order and by considering the interaction of the three-level atoms with the vacuum reservoir outside the cavity. Results show that the presence of parametric amplifier is to increase the squeezing and the mean photon number of the two-mode cavity light significantly. It is found that the photon-states of the system is strongly entangled at steady state where as the atomic state of the system is not entangled. We have also shown that as the stimulated decay constant increases, the degree of entanglement decreases. In addition, we have established that the photons in the laser cavity are highly correlated and the degree of photon number correlation and entanglement increases as the amplitude of the coherent light driving the pump mode increases. Moreover, we have shown that the presence of the subharmonic generator leads to an increase in the degree of entanglement and correlation. Moreover, we point out that in the absence of subharmonic generator, one can never realize correlated photons.

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The Question of Space-Time Singularities in General Relativity and Einstein's Errors

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Abstract- In general relativity, the existence of space-time singularities plays a central role on the notion of black holes and the expanding universe. However, these two speculations have not been firmly verified in spite of the efforts of generations of physicists. The existence of space-time singularities is due to the spacetime singularity theorems of Hawking and Penrose, whose implicit physical assumption is the general validity of $E = mc^2$ that leads to the unique sign for all the couplings. However, recently it is found that such an assumption is not supported by various experiments. In particular, the electromagnetic energy is not equivalent to mass. In fact, the Einstein equation with massive sources has no dynamic solution unless the gravitational energy-stress tensor with an anti-gravity coupling is added to the source.

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The Question of Space-Time Singularities in General Relativity and Einstein's Errors

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Abstract- In general relativity, the existence of space-time singularities plays a central role on the notion of black holes and the expanding universe. However, these two speculations have not been firmly verified in spite of the efforts of generations of physicists. The existence of space-time singularities is due to the spacetime singularity theorems of Hawking and Penrose, whose implicit physical assumption is the general validity of $E = mc^2$ that leads to the unique sign for all the couplings. However, recently it is found that such an assumption is not supported by various experiments. In particular, the electromagnetic energy is not equivalent to mass. In fact, the Einstein equation with massive sources has no dynamic solution unless the gravitational energy-stress tensor with an anti-gravity coupling is added to the source. Moreover, for the electromagnetic wave to have a physically gravitational effect, the related Einstein equation must additionally have a photonic energy-stress tensor with an anti-gravity coupling. Thus, Einstein's understanding of general relativity is inadequate. Since the energy conditions in the space-time singularity theorems actually cannot be satisfied in physics, these mathematical theorems are actually irrelevant to physics. Their claims have been proven as nonsense in physics. Further more, recognizing the nonexistence of dynamic solution for the Einstein equation is the first step to the unification of gravitation and electromagnetism. Many overlooked the crucial charge-mass interaction. Due to inadequate understanding of the principle of causality and non-linear mathematics, Einstein failed to show his unification. He has made three major errors: 1) He is mistaken that the Einstein equation has dynamic solutions. 2) He speculated that $E = mc^2$ was generally valid. 3) He invalidly rejected repulsive gravitation, which is supported by experiments. Also, the Physical Review, the Proceedings of the Royal Society A, the Annals of Physics and the Chinese Physics. accepted the space-time singularity theorems as valid because theorists make errors in the non-linear mathematics and physics.

Keywords: anti-gravity coupling; dynamic solution; gravitational radiation; repulsive gravitation; principle of causality.

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"Unthinking respect for authority is the greatest enemy of truth." – A. Einstein

1. Introduction

In physics, the existence of singularities suggests problematic assumptions. Nevertheless, in current theory of general relativity, the existence of space-time singularities plays a central role on the notion of black holes and the expanding universe (see Appendix A). However, these two speculations have not been firmly verified in spite of the efforts of generations of physicists. Thus, one may question the general validity of the theory of general relativity in spite of its earlier success.

The existence of space-time singularities is due to the spacetime singularity theorems of Hawking and Penrose [1]. The mathematical validity of these theorems is highly reliable because Penrose have won his arguments in mathematics against the theoretical physicist, E. M. Lifshitz [2] in a long dispute. Moreover, the static Einstein equation in general relativity has passed various tests with surprises. Since the physical assumptions on the energy conditions of these theorems seem to be very natural, there would be little doubt on the validity of these assumptions.

An implicit assumption on these singularity theories is that all the coupling constants have the same sign. Such an assumption would be necessarily valid if the formula $E = mc^2$ is unconditional. However, recently it has been found that the general validity of this formula is questionable. In contrast to Einstein's prediction [3], a piece of heated-up metal actually has reduced weight [4]. Moreover, a charged capacitor also has reduced weight, which is proportional to the square of the difference in the electric potential of the capacitor [5, 6]. Theoretically, it has been found that the equivalence between mass and the electromagnetic energy is in conflict with the Einstein equation because the electromagnetic energy-stress tensor is traceless [7]. Thus, the assumption of unique coupling sign is questionable.

In this paper, it will be shown that the assumption of unique coupling sign is, indeed, not valid for the dynamic case. Therefore, the space-time singularity theorems of Hawking and Penrose are actually irrelevant to physics. A root of the problem is, however, that many relativists have lost their touch with experiments, in addition to inadequacy in non-linear mathematics.

2. The Space-Time Singularity Theorems and the Assumption of Unique Sign of Couplings

Let us examine the energy conditions in the singularity theorems. These theorems [1] are listed as the following:
Theorem 1. Let \((M, g_{ab})\) be a globally hyperbolic spacetime with \(R_{ab}^\Psi g_{ab} \geq 0\) for all timelike \(\Psi\), which will be the case if Einstein equation is satisfied with the strong energy condition holding for matter. Suppose there exists a smooth (or at least \(C^1\)) spacelike Cauchy surface \(\Sigma\) for which the trace of the extrinsic curvature (for the past directed normal geodesic congruence) satisfies \(0 > C \geq K\) everywhere \(C\) is a constant. Then no past directed timelike curve from \(\Sigma\) can have length greater than \(3/\sqrt{C}\). In particular, all past directed timelike geodesic are incomplete.

Theorem 2. Let \((M, g_{ab})\) be a strongly causal spacetime with \(\Xi_{ab} g^{ab} \geq 0\) for all timelike \(\Xi\), as will be the case if Einstein’s equation is satisfied with the strong energy condition holding for matter. Suppose there exists a compact, edgeless, achronal smooth spacelike hypersurface \(S\) such that for the past directed normal geodesic congruence form \(S\) we have \(0 > K\) everywhere on \(S\). Let \(C\) denote the maximum value for \(K\), so \(0 > C \geq K\) everywhere on \(S\). Then at least one inextendible past directed timelike geodesic from \(S\) has length no greater than \(3/\sqrt{C}\).

Theorem 3. Let \((M, g_{ab})\) be a connected, globally hyperbolic spacetime with a noncompact Cauchy surface \(\Sigma\). Suppose \(R_{ab}^k k^b \geq 0\) for all null \(k^a\), as will be the case if \((M, g_{ab})\) is a solution of Einstein’s equation with matter satisfying the weak or strong energy condition. Suppose, further, that \(M\) contains a trapped surface \(T\). Let \(0 > \theta_i\) denote the maximum value of \(\theta\) for both sets of orthogonal geodesic on \(T\). Then at least one inextendible future directed orthogonal null geodesic from \(T\) has affine length no greater than \(2/\theta_i\).

Theorem 4. Suppose a spacetime \((M, g_{ab})\) satisfies the following four conditions. (1) \(R_{ab}^\Sigma v^b \geq 0\) for all timelike and null \(v^a\), as will be the case if Einstein’s equation is satisfied with the strong energy condition holding for matter. (2) The timelike and null generic conditions are satisfied. (3) No closed timelike curve exists. (4) At least one of the three properties holds: (a) \((M, g_{ab})\) possesses a compact achronal set without edge [i.e., \((M, g_{ab})\) is a closed universe], (b) \((M, g_{ab})\) possesses a trapped surface, or (c) there exists a point \(p \in M\) such that the expansion of the future (or past) directed null geodesics emanating from \(p\) becomes negative along each geodesic in this congruence. Then \((M, g_{ab})\) must contain at least one incomplete timelike or null geodesic.

Originally, the energy condition is related to the energy-momentum tensor \(T_{ab}\). According to the Einstein equation [1]

\[
G_{ab} = R_{ab} - (1/2) g_{ab} R = 4\pi T_{ab},
\]

one would have

\[
R_{ab} = 8\pi [T_{ab} - (1/2) g_{ab} T] \quad \text{where} \quad T = g^{ab} T_{ab}.
\]

Then,

\[
R_{ab} \xi^a \xi^b = 8\pi [T_{ab} - (1/2) g_{ab} T] \xi^a \xi^b = 8\pi [T_{ab} \xi^a \xi^b + (1/2) T],
\]

for a unit timelike \(\xi^a\). This assumption is known as the weak energy condition. However, it also seems physically reasonable that the stress of matter will not become so large and negative as to make the right-hand side of eq. (3) negative. This assumption,

\[
T_{ab} \xi^a \xi^b \geq -(1/2) T
\]

for all unit timelike unit vector \(\xi^a\), is known as the strong energy condition. An implicit assumption of these energy-conditions (3)-(5) is that all the coupling constants have the same sign. However, as will be shown such an assumption leads to the invalidity of the Einstein equation because of the non-existence of dynamic solutions.

To illustrate this, we shall first show examples that for the case of gravitational waves; there is no bounded dynamic solution. Now, consider a well-known metric obtained by Bondi, Pirani, & Robinson [8] as follows:
valid. These conflicting views are supported respectively by the editors of the “Royal Society Proceedings A” and the “Physical Review D”; thus there is no general consensus. Note that Einstein’s covariance principle has been proven invalid with counter examples [9].

III. The Non-Existence of a Bounded Dynamic Solution for a Two-Body Problem in General Relativity

According to the principle of causality, weak sources would produce a weak field, i.e.,

\[ g_{\mu \nu} = \eta_{\mu \nu} + \gamma_{\mu \nu}, \text{ where } 1 >> |\gamma_{\mu \nu}|. \]  

(7)

\[ \frac{1}{2} \delta^{\alpha} \delta_{\alpha} F_{\mu \nu} = \kappa T_{\mu \nu}, \text{ where } F_{\mu \nu} = \gamma_{\mu \nu} - \frac{1}{2} \eta_{\mu \nu} (\eta^{cd} \gamma_{cd}), \]  

(8)

Note that we have

\[ G_{\mu \nu} = G^{(1)}_{\mu \nu} + G^{(2)}_{\mu \nu} \] and \[ G^{(1)}_{\mu \nu} = \frac{1}{2} \delta^{\alpha} \delta_{\alpha} F_{\mu \nu} + H^{(1)}_{\mu \nu}, \]  

(9)

where

\[ H^{(1)}_{\mu \nu} = -\frac{1}{2} \delta^{\alpha} [\delta_{\mu \nu} F_{\alpha \alpha} + \delta_{\mu} F_{\alpha \alpha}] + \frac{1}{2} \eta_{\mu \nu} \delta^{\alpha} \delta^{\beta} F_{\alpha \beta}. \]

The linearized vacuum Einstein equation means \[ G^{(1)}_{\mu \nu} \gamma^{(1)}_{\alpha \beta} = 0. \] Thus, to have a solution of the second order we must correct \( \gamma^{(1)}_{\mu \nu} \) by adding to it the term \( \gamma^{(2)}_{\mu \nu} \) that satisfies

\[ G^{(1)}_{\mu \nu} \gamma^{(2)}_{\alpha \beta} + G^{(2)}_{\mu \nu} \gamma^{(2)}_{\alpha \beta} = 0, \text{ where } \gamma_{\mu \nu} = \gamma^{(1)}_{\mu \nu} + \gamma^{(2)}_{\mu \nu}. \]

(10)

which is the correct form of eq. (4.4.52) in Wald's book [1] (Wald did not distinguish \( \gamma_{\mu \nu} \) from \( \gamma^{(1)}_{\mu \nu} \)).\(^{41}\) However, detailed calculation shows that this equation does not have a solution for the dynamic case [10-13].\(^{5}\) In fact, as shown by the example in the last section, for a dynamic case, the linearized equation and the Einstein equation are independent equations [14].

It was believed that the linear Maxwell-Newton Approximation [11] (or the linearized Einstein equation [15, 16])

\[ \frac{1}{2} \delta^{\alpha} \delta_{\alpha} F_{\mu \nu} = K T(m)_{\mu \nu}, \text{ where } F_{\mu \nu} = \gamma_{\mu \nu} - \frac{1}{2} \eta_{\mu \nu} (\eta^{cd} \gamma_{cd}). \]  

(11a)

and

\[ F_{\mu \nu} (x', t) = \frac{K}{2\pi} \int_{R} \frac{1}{R} T_{\mu \nu}[y', (t - R)] d^3 y, \text{ where } R^2 = \sum_{i=1}^{3} (x' - y')^2. \]  

(11b)

provides the first-order approximation for the Einstein equation (1). However, this belief was verified for the static case only.

The Cauchy data of eq.(1) must satisfy four constraint equations, \( G_{\mu \nu} = -KT(m)_{\mu \nu} \) (\( \mu = x, y, z, t \)) since \( G_{\alpha \mu} \) contains only first-order time derivatives [17]. This shows that (11a) would be dynamically incompatible with Einstein equation (1).

In 1957, Fock [18] pointed out that, in harmonic coordinates, there are divergent logarithmic deviations from expected linearized behavior of the radiation. This was misinterpreted to mean merely that the contribution of the complicated nonlinear terms in the Einstein equation cannot be dealt with satisfactorily following this method and that another approach is needed.

Unfortunately, many believe that condition (7) for weak gravity is always valid for the Einstein equation. They believed that an approximate weak solution can be derived through the approach of the field equation being linearized. The linearized Einstein equation with the linearized harmonic gauge \( \partial_{\nu} F_{\mu \nu} = 0 \) is
isolated system located near the origin of the space coordinate system, $G^{(2)}_{\mu\nu}$ at large $r (= \sqrt{x^2 + y^2 + z^2})$ is of $O(K^2/r^2)$ [1, 17, 19].

One may obtain some general characteristics of a dynamic solution for an isolated system as follows:

1) The characteristics of some physical quantities of an isolated system:

   For an isolated system consisting of particles with typical mass $M$, separation $\bar{r}$, and velocities $\bar{v}$, Weinberg [17] estimated, $O(1/r^2)$ the power radiated at a frequency $\omega$ of order $\bar{v}/\bar{r}$ will be of order

   $$P \approx \kappa(\bar{v}/\bar{r})^6 M^2 \bar{r}^{-4} \text{ or } P \approx \kappa M \bar{r}^4/\bar{r},$$

   since $\kappa M/\bar{r}$ is of order $\bar{v}^2$. The typical deceleration $\bar{\alpha}_n$ of particles in the system owing this energy loss is given by the power $P$ divided by the momentum $\kappa M \bar{v} \bar{r}/\bar{r}$. This may be compared with the accelerations computed in Newtonian mechanics, which are of order $\bar{v}^2/\bar{r}$, and with the post-Newtonian correction of $\bar{v}^3/\bar{r}$. Since radiation reaction is smaller than the post-Newtonian effects by a factor $\bar{r}^{-1}$, if $\bar{r} \ll c$, the velocity of light, the neglect of radiation reaction is perfectly justified. This allows us to consider the motion of a particle in an isolated system as almost periodic.

   Consider two particles of equal mass with an almost circular orbit in the x-y plane whose origin is the center of the circle (i.e., the orbits are a circle if radiation is neglected). Thus, the principle of causality implies that the metric $g_{\mu\nu}$ is weak and very close to the flat metric at distance far from the source and that $g_{\mu\nu}(x, y, z, t)$ is an almost periodic function of $t' (= t - r/c)$.

2) The expansion of a bounded dynamic solution $g_{\mu\nu}$ for an isolated weak gravitational source:

   According to eq. (11), a first-order approximation of metric $g_{\mu\nu}(x, y, z, t')$ is bounded and almost periodic since $T_{\mu\nu}$ is. Physically, the principle of causality requires $g_{\mu\nu}$ to be almost periodic in time since the motion of a source particle is. Such a metric $g_{\mu\nu}$ is asymptotically flat for a large distance $r$, and the expansion of a bounded dynamic solution is

   $$g_{\mu\nu}(n^\alpha, n^\beta, r, t') = \eta_{\mu\nu} + \sum_{k=1}^\infty f_{\mu\nu}^{(k)}(n^\alpha, n^\beta, t'/r^k), \quad \text{where } n^\alpha = x^\alpha/r.$$  (13a)

3) The non-existence of dynamic solutions:

   It follows expansion (13a) that the non-zero time average of $G^{(1)}_{\mu\nu}$ would be of $O(1/r^2)$ due to

   $$\bar{\alpha}_n n^\alpha = (\bar{\alpha}^\mu_n + n^\mu \eta_{\mu\alpha})/r,$$  (13b)

   since the term of $O(1/r^2)$, being a sum of derivatives with respect to $t'$, can have a zero time-average. If $G^{(2)}_{\mu\nu}$ is of $O(K^2/r^2)$ and has a nonzero time-average, consistency

   $$\gamma_{\mu\nu} = \gamma^{(1)}_{\mu\nu} + \gamma^{(2)}_{\mu\nu}; \quad P^{(1)}_{\mu\nu} = \gamma^{(1)}_{\mu\nu} - \frac{1}{2} \eta_{\mu\nu} (\gamma^{(1)}_{\rho\sigma} \eta_{\rho\sigma}), \quad \text{where } i = 1, 2;$$

   and

   $$\frac{1}{2} \partial^\alpha \partial_\alpha P^{(1)}_{\mu\nu} = K T(m)_{\mu\nu}. \quad \text{(14)}$$

   Then $P^{(1)}_{\mu\nu}$ is of a first-order; and $\gamma^{(2)}_{\mu\nu}$ is finite. On the other hand, from the Einstein equation (1), one has

   $$\frac{1}{2} \partial^\alpha \partial_\alpha P^{(2)}_{\mu\nu} + H^{(1)}_{\mu\nu} + G^{(2)}_{\mu\nu} = 0 \quad \text{(15)}$$

   Note that, for a dynamic case, equation (15) may not be satisfied. If (14) is a first-order approximation, $G^{(0)}_{\mu\nu}$ has a nonzero time-average of $O(K^2/r^2)$ [1] (but $[\partial^\alpha \partial_\alpha P^{(2)}_{\mu\nu} + H^{(1)}_{\mu\nu}]$ would have zero time-average); and thus $P^{(2)}_{\mu\nu}$ cannot have a solution.

   However, if $P^{(0)}_{\mu\nu}$ is also of the first-order of $K$, one cannot estimate $G^{(0)}_{\mu\nu}$ by assuming that $P^{(1)}_{\mu\nu}$ provides a first-order approximation. For example, equation (11) does not provide the first approximation for the static Schwarzschild solution, although it can be transformed to a form such that (11) provides a first-order approximation [15]. According to eq. (9), $P^{(0)}_{\mu\nu}$ will be a second order term if the sum $H^{(1)}_{\mu\nu}$ is of second order. From (9), this would require $\partial^\alpha \partial_\alpha P^{(1)}_{\mu\nu}$ being of second order. For weak gravity, it is known that a coordinate transformation would turn $\partial^\alpha \partial_\alpha P^{(1)}_{\mu\nu}$ to a second order term [17, 18, 21]. (Eq. [15] implies that $\partial^\alpha \partial_\alpha P^{(1)}_{\mu\nu} - \partial^\alpha \partial_\alpha P^{(1)}_{\mu\nu} = \partial^\alpha \partial_\alpha P^{(1)}_{\mu\nu}$ would be of second order.) Thus, it is possible to turn (14) to become an equation for a first-order approximation for weak gravity.

   Since it has been proven that (11) necessarily gives a first-order approximation [15], a failure of such a coordinate transformation means only that such a
solution is not valid in physics. Moreover, for the dynamic of massive matter, experiment [22] supports the fact that Maxwell-Newton Approximation (11) is related to a dynamic solution of weak gravity [16]. Thus, theoretical considerations as well as experiments eliminate other unverified speculations thought to be possible since 1957.

As shown, the difficulty comes from the assumption of boundedness, which allows the existence of a bounded first-order approximation, which in turn implies that a time-average of the radiative part of $G^{(2)\mu\nu}$ is non-zero. The present method has an advantage over Fock’s approach to obtaining logarithmic divergence [18] for being simple and clear.

In short, according to Einstein’s radiation formula, a time average of $G^{(2)\mu\nu}$ is non-zero and of $O(K^2/r^2)$ [17]. Although (11) implies $G^{(1)\mu\nu}$ is of order $K^2$, its terms of $O(1/r^2)$ can have a zero time average because $G^{(1)\mu\nu}$ is linear on the metric elements. Thus, the Einstein equation (1) in vacuum cannot be satisfied. Nevertheless, a static metric can satisfy (1), since both $G^{(1)\mu\nu}$ and $G^{(2)\mu\nu}$ are of $O(1/r^2)$ in vacuum. Note that $G_{\mu\nu} = KT(m)_{\mu\nu}$ are constraints on the initial data.

In conclusion, assuming the existence of dynamic solutions of weak gravity for Einstein equation (1) [8, 18, 21, 23-28] is invalid. This means that general relativity has not yet totally superseded Newtonian gravity [12]. This illustrates also that theorists should not carelessly follow the erroneous and groundless claims of Christodoulou and Klainerman (see Section 6).

Nevertheless, because of inadequacy in mathematics, many theorists following Einstein’s error, claimed or believed that there are dynamic solutions. A good example is that Misner, Thorne and Wheeler [19] claimed they have an explicit bounded dynamic solution of the following form,

$$- ds^2 = c^2 dt^2 - dx^2 - L^2 \left( e^{2\beta} dy^2 + e^{-2\beta} dz^2 \right)$$  \hspace{1cm} (16)

where $L = L(u)$, $\beta = \beta(u)$, $u = ct - x$, and $c$ is the light speed. Then, the Einstein equation $G_{\mu\nu} = 0$ becomes

$$\frac{d^2 L}{du^2} + L \left( \frac{d\beta}{du} \right)^2 = 0$$  \hspace{1cm} (17)

Misner et al. [19] claimed that Eq. (17) has a bounded approximate solution, compatible with a linearization of metric (16). However, it has been shown with undergraduate mathematics [29] that Misner et al. are incorrect and Eq. (17) does not have a physical solution that satisfies Einstein’s requirement on weak gravity. In fact, $L(u)$ is unbounded even for a very small $\beta(u)$.

On the other hand, from the Maxwell-Newton approximation in vacuum, Einstein [30] obtained a solution as follows:

$$- ds^2 = c^2 dt^2 - dx^2 - (1 + 2\phi)dy^2 - (1 - 2\phi)dz^2 $$  \hspace{1cm} (18)

where $\phi$ is a bounded function of $u (= ct - x)$. Note that metric (18) is the linearization of metric (16) if $\phi = \beta(u)$.

Thus, the waves illustrate that the linearization is not valid for the dynamic case when gravitational waves are involved.

Moreover, Misner et al. [19] also make other serious errors in physics as shown in their eq. (40.14) for the proper time measured by an earth-based clock, but other theorists such as Wald [1] and Weinberg [17] did not make the same mistake.

**IV. The Anti-Gravity Coupling and Invalidity of the Space-Time Singularity Theorems to Physics**

From the above analysis, there is a conflict between the Einstein equation, which has no dynamic solution and its linearized equation, which has a dynamic solution. The conflict is due to that the second order terms $G^{(2)\mu\nu}$ cannot be eliminated in the Non-linear Einstein equation. Thus, a simple solution is the 1995 update of the Einstein equation [10] as follows:

$$G_{\mu\nu} \equiv R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = K [T(m)_{\mu\nu} - t(g)_{\mu\nu}],$$  \hspace{1cm} (19)

where $t(g)_{\mu\nu}$ is the energy-stress tensors for gravity. Then, from (19), the equation in vacuum is

$$G_{\mu\nu} \equiv R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = -K t(g)_{\mu\nu}$$  \hspace{1cm} (19')

Note that $t(g)_{\mu\nu}$ is equivalent to $G^{(2)\mu\nu}$ (and Einstein’s gravitational pseudotensor) in terms of his radiation formula.

When gravitational wave is present, the gravitational energy-stress tensor $t(g)_{\mu\nu}$ is non-zero. Thus, a radiation does carry energy-momentum as physics requires. This explains also that the absence of an anti-gravity coupling which is determined by Einstein’s radiation formula, is the physical reason that the 1915 Einstein equation (1) is incompatible with radiation.

Note that the radiation of the binary pulsar can be calculated without detailed knowledge of $t(g)_{\mu\nu}$. From (19), the approximate value of $t(g)_{\mu\nu}$ at vacuum can be calculated through $G_{\mu\nu} K$ as before since the first-order approximation of $g_{\mu\nu}$ can be calculated through (11). In view of the facts that $K t(g)_{\mu\nu}$ is of the fifth order in a post-Newtonian approximation, that the deceleration due to radiation is of the three and a half order in a post-Newtonian approximation [17] and that the perihelion of Mercury was successfully calculated with the second-order approximation from (1), the orbits of the binary pulsar can be calculated with the second-order post-Newtonian approximation of (19) by using (1). Thus, the calculation approaches of Damour and Taylor [31, 32] would be essentially valid exact that they did not realize
the crucial fact that (11) is actually an approximation of the updated equation (19) [33].

In light of the above, the Hulse-Taylor experiments support the anti-gravity coupling being crucial to the existence of the gravitational wave [34], and (11) being an approximation of weak waves generated by massive matter. Thus, it has been experimentally verified that Einstein equation (1) is not compatible with radiation, but the updated Einstein equation is.

The 1995 updated Einstein equation actually was first proposed by Lorentz [35] and Levi-Civita [36] as follows;

\[ k T(g)_{ab} = G_{ab} + \kappa T_{ab} \]  

(20)

where \( T_{ab} \) is the sum of other massive energy-stress tensors. Then, the gravitational energy-stress tensor takes a covariant form. However, Einstein [37] objected to this form on the grounds that his field equation implies \( t(g)_{ab} = 0 \). Now, Einstein is wrong since his equation is proven invalid for the dynamic case. An independent evidence for unboundedness is that the equation is proven invalid for the dynamic case. An inference of coupling would suggest that \( E = mc^2 \).

Moreover, eq. (19) should be called the Lorentz-Levi-Einstein equation.

\[ G_{ab} = K[T(E)_{ab} - T(P)_{ab}], \quad \text{and} \quad T_{ab} = - T(g)_{ab} = T(E)_{ab} - T(P)_{ab}, \]  

(21)

where \( T(E)_{ab} \) and \( T(P)_{ab} \) are the energy-stress tensors for the electromagnetic wave and the related photons. The photonic energy-stress is necessary; otherwise there is no bounded gravitational wave solution for the electromagnetic energy-stress tensor. Then, the gravitational energy-stress tensor takes a covariant form. However, Einstein [37] objected to this form on the grounds that his field equation implies \( t(g)_{ab} = 0 \). Now, Einstein is wrong since his equation is proven invalid for the dynamic case. An independent evidence for unboundedness is that the equation is proven invalid for the dynamic case. An inference of coupling would suggest that \( E = mc^2 \).

Moreover, if the unique sign for couplings could be attributed to a general \( E = mc^2 \), the non-unique signs of coupling would suggest that \( E = mc^2 \) is only conditionally valid. It has been shown explicitly that the electromagnetic energy is not equivalent to mass.

It should be noted that the anti-gravity coupling is a general feature that would appear in where the gravitational wave is present. For instance, it is necessary to appear in the Einstein equation for the gravitational waves generated by an electromagnetic wave [39, 40]. For the validity of the calculation on light bending, it is necessary that an electromagnetic wave would generate a negligible gravitational wave because this was implicitly assumed in such a calculation. For this case the related equation is the following:

\[ E = mc^2, \text{ the Reissner-Nordstrom Metric, and the Question of Black Holes} \]

The existence of the anti-gravity coupling raised a question whether the formula \( E = mc^2 \) is unconditionally valid. It is found that this is only a speculation that Einstein failed to prove (1905-1909) [41]. Moreover, since the electromagnetic energy-stress tensor is traceless, an electromagnetic energy-stress tensor would generate gravitation which does not change the Ricci curvature \( R \) in the Einstein equation. However, nobody seriously studied gravitation generated by the electromagnetic energy, although the Riessner-Nordstrom metric [19] for a charged particle would answer the above issues.

Now, let us examine the Reissner-Nordstrom metric [19] (with \( c = 1 \)) as follows:

\[ ds^2 = \left( 1 - \frac{2M}{r} + \frac{q^2}{r^2} \right) dr^2 - \left( 1 - \frac{2M}{r} + \frac{q^2}{r^2} \right)^{-1} dr^2 - r^2 d\Omega^2 \]  

(22)
where q and M are the charge and mass of a particle, and r is the radial distance (in terms of the Euclidean-like structure \([42]\)) from the particle center. In this metric \((22)\), the gravitational components generated by electricity have not only a very different radial coordinate dependence but also a different sign that makes it a new repulsive gravity in general relativity \([43]\). Thus, general relativity must be extended to include the unification of electromagnetism and gravitation \([43]\).

Nevertheless, some argued that the effective mass could be considered as

\[
M - \frac{q^2}{2r},
\]

(23)
because the total electric energy outside a sphere of radius \(r\) is \(q^2/2r\), and thus (23) could be interpreted as supporting \(m = \frac{E}{c^2}\). If the electric energy has a mass equivalence, an increase of such energy should lead to an increment of gravitational strength. However, from metric (22), the strength of a gravitational force decreases everywhere after an increase of the electric energy.

Moreover, the gravitational forces would be different from the force created by the “effective mass” \(M - q^2/2r\) because

\[
- \frac{1}{2} \frac{\partial}{\partial r} \left( 1 - \frac{2M}{r} + \frac{q^2}{r^2} \right) = -\frac{1}{r^2} \left( M - \frac{q^2}{2r} \right)
\]

(33)

Thus Will was defeated because he could not defend his interpretation of \(m = \frac{E}{c^2}\) \([7]\).

The validity of \(E = mc^2\) was questioned because for the binary pulsars experiment the coupling constants necessarily have different signs \([11]\). Nevertheless, with supports from editorials of Nature, the Physical Review D, and Science, Will continued to misinterpret the formula. Also, some theorists \([44, 45]\) argued that M in (22) includes the external electric energy.

For instance, Herrera, Santos, & Skea \([45]\), also argued that M in (31) involves the electric energy. They follow the error of Whittaker \([46]\) and Tolman \([47]\) who believed the equivalence of mass and electric energy. Then they obtained a metric that would imply a charged ball would increase its weight as the charge \(Q\) increased, in disagreement with experiments \([48]\).

The above approach is essentially the same as that of Pekeris \([44]\), who gets a similar metric in 1982. The difference is due to that Pekeris requires that \(\left| g_{uu} \right| = g = -1\). Thus, the approach of Herrera et al. \([45]\) is essentially what Pekeris had done. Apparently, theorists have run out of ways that can be used against the repulsive force. Nevertheless, Nobel Laureate ’t Hooft even claimed incorrectly that the electric energy of an electron contributed to the inertial mass of an electron \([49]\).

On the other hand, if the mass M is just the inertial mass of the particle, the weight of a charged metal ball can be reduced \([50]\). Thus, as Lo expected \([7]\), experiments of Tsipenyuk and Andreev on two metal balls \([48]\) rejects the claims of Herrera et al. \([45]\) since the charged ball has reduced weight. This is an experimental direct proof. We recommend that the detailed investigation of such experiments \([50]\) should be continued such that this static case of general relativity is fully verified.

Note that the appearing of the repulsive gravitation is important because it would solve a puzzle as to why we have never seen a black hole. If gravity is always attractive to mass, Wheeler simulation convinces him that a black hole must be formed \([2]\). Another piece of information for the existence of black holes is the existence of space-time singularities, proven by Hawking and Penrose \([1]\). Now, because the necessity of the existence of the anti-gravity coupling the energy conditions of their theorems cannot be satisfied. Thus, their space-time singularity theorems are actually irrelevant to physics.

More important, this repulsive force is crucial for establishing the unification of gravitation and electromagnetism \([43]\).

VI. DISCUSSIONS AND CONCLUSIONS

In current theory of general relativity, essentially only the case of massive sources is studied, due to Einstein’s speculation on mass and energy, \(E = mc^2\) being unconditionally true. Moreover, because of such speculation, physicists accepted the assumption that all the coupling constants have the same sign. For instance, such assumption was implicitly included in the energy-conditions used in the space-time singularity theorems of Hawking and Penrose \([1]\). In turn, such theorems would imply that general relativity is inapplicable for microscopic phenomena. The problem actually is due to a lack of understanding the non-linear mathematics. However, many incorrectly blame the problem as due to the classical nature of general relativity. Furthermore, this leads to their speculation that there was a conflict between general relativity and quantum mechanics.

In spite of the efforts of generations of physicists, there is no experimental evidence to support their claims (see Appendix A). Nevertheless, the Spacetime singularity theorems provide a convenient excuse for the Big Bang Theory of the expanding universe and the notion of black holes. However, although Penrose has won his arguments against the theorist, E. M. Lifshitz \([2]\), the problem is, however, not in mathematics. A time tested practice in physics is that if the conclusion is unusual, one should go back to examine their assumptions. However, the singularity theorems have been treated as exceptions.

Consequently, many believed that there was a conflict between general relativity and quantum
mechanics. The fact is, however, that not only this is not true but also general relativity actually necessitates the existence of photons [39, 40].

Nevertheless, Einstein has commanded such a faith and thus nobody ever questions his speculations $E = mc^2$ as unconditional although Einstein has failed to prove it for years (1905-1909) [41]. Moreover, people over-looked that $E = mc^2$ being unconditionally true is in direct conflict with general relativity because of the fact that the electromagnetic energy-momentum tensor is traceless [43]. Some theorists even supply their own errors that lead to further confusion [34].

According to their theorems, Hawking and Penrose claimed that general relativity is unsuitable for microscopic phenomena [1]. However, they were not aware that the assumption of unique coupling sign also implies that general relativity is not suitable for macroscopic phenomena [39, 40]. This is so because in the light bending, it is implicitly assumed that the gravity due to the light ray is negligible [15, 16]. Since the energy-stress tensor of an electromagnetic wave can be a source term, gravitational waves would be generated [51]. However, if such gravity is not negligible or having no solution due to the assumption of unique coupling sign, then general relativity would not be valid even for macroscopic phenomena. Since Einstein was not aware of this, his understanding in general relativity also needs to be improved.

A major problem is that Einstein and his followers do not understand non-linear mathematics. As Gullstrand [52] pointed out, Einstein’s calculation on the perihelion of Mercury is problematic. Nevertheless, the coincidence between his calculation and observation was the source of Einstein’s confidence in his theory. Understandably, almost the whole physics community was against Gullstrand. Ironically, Gullstrand is right. In fact, many failed to understand that the Einstein equation does not have a bounded solution for a two-body problem [13] as in Newtonian theory. Moreover, for the dynamic case, the Einstein equation and the linearized equation are actually not compatible, but independent equations [14]. Another problem was Einstein’s partially verified formula $E = mc^2$ which turns out to be invalid for the electromagnetic energy.

Einstein’s false confidence leads to serious problems. One of them is the acceptance of space-time singularity theorems of Hawking and Penrose. They serve as the justification for the Big Bang Theory that has been acknowledged to have many problems [53, 54], and black holes that have not been observed. Hawking and Penrose invalidly blame their claim of inapplicability to microscopic problem as due to being a classical theory. Moreover, the Wheeler School, in particular the errors of Christodoulou [55], have been proven as creating further confusions [34] that even misled the 1993 Nobel Prize Committee for physics [56] to claim erroneously that the Einstein equation has bounded dynamic solutions [10-13].

The formula $E = mc^2$ was proved for the case of light rays [15]. However, it remains to reconcile that the electromagnetic energy-stress tensor is traceless. Now, the notion of a photonic energy-stress tensor of massless particles solves this puzzle since the photonic energy can be equivalent to mass because photons are massless particles, but the electromagnetic energy alone cannot. Note that both quantum theory and relativity are based on the phenomena of light. Now, it is gravity in general relativity that makes photons necessary for electromagnetic waves, and thus Einstein’s photonic proposal is inadequate.

The important results from this analysis are: 1) The invalid covariance principle confuses mathematics and physics. 2) The electromagnetic energy is not equivalent to mass. 3) The photons include energy from its gravitational components. 4) Einstein’s general relativity is invalid for the dynamic case, for which it remains to be rectified and completed in at least two aspects: a) The exact form of the gravitational energy-stress tensor is not known; and b) The radiation reaction force is also not known. Since the photons include gravitational energy, general relativity is clearly compatible with quantum theory.

Thus, the space-time singularity theorems of Hawking and Penrose are actually irrelevant to physics. Using the same invalid unique sign assumption, the positive energy theorem of Schoen and Yau actually does not include the case of the dynamic solutions [57, 58]. Thus, such a theorem is misleading because it is based on an invalid assumption. In fact, recognizing $E = mc^2$ as only conditionally valid [6], is crucial to identify the charge-mass interaction. Moreover, such a force is coupled to the charge square, and thus such a force exists naturally in a five-dimensional theory of Lo et al. [59].

Einstein failed to show such unification because of his three shortcomings: 1) He failed to see, as Maxwell showed, that unification is necessary to have new interactions. 2) He has mistaken that $E = mc^2$ was unconditional. 3) Einstein invalidly rejected the repulsive gravitation [7]. Einstein’s invalid covariance principle also added confusions [9]. However, this new repulsive force can also be detected from a charged capacitor. Thus, unification of electromagnetism and gravitation beyond Einstein is confirmed [6]. Hence, Einstein turns out to be the biggest winner from the rectification of his errors.

The earliest error of Einstein started from his inadequate notion of photons which include only electromagnetic energy. This led him to believe erroneously that $E = mc^2$ could be generally valid [15]. Consequently, he rejected repulsive gravitation [7] and believed all the coupling constants had the same sign.
Einstein incorrectly believed that his test particle approach could be derivable as a limit of a dynamic solution [81] because he has never derived one with nonlinear mathematics. A serious problem in general relativity is that many rush to obtain new conclusions without careful deliberations [10].

Clearly, the errors of Einstein and his followers are the obstacle of progress in physics. However, if one has any doubt on my claims, it would be beneficial for him to find examples to support his objections.


Hubble’s law is often considered as the observational evidence of an expanding universe. Then, the further a galaxies is from the Milky Way, the faster it appears to recede. However, Hubble himself concluded in 1936 that the Galaxies are stationary [60]. In fact, such a receding velocity is incompatible with the local light speeds used in deriving the light bending. Thus, such a questionable assumption that has been pointed out by Whitehead [61] and also proven as theoretically invalid.

Note that the Doppler redshifts of the light from receding Galaxies is based on an implicit assumption that there is no expansion for the space coordinates. Moreover, the receding velocity is incompatible with the light speeds used in deriving the light bending. In short, the notion of expanding universe is a production due to an inadequate understanding of a physical space. Thus, it is questionable that such a universe is related to the reality.

A.1. Hubble’s Law

Hubble observed from light emitted by galaxies that the redshifts $S$ are linearly proportion to the distance $L$ from the Milky Way as,

$$S = HL$$

(A1)

where $H$ is the Hubble constant although the redshifts of distant galaxies will deviate from this linear law slightly.

A.2. The Redshifts

In terms of a theory from general relativity, it is well known that this law can be derived with the following metric [1],

$$ds^2 = -d\tau^2 + a^2(\tau)(dx^2 + dy^2 + dz^2),$$

(A2)

since

$$S = \frac{\lambda_2 - \lambda_1}{\lambda_1} = \frac{\omega_1}{\omega_2} - 1 = \frac{a(\tau_2)}{a(\tau_1)} - 1,$$

(A3)

where $\omega_i$ is the frequency of a photon emitted at event $P_i$ at time $\tau_i$, and $\omega_2$ is the frequency of the photon observed at $P_2$ at time $\tau_2$. Furthermore, for nearby galaxies, one has

$$a(\tau_2) \approx a(\tau_1) + (\tau_2 - \tau_1)a$$ and $\tau_2 - \tau_1 \approx R$ (A4)

Thus,

$$S = \frac{a}{a} L = H L, \text{ and } H = \frac{a}{a} \quad (A5)$$

Note that Hubble’s Law need not be related to the Doppler redshifts. In fact, Hubble rejected such an interpretation [61].

A.3. Hubble’s Law and the Doppler Redshifts

If one chooses to define the distance between two points as

$$L = \int \sqrt{dx^2 + dy^2 + dz^2},$$

(A6)

Then

$$v = \frac{dR}{d\tau} = \frac{da}{d\tau} L + \frac{dL}{d\tau} a = \frac{da}{d\tau} a = HR$$

(A7)

Thus,

$$v = S.$$  \quad (A8)

This means that the redshifts could be superficially considered as a Doppler effect.
A.4. Remarks

However, if we define the distance as \( L \), there is actually no receding velocity since \( L \) is fixed (i.e., \( \frac{dL}{d\tau} = 0 \)).

Thus, whether Hubble’s Law represents the effects of an expanding universe is a matter of the interpretation of the local distance. From the above analysis, the crucial point is what a valid physical velocity in a physical space is.

It should be noted that \( \frac{dL}{d\tau} = 0 \) means that the space coordinates are independent of physics. In other words, the physical space has a Euclidean-like structure, which is independent of time. However, since \( L \) between any two space-points is fixed, the notion of an expanding universe, if it means anything, is just an illusion. Moreover, the validity of (A6) as the physical distance has no known experimental supports since it is not even clearly measurable. Also, a problem is that the notion of velocity in (A7) would be incompatible with the

\[ -ds^2 = \left[ 1 - \frac{2M}{r} \right] c^2 dt^2 + \left( 1 + \frac{M}{2r} \right) \left( dx^2 + dy^2 + dz^2 \right) \]

where \( \kappa = G/c^2 \) (\( G = 6.67 \times 10^{-8} \text{ erg cm/gm}^2 \)), \( M \) is the total mass, and \( r = \sqrt{x^2 + y^2 + z^2} \). Then, if the equivalence principle is satisfied, the light speeds are determined by \( ds^2 = 0 \) [12, 13], i.e.,

\[ \frac{\sqrt{dx^2 + dy^2 + dz^2}}{dt} = c \left( 1 - \frac{M\kappa}{2r} \right) \left( 1 + \frac{M\kappa}{2r} \right)^{3/2} \]

(A11)

However, such a definition of light speeds is incompatible with the definition of velocity (A7). Since this light speed is supported by observations, definition (A7) is invalid in physics.

Nevertheless, Liu [63] has defined light speeds, which is more compatible with (A7), as

\[ \frac{\sqrt{g_{ij}dx^i dx^j}}{dt} = c \left( 1 - \frac{M\kappa}{2r} \right) \left( 1 + \frac{M\kappa}{2r} \right) \]

(A12)

for metric (A10). However, (A12) implies only half of the deflection implied by (A11) [15].

The above analysis also explains why many current theorists insist on that the light speeds are not defined even though Einstein defined them clearly in his 1916 paper [15] as well as in his book [16]. The light speeds are well defined although diffeomorphic metrics give different sets of light speeds for the same frame of reference. However, Einstein defines light speeds after the assumption that his equivalence principle is satisfied. Thus, at most only one of such metrics is valid in physics.

Moreover, it has been proven that the Maxwell-Newton Approximation gives the valid first order approximation of the physical metric [11-13]. Since metric (A10) is compatible with the Maxwell-Newton light speeds in the calculation of light bending experiment.

A.5. The Coordinates of an Einstein Physical Space, and Definition of Velocity

If the Riemannian space is embedded in a higher dimensional flat space [62], then the coordinates \( dx^i \) are determined by

\[ ds^2 = g_{ij}dx^i dx^j, \quad \text{or} \quad -g_{\tau\tau}dt^2 + g_{ij}dx^i dx^j \]  \hspace{1cm} (A9)

such as the surface of a sphere in a three dimensional Euclidean space. For a physical space since the metric is a variable function, it is impossible to determine the coordinates with the metric. Moreover, it has been proven [42] that a frame of reference with the Euclidean-like structure must exist for a physical space.

For a spherical mass distribution with the center at the origin, the metric with the isotropic gauge is,

\[ \kappa = G/c^2 \]  \hspace{1cm} (A10)

Appendix B: The Principle of Causality and the Physics of Plane-Waves

There are two aspects in causality: its relevance and its time ordering. In time ordering, a cause event must happen before its effects. This is further restricted by relativistic causality that no cause event can propagate faster than the light speed in vacuum. The time-tested assumption that phenomena can be explained in terms of identifiable causes will be called
the principle of causality. This is the basis of relevance for all scientific investigations.

Thus, the principle of causality implies that any parameter in a solution for physics must be related to some physical causes. Moreover, Einstein's notion of weak gravity is also based on the principle of causality that implies a weak source would produce a weak gravity. Here this principle will be elucidated first in connection with symmetries of a field, the boundedness of a field solution, and consequently in the validity of a field equation in physics.

In practice, when the considered field is absent, physical properties are ascribed to the space-time as in a "normal" state. For example, the electromagnetic field is zero in a normal state. Then, any deviation from the normal state must have physically identifiable causes. Thus, the principle of causality implies that the symmetry must be preserved if no cause breaks it. The implication of causality to symmetry has been used in deriving the inverse square law from Gauss's law.

The normal state of a space-time metric is the flat metric in special relativity. Thus, if a metric does not possess a symmetry, then there must be physical cause(s) which has broken such a symmetry. For a spherically symmetric mass, causality requires that the metric is spherically symmetric and asymptotically flat. Also, since gravity must have a cause, a weak cause can lead to only weak gravity. Therefore, Einstein's notion of weak gravity is also a consequence of the principle of causality.

However, the physical cause(s) should not be confused with the mathematical source term in the field equation. In general relativity, the cause of gravity is the physical matter itself, but not its energy tensors in the source term of Einstein's field equation. The energy-stress tensors (for example the perfect fluid model) may explicitly depend on the metric. Since nothing should be a cause of itself, such a source tensor does not represent the cause of a metric. For the accompanying gravitational wave of an electromagnetic wave, the physical cause is the electromagnetic wave. Thus, one should not infer the symmetries of the metric based on the source term (instead of its causes) although their symmetries are not unrelated.

Moreover, inferences based on the source term can be misleading. The source term may have higher symmetries than those of the cause and the metric. For instance, a transverse electromagnetic plane-wave (1) is not rotationally invariant with respect to the z-direction of propagation. But the related electromagnetic energy-stress tensor component $T(E)$, for a circularly polarized wave is rotationally invariant. This assumption violates causality and results in theoretical difficulties.

Classical electrodynamics implies that the flat metric is an accurate approximation, caused by the presence of weak electromagnetic waves. This physical requirement is supported by the principle of causality which implies such a metric to be a bounded periodic function. However, this required boundedness is not satisfied by solutions in the literature [66-68]. These solutions also violate causality directly since they involve parameters without any physical cause [67]. They also do not satisfy the equivalence principle [69, 70] although they are Lorentz manifolds.

A necessary and sufficient condition for satisfying the equivalence principle $^{21}$ is that a time-like geodesic represents a physical free falling; but the mathematical existence of local Minkowski spaces is only necessary. A major problem in general relativity is that many theorists and journals do not understand related physics, in particular, the principle of causality adequately.

**Endnotes**

1. Although a Nobel Prize in Physics has been awarded to S. Perlmutter, B. P. Schmidt, and A. G. Riess for the accelerating expansion of the universe in 2011, the expanding universe actually has not been verified (See Appendix A).
2. The existence of anti-gravity coupling has been considered by Lorentz [35], Levi-Civita [36] and Pauli [71].
3. Thus, the observation of Galileo that all neutral matter falls in the same rate under gravitation is actually incomplete [72].
4. Wald has never provided a dynamic solution [73].
5. The proof on the non-existence of dynamic solution [11] was published in 1995 Astrophys. J. when S. Chandrasekhar, a Nobel Laureate, was the editor-in-chief. This was two years after the 1993 Nobel Prize was awarded to Hulse and Taylor. Thus, Chandrasekhar also agreed that there are problems in the 1993 Nobel prize in physics.
6. Prof. S. Weinberg taught us that general relativity must be understood in terms of physics, and thus summarized the viewpoints and tradition of M.I.T on general relativity. This tradition has a long history, starting from N. Rosen and A. Einstein's paper of 1937, followed by H. Yilmaz, advocated by V. F. Weisskopf and P. Morrison, and so on. It is a pleasure to be able to contribute to such an outstanding tradition. However, to repair such a tradition is urgently needed since it has been broken by the Wheeler School [34] after Prof. Morrison passed away. This would not be an easy task for MIT since Einstein also has mistakes. And Harvard University as well as Princeton Advanced Studies were also sources of errors [57].
7. For a thorough discussion on the relation between the mass and the total energy of a particle, one can read the paper of L. B. Okun [74]. However, since Okun believed that $E= mc^2$ is generally true [75], Okun did not understand that the electromagnetic energy is not equivalent to mass [75]. Nevertheless,
Okun has some interesting thought [76] about the energy of photon related to gravity, and would question to interpret the Hubble’s law as due to receding of the stars.

8. Now, we understand that Einstein’s proposal of the photons is inadequate, and moreover it is a necessary consequence of general relativity. It is interesting that this is a major triumph of general relativity, but shows also a major error of Einstein in general relativity [77]. The Chinese Physics also mistaken that a bounded solution can be obtained by perturbation.

9. I have reported these to MIT President Hockfield and the subsequent President Reif. They have promised to up-grade the related education in gravitation.

10. The unconditional validity of \( E = mc^2 \) is responsible for the invalid notion that energy always produces attractive gravity [2; p.488]. Thus, the notion of black holes could be considered as due to the errors of Einstein.

11. Because of inadequacy in non-linear mathematics, theorists such as Hod [78], like many other “theorists”, carelessly failed in recognizing the problem is that there is no bounded dynamic solution [10-13] since linearization for the static case is valid. Thus, they claimed that general relativity has superseded Newtonian theory in every aspects. Unfortunately, this is simply not true although Einstein also wrongly believed this as Gullstrand [52] pointed out.

12. Bertschinger [79] also does not know that, for the dynamic case, the linearized equation and the non-linear Einstein equation have only unrelated solutions [14]. Because he does not understand non-linear mathematics, Bertschinger erroneously [14, 34] believed that the linearization of Einstein equation was in general mathematically valid [79].

13. The space-time singularity theorems made sense only if the Einstein equation has bounded dynamic solutions. This is why Hawking and Penrose and their followers had to believe the existence of bounded dynamic solutions.

14. The Ph. D. degree advisor of D. Christodoulou is J. A. Wheeler, whose mathematics has been shown also in his book Gravitation [19] having errors in crucial arguments and unreliable at the undergraduate level. In fact, mathematician Perlick, [80, 81] has pointed out the book of Christodoulou and Klainerman is incomprehensible. Accordingly, the honors awarded to Christodoulou, in fact, reflected, the blind faith toward Einstein and accumulated errors in general relativity [82]. These expose that many theorists just do not understand non-linear mathematics. In fact, Christodoulou has never completed the construction of dynamics solutions [83]. In short, the contributions of Christodoulou to general relativity are just errors.

15. Michael Francis Atiyah has been president of the Royal Society (1990-1995), and President of the Royal Society of Edinburgh (2005-2008). Since 1997, he has been an honorary professor at the University of Edinburgh (Wikipedia). However, like many mathematicians, clearly he does not understand general relativity just as Hilbert [84] did not and thus, Yau and Witten were awarded the Fields Medal for their errors [58].

16. Due to making the same erroneous assumptions in physics (claiming the existence of dynamic solution for the Einstein equation), S. T. Yau had organized seminars for Hawking in Hong Kong and other cities of China. Now, he claimed, however, that he is no longer interested in general relativity. Thus, he ignores that his positive mass theorem [85] is misleading in physics. [57, 58]. Moreover, later the same error was made by Witten [86]. This error may also explain the fact that there is little progress in the string theory. Thus, it seems, many mathematicians at the top as well as physicists “at the top” have made errors in general relativity.

17. Due to the influence of L. Z. Fang and C. N. Yang, currently in China few understand general relativity after P. Y. Zhou [87]. Yang is against Zhou, who correctly pointed out that Einstein’s covariance principle is invalid [34]. However, as Weinberg [88] pointed out, Yang’s understanding on the gauge theories is incorrect [34]. Moreover, Yang is also proven wrong by explicit examples [89].

18. Apparently, Einstein did not know that his unification was that close to confirmation. If he had known this, he may not be that willing to go by rejecting the modern medicine to prolong his life [90].

19. It has never occurred to Einstein that his field equation is invalid for the dynamic case, and this is a main reason that he failed to see the necessary unification of gravitation and electromagnetism.

20. I claim a statement in physics is wrong only under two conditions: 1) it is logically not self-consistent; and 2) it is against by experiments or observations. Otherwise, I claim them as disagreements only.

21. Eric J. Weinberg, editor of the Physical Review D, invalidly insists that there is no difference in physics between Einstein’s equivalence principle and Pauli’s version [71] although Einstein pointed out that Pauli’s is a misinterpretation [91]. Eric does not understand the functional analysis related to Einstein’s equivalent principle [34], and the non-linear mathematics with related physics. His incompetence is a main reason that APS is lack behind in the physics of gravitation [92].
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Proofs must be returned to the dean at dean@globaljournals.org within three days of receipt.

As changes to proofs are costly, we inquire that you only correct typesetting errors. All illustrations are retained by the publisher. Please note that the authors are responsible for all statements made in their work, including changes made by the copy editor.

6.2 Early View of Global Journals Inc. (US) (Publication Prior to Print)

The Global Journals Inc. (US) are enclosed by our publishing’s Early View service. Early View articles are complete full-text articles sent in advance of their publication. Early View articles are absolute and final. They have been completely reviewed, revised and edited for publication, and the authors’ final corrections have been incorporated. Because they are in final form, no changes can be made after sending them. The nature of Early View articles means that they do not yet have volume, issue or page numbers, so Early View articles cannot be cited in the conventional way.

6.3 Author Services

Online production tracking is available for your article through Author Services. Author Services enables authors to track their article - once it has been accepted - through the production process to publication online and in print. Authors can check the status of their articles online and choose to receive automated e-mails at key stages of production. The authors will receive an e-mail with a unique link that enables them to register and have their article automatically added to the system. Please ensure that a complete e-mail address is provided when submitting the manuscript.

6.4 Author Material Archive Policy

Please note that if not specifically requested, publisher will dispose off hardcopy & electronic information submitted, after the two months of publication. If you require the return of any information submitted, please inform the Editorial Board or dean as soon as possible.

6.5 Offprint and Extra Copies

A PDF offprint of the online-published article will be provided free of charge to the related author, and may be distributed according to the Publisher’s terms and conditions. Additional paper offprint may be ordered by emailing us at: editor@globaljournals.org.
Before start writing a good quality Computer Science Research Paper, let us first understand what is Computer Science Research Paper? So, Computer Science Research Paper is the paper which is written by professionals or scientists who are associated to Computer Science and Information Technology, or doing research study in these areas. If you are novel to this field then you can consult about this field from your supervisor or guide.

TECHNIQUES FOR WRITING A GOOD QUALITY RESEARCH PAPER:

1. **Choosing the topic:** In most cases, the topic is searched by the interest of author but it can be also suggested by the guides. You can have several topics and then you can judge that in which topic or subject you are finding yourself most comfortable. This can be done by asking several questions to yourself, like Will I be able to carry our search in this area? Will I find all necessary recourses to accomplish the search? Will I be able to find all information in this field area? If the answer of these types of questions will be “Yes” then you can choose that topic. In most of the cases, you may have to conduct the surveys and have to visit several places because this field is related to Computer Science and Information Technology. Also, you may have to do a lot of work to find all rise and falls regarding the various data of that subject. Sometimes, detailed information plays a vital role, instead of short information.

2. **Evaluators are human:** First thing to remember that evaluators are also human being. They are not only meant for rejecting a paper. They are here to evaluate your paper. So, present your Best.

3. **Think Like Evaluators:** If you are in a confusion or getting demotivated that your paper will be accepted by evaluators or not, then think and try to evaluate your paper like an Evaluator. Try to understand that what an evaluator wants in your research paper and automatically you will have your answer.

4. **Make blueprints of paper:** The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

5. **Ask your Guides:** If you are having any difficulty in your research, then do not hesitate to share your difficulty to your guide (if you have any). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work then ask the supervisor to help you with the alternative. He might also provide you the list of essential readings.

6. **Use of computer is recommended:** As you are doing research in the field of Computer Science, then this point is quite obvious.

7. **Use right software:** Always use good quality software packages. If you are not capable to judge good software then you can lose quality of your paper unknowingly. There are various software programs available to help you, which you can get through Internet.

8. **Use the Internet for help:** An excellent start for your paper can be by using the Google. It is an excellent search engine, where you can have your doubts resolved. You may also read some answers for the frequent question how to write my research paper or find model research paper. From the internet library you can download books. If you have all required books make important reading selecting and analyzing the specified information. Then put together research paper sketch out.

9. **Use and get big pictures:** Always use encyclopedias, Wikipedia to get pictures so that you can go into the depth.

10. **Bookmarks are useful:** When you read any book or magazine, you generally use bookmarks, right! It is a good habit, which helps to not to lose your continuity. You should always use bookmarks while searching on Internet also, which will make your search easier.

11. **Revise what you wrote:** When you write anything, always read it, summarize it and then finalize it.
12. **Make all efforts**: Make all efforts to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in introduction, that what is the need of a particular research paper. Polish your work by good skill of writing and always give an evaluator, what he wants.

13. **Have backups**: When you are going to do any important thing like making research paper, you should always have backup copies of it either in your computer or in paper. This will help you to not to lose any of your important.

14. **Produce good diagrams of your own**: Always try to include good charts or diagrams in your paper to improve quality. Using several and unnecessary diagrams will degrade the quality of your paper by creating "hotchpotch." So always, try to make and include those diagrams, which are made by your own to improve readability and understandability of your paper.

15. **Use of direct quotes**: When you do research relevant to literature, history or current affairs then use of quotes become essential but if study is relevant to science then use of quotes is not preferable.

16. **Use proper verb tense**: Use proper verb tenses in your paper. Use past tense, to present those events that happened. Use present tense to indicate events that are going on. Use future tense to indicate future happening events. Use of improper and wrong tenses will confuse the evaluator. Avoid the sentences that are incomplete.

17. **Never use online paper**: If you are getting any paper on Internet, then never use it as your research paper because it might be possible that evaluator has already seen it or maybe it is outdated version.

18. **Pick a good study spot**: To do your research studies always try to pick a spot, which is quiet. Every spot is not for studies. Spot that suits you choose it and proceed further.

19. **Know what you know**: Always try to know, what you know by making objectives. Else, you will be confused and cannot achieve your target.

20. **Use good quality grammar**: Always use a good quality grammar and use words that will throw positive impact on evaluator. Use of good quality grammar does not mean to use tough words, that for each word the evaluator has to go through dictionary. Do not start sentence with a conjunction. Do not fragment sentences. Eliminate one-word sentences. Ignore passive voice. Do not ever use a big word when a diminutive one would suffice. Verbs have to be in agreement with their subjects. Prepositions are not expressions to finish sentences with. It is incorrect to ever divide an infinitive. Avoid clichés like the disease. Also, always shun irritating alliteration. Use language that is simple and straight forward. put together a neat summary.

21. **Arrangement of information**: Each section of the main body should start with an opening sentence and there should be a changeover at the end of the section. Give only valid and powerful arguments to your topic. You may also maintain your arguments with records.

22. **Never start in last minute**: Always start at right time and give enough time to research work. Leaving everything to the last minute will degrade your paper and spoil your work.

23. **Multitasking in research is not good**: Doing several things at the same time proves bad habit in case of research activity. Research is an area, where everything has a particular time slot. Divide your research work in parts and do particular part in particular time slot.

24. **Never copy others' work**: Never copy others' work and give it your name because if evaluator has seen it anywhere you will be in trouble.

25. **Take proper rest and food**: No matter how many hours you spend for your research activity, if you are not taking care of your health then all your efforts will be in vain. For a quality research, study is must, and this can be done by taking proper rest and food.

26. **Go for seminars**: Attend seminars if the topic is relevant to your research area. Utilize all your resources.
27. Refresh your mind after intervals: Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

29. Think technically: Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

31. Adding unnecessary information: Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

32. Never oversimplify everything: To add material in your research paper, never go for oversimplification. This will definitely irritate the evaluator. Be more or less specific. Also too, by no means, ever use rhythmic redundancies. Contractions aren’t essential and shouldn’t be there used. Comparisons are as terrible as clichés. Give up ampersands and abbreviations, and so on. Remove commas, that are, not necessary. Parenthetical words however should be together with this in commas. Understatement is all the time the complete best way to put onward earth-shaking thoughts. Give a detailed literary review.

33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

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.
Please carefully note down following rules and regulation before submitting your Research Paper to Global Journals Inc. (US):

**Segment Draft and Final Research Paper:** You have to strictly follow the template of research paper. If it is not done your paper may get rejected.

- **The major constraint** is that you must independently make all content, tables, graphs, and facts that are offered in the paper. You must write each part of the paper wholly on your own. The Peer-reviewers need to identify your own perceptive of the concepts in your own terms. NEVER extract straight from any foundation, and never rephrase someone else’s analysis.

- Do not give permission to anyone else to “PROOFREAD” your manuscript.

- Methods to avoid Plagiarism is applied by us on every paper, if found guilty, you will be blacklisted by all of our collaborated research groups, your institution will be informed for this and strict legal actions will be taken immediately.

- To guard yourself and others from possible illegal use please do not permit anyone right to use to your paper and files.
Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals Inc. (US).

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