Chemical Physics Letters 815 (2023) 140343

Contents lists available at ScienceDirect

Chemical Physics Letters

journal homepage: www.elsevier.com/locate/cplett

Calculations of Rényi entropy, Tsallis entropy and Onicescu information energy for helium, lithium and beryllium atoms using an analytic correlated wave function

Anupam Sarkar

Abhedananda Mahavidyalaya, Sainthia, Birbhum, West Bengal, India

ARTICLE INFO

Keywords:
Information theoretic quantities
correlated wave function
correlation measure.

ABSTRACT

A comparative study using an analytical correlated wave function for two K-shell active electrons and two electron uncorrelated wave function for two K-shell bare electrons, on information theoretic quantities such as, Rényi entropy, Tsallis entropy and Onicescu information energy are presented for helium, lithium and beryllium. Obtained differences can be interpreted as a measure of electron correlation and quantified for these quantities. Correlated one electron probability density is delocalized with respect to uncorrelated one-electron probability which increases/decreases the correlated values of these quantities. Results for helium atom are in good agreement with the available data in the literature.

1. Introduction

The growth of telecommunications in the early twentieth century led several researchers to study the information content of signals. In 1948, Claude E. Shannon set out to find fundamental limits on signal processing operations such as data compression, data storage and communication reliability through his paper " A Mathematical Theory of Communication"[1]. On the basis of earlier works by Nyquist [2,3] and Hartley [4], the seminal work of Shannon [1] rationalized these efforts of early twentieth century into a coherent mathematical theory of communication and initiated a new area of research, currently known as Information Theory. In other fields like statistical mechanics, applied mathematics, computer science, atomic and molecular physics and chemistry, this theory has been extended as an application since its proposal.

Since then, there has been continuous interest in the studies on information theoretic measures for quantum mechanical systems. In recent years, much effort has been invested to understand physical and chemical processes in the framework of information theory [5–10]. In information theory, entropy is a measure of uncertainty associated with the random variable. Here, the entropic uncertainty relation based on information entropies is considered as a stronger version of Kennard's relation (Heisenberg uncertainty principle), in the sense the Kennard's relation can be obtained from entropic uncertainty relation [11,12]. Entropy usually refers to the Shannon entropy in this field, which measure the expected value of the information stored in a massage. Shannon entropy is the hallmark of information theory [1,13,14]. In addition, in the context of atomic and molecular physics, Shannon entropy can be employed in the investigation of the localization or delocalization of electron distribution [1,15,16].

In the context of atomic and molecular physics, Shannon entropy is a hypothesis that describes the spatial distribution of the wave function for different states. When the concentration of the wave function is higher, Shannon entropy is small i.e. the wave function is localized when Shannon entropy is low and wave function is delocalized when Shannon entropy is high [1]. As a consequence Shannon entropy can be used to estimate the stability of a system i.e. system is likely to be more stable when the Shannon entropy is low and system is unstable when the Shannon entropy is high. Later, extensions of Shannon entropy have resulted in many alternative measures of information or entropy. For instance, by relaxing the Shannon's requirement, Rényi [17] was able to extend Shannon entropy to an alternative measure of information or entropy. In addition, Tsallis [18] also introduced alternative entropy as an extension of Shannon entropy. Both Rényi entropy [17] and Tsallis entropy [18] serve as one-parameter generalizations of Shannon entropy. Moreover, Onicescu information energy [19] serves to complement the concept of Shannon entropy.

Rényi entropies are widely used to examine quantum entanglement [20–21]. Tsallis statistics emerges in different systems of ultra cold atoms [22–23]. Furthermore, Onicescu information energy is relevant to the frequency moment of the electron density, up to a factor [24–25]. These information theoretic (IT) quantities have been applied to various atomic and molecular systems [26–27] and potentials [28–29]. Moreover these IT quantities are also applied in Statistical Mechanics [30–31], entropic uncertainty relation [32–33], orbital-free density-functional theory [5,34] and in electron-correlation [35–36].

https://doi.org/10.1016/j.cplett.2023.140343
Received 27 August 2022; Received in revised form 27 January 2023; Accepted 27 January 2023
Available online 31 January 2023
0009-2614/

HUMAN RESOURCE ACCOUNTING PRCATICES: AN EMPIRICAL STUDY OF INDIAN COMPANIES

* Dr Suvarun Goswami

** Biki Hawlader

INTRODUCTION

In recent years, human resources have been recognized as an important source of sustained competitive advantage. The American Accounting Association's definition of human asset accounting is the process of identifying and measuring information about human assets and communicating this data to interested parties. HR Accounting **concentrates** on the cost incurred in improving and developing human resources. Human resource is the most fundamental part of any organization, as it makes sure that there an interaction between financial and all other physical resources towards the achievement of organizational objectives and goals. Though the idea of accounting for human resources started many years back, the concept still lacks general acceptability. Many authors and scholars have conducted researches on how humans within an organization can be valued and reported in the financial statements of such organization. The increased Human Resource costs have converted more apparent in the service industry than in the manufacturing industry, as Human Resource was the leading contributor in the service sector.

Traditionally, according to general accounting principles, only monetary and physical assets are accounted in the books of account and there has been a failure to value human resources of an organization. Traditionally, all the expenses on human resources like cost of recruitment, selection, training and development are taken into consideration and are treated as a charge against revenue because it is assumed that such expenses do not create any physical asset.

---

* Assistant Professor, Rishi Bankim Chandra Evening College, Naihati , North 24 Parganas, West Bengal, Pin-743165, Email id: suvarungoswami@gmail.com

** Research Scholar, Department of Commerce, The University of Burdwan,
Email id: bikihawlader@gmail.com

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:05/Issue:02/February-2023 Impact Factor- 6.752 www.irjmets.com

HUMAN RESOURCE ACCOUTING: A LITERATURE REVIEW

Dr. Suvarun Goswami*1, Biki Hawlader*2

*1Assistant Professor, Rishi Bankim Chandra Evening College, Naihati, North 24 Parganas, West Bengal, India.

*2Research Scholar, Department Of Commerce, The University Of Burdwan, India.

DOI : https://www.doi.org/10.56726/IRJMETS33759

ABSTRACT

Human resource accounting is of recent origin and is striving for acceptance. Human resources. Accounting is an accounting analysis system and in the last decade a large body of literature has been published for setting the various procedures for analysis. At the same time from academicians the theory and underlying concepts of accounting measurement have received sizeable attention and a considerable body of literature has developed. The conventional accountings of human resources are not perceived as physical or financial assets.

This paper reviews the literature available on the perception of human resource accounting. In worth, previous study have shown and debated various magnitudes related to valuing human resource. For accounting human resources, different models have been developed which are helpful to identify and report investment made in the human resource of an organization that are not presently accounted for under conventional accounting practice.

I. INTRODUCTION

Winds of change are exhaustive over the corporate landscape and there is an increasing urgency to cope with the continually changing forces of competition, technological development and new trend in the economy which has force to a growing awareness that productive utilization of human resource which is the key to organizational success. Human resource accounting is of recent origin and is striving for acceptance. Human resources accounting is an accounting analysis system and in the last decade a large body of literature has been published for setting the various procedures for analysis. At the same time from academicians the theory and underlying concepts of accounting measurement have received sizeable attention and a considerable body of literature has developed. The conventional accountings of human resources are not perceived as physical or financial assets. HRA is a management tool which is designed to assist senior management in understanding the long term cost and benefit implication of their HR decision so that better business decision can be taken. If such accounting is not there, then the management runs the risk of taking decision that may improve profit in the short run but may also have severe results in future.

II. REVIEW OF LITERATURE

1st. **Elias (1976)** attempted to provide framework for analyzing the behavioral aspects of accounting methods. It was found that HRA due to its behavioral impact had a distinct effect on decision making. It had a potential impact for both functional and dysfunctional consequences which were different depending on the circumstances and management philosophy. All expenditures related to HR were considered to have been made for the acquisition and maintenance ofhuman assets and are therefore capitalized. It was suggested to consider sunk cost in the various analysis of the company.

2nd. **Fleming (1977)** assessed the behavioral implications if a value for employee published as an asset on the balance-sheet. For the purpose of the study a survey was done on faculty members and students, which was based on a questionnaire. It was revealed that 43% of faculty and 38% of students were against the statement that placing a dollar value on human being is an insult to their dignity and an equal percentage of faculty felt that it was not only an insult but also a way treating people as slaves or machines. 85% of students were against the discloser of information publicly related with individual.

3rd. **Tsay (1977)** analyzed the relevance of internal and external reporting in an organization. The mutual dependence of measurements & decisions was defined by considering some examples and found that the internal reporting was relevant of effective decision making. It was concluded that measurement can be proposed after considering its purpose. HRA measures proposed for financial reporting should be based on

IN SEARCH OF UNIQUE HR PRACTICES: A STUDY WITH PARTICULAR REFERENCE TO INDIAN ITS SECTOR

*Prof (Dr) Suvarun Goswami

** Biki Hawlader

1. Introduction

In small as well as in large companies, and HR function needs a balanced approach between industry standards and innovative business techniques. The other truth about the High Impact organizations is "the basic rights for HR leaders". Perfect execution of the fundamentals of HR functions of recruitment, handling Payroll, remuneration, employee growth & development should be efficacious and timely and the organization would be known to it. The HR professionals are provided with the strategic agenda and all rights for the execution of the HR functions in the organization. Rights are necessary for taking the responsibility and authority of work.

On the other hand, there is a need for continuous improvement at every step of operations. For the incremental transformation and continuous improvement, the High Impact HR organization keeps moving with the changes and improvement processes. No doubt, the better results need efforts while restricting, repairing and rebuilding the functions. Change is essential in the process of transformation. High –Impact HR organizations leaders design the decisive HR functions that can be easily adopted by the workforce, management as well as by the workforce.

Remember, HR resource is not a machine or object –they are living beings. They have feelings, they think, they perceive, they analyse, and they are different in terms of background, experience, culture, age and knowledge. HR leaders should take easy and agile steps for the improvement of this source. However, things are changing at a rapid speed. The working environment and would change in the coming years because of the latest technology updates and user- friendly organization system.

---

* Assistant Professor (Stage III) , Rishi Bankim Chandra Evening College, Naihati , North 24 Parganas, & Guest Lecturer in Department of Commerce, WBSU, Barasat, West Bengal, Pin-743165, Whatapps No: 8900632988,

** Research Scholar, Department of Commerce, The University of Burdwan , Whatapps No: 7908190263,

ACS OMEGA

http://pubs.acs.org/journal/acsodf

Article

Interfacial Interactions of a Myoglobin/DOPC Hybrid System at the Air−Water Interface and Its Physicochemical Properties

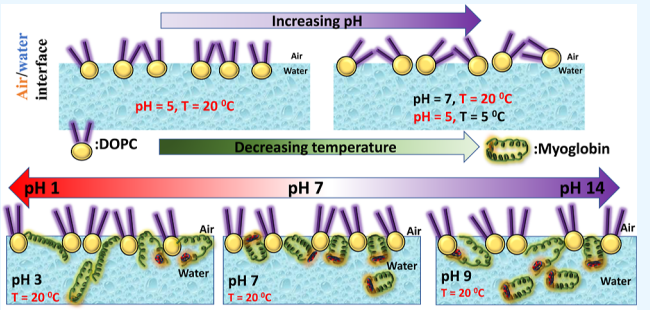
Ikbal Ahmed, Nilanjan Das, A. K. M. Maidul Islam,* Jasper Rikkert Plaisier, Pietro Parisse, and Jayanta Kumar Bal*

Cite This: *ACS Omega* 2023, 8, 30199−30212

Read Online

ACCESS | Metrics & More | Article Recommendations | Supporting Information

ABSTRACT: In the present study, the intermolecular interactions between a water-insoluble phospholipid (DOPC) and water-soluble protein (myoglobin) and the interaction among themselves were investigated at the air−water interface using the Langmuir and Langmuir−Blodgett techniques. The effects of changes in physicochemical factors, like pH and temperature, on these interactions were also examined. Surface pressure−molecular area (π−A) isotherms of the DOPC monolayer at the air−water interface, with and without myoglobin (Myo) revealed the evolution of various physical properties, such as elastic, thermodynamic, and hysteric properties, in response to changes in subphase pH and temperature. With the increment of subphase pH from 5 to 7 at a fixed temperature (20 °C), the DOPC isotherm expanded, and the in-plane elasticity (C_S^{-1}) decreased, but no significant presence of hysteresis was encountered in either of the pH values. On the other hand, a diminution of temperature (from 20 to 5 °C) leads to an expansion of monolayers yielding low elasticity and significant hysteresis. The incorporation of Myo molecules within the DOPC monolayer decreased the C_S^{-1} value of the DOPC monolayer. Such a decrement in C_S^{-1} was also encountered while increasing the pH and decreasing the temperature (T) of the subphase in the absence of Myo. Systematic expansion of DOPC isotherm and increased hysteric area with the increase in Myo proportion were observed and the atomic force microscopy (AFM) observations suggested a strong conjugation between Myo and DOPC in the mixed monolayer. The denaturation effect of Myo molecules was studied using AFM at different temperatures. Furthermore, the Myo molecules were found to be most surface active at pH = 7, which is very close to its isoelectric point. These observations come up with the interaction mechanism between biomolecules under dynamically varied conditions.



1. INTRODUCTION

The lipid monolayer that forms at the air−water interface can be viewed as a valuable model membrane for studying the interactions of biomolecules, such as DNA, proteins, cellulose, and others, with cell membranes.[1−7] This is because the model membrane mimics the physical and chemical properties of the cell membrane, providing a simplified but representative system for investigating these interactions. Studies of this model membrane have led to a deeper understanding of how biomolecules interact with cell membranes, which is crucial for understanding how cells function and communicate with each other. Additionally, studies of the model membrane have provided insights into biomolecules' fundamental properties and behavior in solution and at interfaces. A particular focus of these studies has been on the role of phospholipids in biological membranes. Due to their unique amphiphilic properties, phospholipids, which are major components of biological membranes,[8] are currently being studied in the fields of biochemistry, chemistry, and polymer science.[9] These studies aim to better understand the structure of phospholipids and how it relates to the biophysical characteristics of biological membranes, as well as the specific molecular interactions of medicinal drugs with biological membranes.[10] Moreover, it is particularly intriguing to observe how phospholipid monolayers spread and develop at the air−water interface because it resembles the physiological function of lung surfactant.[4] Lung surfactant, a crucial component in breathing, comprises phospholipids and determined amounts of surface-active proteins. It works by spreading across the aqueous alveolar−air interface and significantly reducing surface tension, which lessens the effort required for breathing and plays a vital role in controlling pulmonary immunity and other related physiological functions within the lungs.[4] This

Received: April 27, 2023
Accepted: July 31, 2023
Published: August 12, 2023

Biointerface Research in Applied Chemistry
Open-Access Journal (ISSN: 2069-5837)

Article
Volume 13, Issue 6, 2023, 503
https://doi.org/10.33263/BRIAC136.503

Transitions Among Doped *GaAs* Quantum Dot Eigenstates Initiated by Time-Varying Impurity Potential: Influence of Noise

Swarnab Datta [1], Sekh Mohammed Arif [2], Debi Roy [3], Manas Ghosh [2,*]

[1] Eklavya Model Residential School, Kanksa, West Burdwan-713148, West Bengal, India
[2] Department of Chemistry, Physical Chemistry Section, Visva-Bharati University, Santiniketan, Birbhum 731 235, West Bengal, India; arif8talpur@gmail.com(S.M.A.);pcmg77@rediffmail.com (M.G.);
[3] Department of Chemistry, Abhedananda Mahavidyalaya, Sainthia, Birbhum 731234, West Bengal, India
* Correspondence: pcmg77@rediffmail.com(M.G.);

Scopus Author ID 8258661600
Received: 18.10.2022; Accepted: 24.11.2022; Published: 31.01.2023

Abstract: The study thoroughly analyzes the time-average excitation rate of impurity-doped *GaAs*quantum dots under the supervision of Gaussian white noise. The excitation of the ground state population has been initiated by a time-dependent impurity potential strength. Gaussian whitenoise links with the system by additive and multiplicative modes. The study unveils the outcomeof some parameters' concerted impact, which ultimately designs the characteristics of the timeaverageexcitation rate plots. These parameters include a variation of several physical quantities andtheir magnitude, the presence of Gaussian white noise in a given mode, and the time-dependent fluctuation of impurity potential strength (periodic/random). As a result, the time-average excitation rate diagramsconsist of monotonic growth, monotonic drop, maximization (importantgiventhe production of large nonlinear optical properties), and minimization and saturation (relevant to dynamic freezing). The observations highlight the means of exploiting time-dependent impuritypotential strength to regulate the time-average excitation rate among the doped *GaAs* quantumdot eigenstates.

Keywords: quantum dot; Gaussian white noise; time-average excitation rate; time-dependent impuritypotential strength.

1. Introduction

Quantum dots (QDs) are a special class of low-dimensional nanostructures characterized by the completely restricted motion of the carriers (electrons and holes) in space. By virtue of their extremely small size, they become able to exhibit a number of quantum phenomena. QDs manifest remarkable size-dependent electronic, electrical, optical, magnetic, and thermodynamic properties. These properties are often found to be quite tunable and lead to widespread usage of QDs in various technologically advanced devices.

Doping of impurity to QD affects its effective confinement potential (ECP) and altersits energy spectrum and eigenstates. The above alteration makes external regulation ofthe physical properties of QDs quite achievable, giving rise to the enormous scope of fabricatingadvanced quantum devices. As a result, we find lots of research works examining the impurity effects in QD and other low-dimensional semiconductor systems (LDSS) [1-10].

ChemistrySelect

Research Article
doi.org/10.1002/slct.202203839

Chemistry Europe
European Chemical Societies Publishing

www.chemistryselect.org

External Field-induced Transitions in Quantum Dot: Role of Noise-anharmonicity Interplay

Swarnab Datta,[a] Sk. Md. Arif,[b] Debi Roy,[c] and Manas Ghosh*[b]

This work scrutinizes the *time-average excitation rate* (*TAER*) among the *GaAs quantum dot* (*QD*) eigenstates under the aegis of *Gaussian white noise* (*GWN*) and the *parity* of the *anharmonic potential* (*odd/even*). GWN connects with the system by *additive* or *multiplicative* mode. The said excitation of the ground state population has been triggered by an external field which may be a *polychromatic radiation field* (*PRF*), or *pulsed field* (*PF*) or *chirped pulsed field* (*CPF*). The study reveals the subtle nuances of the interplay between noise (additive or multiplicative), anharmonicity (odd or even) and the external field (PRF, PF or CPF) that finally govern the attributes of the TAER diagrams. The TAER profiles exhibit persistent growth, persistent decline, maximization (important in view of production of prominent *nonlinear optical properties*), minimization and saturation (relevant to *the dynamic freezing*). The findings appear useful for regulating the TAER among the *GaAs* QD eigenstates which have substantial technological relevance.

Introduction

Quantum dots (*QDs*) are special kind of low-dimensional nanostructures with totally arrested movement of the carriers (electrons and holes) in space. Exploiting their extremely small size they often manifest quantum behavior consisting of noticeable size-dependent electronic, electrical, optical, magnetic and thermodynamic properties. More often than not, these properties appear to be quite adjustable and make QD an ubiquitous component of various technologically sophisticated devices. In consequence, we find a rich amount of studies devoted to the low-dimensional nanostructures[1–11] with special emphasis on their *nonlinear optical* (*NLO*) properties.[12–39] In this context, a few works that reside in the research frontier of QD systems merit mention.[40–42]

Harnessing the *effective confinement potential* (*ECP*) of QD is a key issue as it modulates its energy spectrum and the eigenstates. Such modulation makes external control of the physical properties of QDs quite viable and opens up new avenues of manufacturing advanced quantum devices. Existence of *anharmonic potential* in QD noticeably affects the ECP which is reflected through substantial change in its various properties. Thus, the performance of the devices consisting of QDs is also modified. This fact makes anharmonicity achieve significant technological relevance, and, indeed, anharmonicity assumes unquestionable prominence in the field of microelectronics and optoelectronics. Furthermore, the *symmetry* (*odd/even*) of the anharmonicity also puts recognizable signature on modulation of several properties of low-dimensional systems. For example, if we envisage QDs composed of circular or parabolic confinement and consisting of single carrier, the symmetry of the system makes first NLO response completely disappear. Interestingly, inclusion of a parity breaking (symmetry removing) anharmonicity in the ECP produces noticeable non-vanishing quadratic hyperpolarizability. Added to this, a regular variation in the anharmonicity strength can also affect the properties of the low-dimensional nanostructures.[43]

Gaussian white noise (*GWN*) can also be introduced to the QD system and becomes another member of the ECP. Presence of noise invariably alters the performance of QD-based devices and thereby deems substantial relevance. GWN, in general, is endowed with two special physical attributes like *zero-average* and *spatial delta-correlation*. The extent to which GWN affects the ECP depends on how it links with the QD, i.e., in other words, how it is applied to the QD. Specifically, GWN is termed as *additive white noise* (*ADWN*) and *multiplicative white noise* (*MLWN*) depending on its way of being applied to the QD. As ADWN and MLWN interact differently with QD, the properties of the system are also modified differently with respect to the situation completely devoid of noise.

External electromagnetic field induces excitation of ground state electronic population of the low-dimensional systems to the higher eigenstates.[44–49] Such excitation bears tremendous importance in view of exploring new pathways of electronic transport, fabrication of advanced opto-electronic and light-emitting devices[46] and quantum computation.[44,50,51] Furthermore, such transitions also become responsible for the production of significant linear and NLO responses. The extent of such transition, on the whole, is governed by the ECP which comprises of the inherent QD confinement potential, presence of noise and the features of the anharmonic potential.

Polychromatic radiation field (*PRF*) is an example of external field which can promote transitions among QD eigenstates. A continuous wave laser can produce PRF. A PRF usually contains

[a] *S. Datta*
Eklavya Model Residential School, Kanksa, West Burdwan- 713148, West Bengal, India
[b] *Dr. S. M. Arif, Dr. M. Ghosh*
Department of Chemistry, Physical Chemistry Section,
Visva-Bharati University, Santiniketan, Birbhum- 731235, West Bengal, India,
E-mail: manasghosh.chem@visva-bharati.ac.in
[c] *D. Roy*
Department of Chemistry, Abhedananda Mahavidyalaya,
Sainthia, Birbhum 731234, West Bengal, India

ChemistrySelect

Research Article
doi.org/10.1002/slct.202204212

Chemistry Europe
European Chemical Societies Publishing

www.chemistryselect.org

Population Transfer Among the Quantum Dot Eigenstates Driven by Time-dependent Anharmonic Potential: Role of Noise

Swarnab Datta,[a] Sk. Md. Arif,[b] Debi Roy,[c] and Manas Ghosh*[b]

The study meticulously inspects the *time-average excitation rate (TAER)*of lowest energy state electronic probability of *GaAs quantum dot (QD)*to the higher energy states. The excitation occurs as the *anharmonic potential*(a part of QD confinement) starts varying with time either *periodically*or *randomly*. The anharmonic potential is characterized by either *even*or *odd*-parity. *Gaussian white noise (GWN)*has also been introduced to the QD either via *additive*or *multiplicative*mode. The study announces that the coupled impact of the given physical quantity, the symmetry of the anharmonicity, presence/absence of noise, the route of entrance of noise, and the nature of time progress of anharmonicity constant, ultimately regulates and fine-tunes the attributes of the TAER diagrams. The TAER diagrams comprise of regular rise, regular fall, maximization (pertinent to production of high value of *nonlinear optical (NLO) properties*), minimization and saturation (pertinent to *dynamic freezing*). The outcomes of the study seem to be recognizable in various applications of devices containing QD.

Introduction

*Quantum dots (QDs)*are renowned low-dimensional nanostructures characterized by total spatial restriction of the movement of the carriers (electrons and holes). By virtue of their extremely small size they often exhibit quantum behavior revealed through the size dependent electronic, electrical, optical, magnetic and thermodynamic properties. These properties generally emerge out to be quite controllable there by making QD a widespread component of several technologically advanced devices. In consequence, we find lots of works that deal with the various aspects of the low-dimensional nanostructures[1–9] with special thrust on their nonlinear optical (NLO) responses.[10–31] Modulation of the *effective confinement potential (ECP)*of QD is a central issue as it affects its energy spectrum and the eigenstates. Such modulation makes it possible to regulate the properties of QDs and plays crucial role in manufacturing improved quantum devices. Presence of *anharmonicity*in QD modifies the ECP and hence its various properties, which, in turn, influences the output of QD-based devices. The anharmonic potential is not any external potential but a part of inherent confinement potential of QD. Luban et al. in theirwork have showed that certain features of energy spectrum of QD nanostructures cannot be explained from purely parabolic confinement. In order to explain these features consideration of anharmonic confinement becomes necessary leading to considerable modifications to parabolicity. The anharmonicity arises due to irregularities in the charge distribution. Consideration of anharmonicity offers new insights and opportunities in device microfabrication and operation.[32] Thus, anharmonicity assumes a lot of importance reflected through its unquestionable technological relevance in the field of microelectronics and optoelectronics. It needs to be mentioned that the *symmetry (odd/even)*of the anharmonicity plays vital role in influencing the properties of the low-dimensional systems. For example, the first NLO response of single carrier QDs with circular or parabolic confinement completely subsides owing to the symmetry of the system. However, the incorporation of a parity breaking (symmetry disrupting) anharmonicity in the ECP generates significant non-vanishing quadratic hyperpolarizability. Obviously, a gradual change in the anharmonicity strength influences the properties of the low-dimensional nanostructures.[33] Introduction of *Gaussian white noise (GWN)*to QD is an alternative way of perturbing its ECP. Noise enjoys utmost importance thanks to its well-known capacity of changingthe performance of devices comprising of low-dimensional systems. GWN is defined by two essential physical criteria of *zero-average*and *spatial delta-correlation*. It is the mode of attachment of GWN to QD which determines how it affects the ECP. To be precise, GWN is called *additive white noise (ADWN)*and *multiplicative white noise (MLWN)*depending on the aforesaid mode. Since ADWN and MLWN couple differently with QD, its physical properties are also changed in diverse ways in comparison with the noise-free environment. Excitation of ground state electronic probability to the higher states in QDs is extremely important for electronic transport, production of large *nonlinear optical (NLO)*responses, designing of novel opto-electronic and light-emitting devices and quantum computation.[34–36] Most often, above transitions take place by the interaction of low-dimensional systems with the impinging electromagnetic radiation.[36–41] The size (extent/

[a] *S. Datta*
Eklavya Model Residential School, Kanksa,
713148 West Burdwan, West Bengal, India
[b] *Dr. S. M. Arif, Dr. M. Ghosh*
Department of Chemistry, Physical Chemistry Section,
Visva-Bharati University, Santiniketan,
731235 Birbhum, West Bengal, India
E-mail: manasghosh.chem@visva-bharati.ac.in
[c] *D. Roy*
Department of Chemistry, Abhedananda Mahavidyalaya,
731234 Sainthia, Birbhum, West Bengal, India

Microsystem Technologies
https://doi.org/10.1007/s00542-023-05474-1

TECHNICAL PAPER

Role of two-dimensional electron gas (2DEG) in GaN/AlGaN avalanche transit time (ATT) oscillator for RF performance boosting: application in THz opto-electronics

Sulagna Chatterjee[1] · Moumita Mukherjee[2]

Received: 4 March 2023 / Accepted: 15 May 2023

Abstract
This article reports opto-electronic switching properties of heterostructure GaN/AlGaN lateral Avalanche Transit Time (ATT) diode oscillator. A novel technique has been adopted for the incorporation of 2DEG effect in two-terminal device. This is achieved through the inherent conduction band offset and subsequent application of Cathode Field Plate (CFP) in combination with lateral orientation. The performance superiority of the proposed electrical and optical switches over conventional silicon devices is evidently established and experimentally verified. Under dark condition, maximum RF power output with and without series resistance has been obtained as, $RFP_{SR} \sim 1.5 \times 10^{11} W/m^2$ and $RFP \sim 2.84 \times 10^{11} W/m^2$ at 0.4THz. Also, the mentioned parasitic series resistance has been obtained to be, $R_{Parasitic} \sim 7 \times 10^{-10} \Omega/m^2$. Under illumination, output power with and without series resistance, have been deduced to be $RFP_{SR} \sim 1 \times 10^{11} W/m^2$ and $RFP \sim 2 \times 10^{11} W/m^2$ at 0.5THz, for $M_N = 10$. To the best of authors' knowledge this is the first report on electro-optical performance optimization study in connection with exotic type GaN/AlGaN two-terminal ATT oscillator. A power combining technique is used in designing a 3×3 array. For the 3×3 array structure, the parasitic series resistance is obtained to be $R_{Parasitic} \sim 8.5 \times 10^{-10} \Omega/m^2$. Value of the series resistance has increased for such array as compared to a single diode, due to circuit loading. In spite of such increase in series resistance, RF output power increases substantially for the array structure, due to enhanced negative conductance. Under dark condition at 0.4THz, $RFP_{SR} \sim 4 \times 10^{11} W/m^2$ and $RFP \sim 7.7 \times 10^{11} W/m^2$ are the RF power output with and without series resistance. Further, for illuminated array structure, peak RF power output, with and without series resistance, is obtained to be $RFP_{SR} \sim 2.4 \times 10^{11} W/m^2$ and $RFP \sim 5.3 \times 10^{11} W/m^2$ at 0.5THz, for $M_N = 10$. The reported performance enhancement of the newly designed ATT diode is due to the high mobility 2DEG transport region. Such 2DEG has resulted from the quantum confinement caused by GaN/ AlGaN conduction band offset in conjunction with the unique CFP and lateral orientation of the proposed diode. For the first time, quantum confined high mobility 2DEG transport region has been formed in a two-terminal ATT device.

1 Introduction

Since the recent past, GaN electronics is gradually gaining prominence and is being thought of as a promising alternative to conventional low mobility Si-based electronics. As a material GaN has multifold advantages compared to Si, namely: mechanical strength and stability with remarkably high breakdown strength, inherent wide band-gap and high thermal conductivity (Boutros et al. 2013; Letellier et al. 2015; Longobardi 2017; Vecchia et al. 2019). Further, GaN is potentially more suitable for power electronics due to its fast switching ability and low ON resistance (Chu 2020). Therefore, both academic and research community have been focusing on GaN based devices (Mukherjee et al. 2007, 2008; Mukherjee and Roy 2009; Kundu et al. 2018). Some important instances of such recent research includes GaN/$Al_{0.3}Ga_{0.7}N$ multilayer nano-heterostructures (Alvi et al. 2010), InN/$Al_{0.30}In_{0.70}N$ multilayer nano-heterostructures (Alvi et al. 2011), GaN based quantum well Light Emitting Diode (LED) for Ultra

✉ Sulagna Chatterjee
chatterjeesulagna45@gmail.com

[1] Department of Electronics and Communication Engineering, Adamas University, Kolkata 700126, India

[2] Department of Physics, Adamas University, Kolkata 700126, India

Published online: 04 June 2023

INTERNATIONAL JOURNAL OF MODELLING AND SIMULATION
https://doi.org/10.1080/02286203.2023.2249656

Taylor & Francis
Taylor & Francis Group

Significance of binary chemical reaction with activation energy in magneto-bioconvection flow of a Powell Eyring nanofluid past an inclined stretching sheet by considering temperature-dependent viscosity and thermal conductivity

Surya Kanta Mondal[a] and Dulal Pal[b]*

[a]Department of Mathematics, Abhedananda Mahavidyalaya, West Bengal, India; [b]Department of Mathematics, Visva-Bharati University, West Bengal, India

ABSTRACT

In this paper, an unsteady magneto-bioconvection flow of Powell Eyring nanofluid over an inclined stretching sheet in the presence of variable viscosity and thermal conductivity with multiple slip effects has been investigated numerically. The binary chemical reaction with activation energy, viscous dissipation and nonlinear thermal radiation effects are included in this study. The fluid viscosity and the thermal conductivity are assumed to be a linear function of temperature. The basic governing equations are solved numerically by the Runge-Kutta Felhberg method after using similarity transformation. The impact of bioconvection and important physical parameters on profiles of velocity and temperature of nanofluid and nanoparticles concentration, the density of motile microorganisms are analyzed graphically. Findings reveal that the velocity profile decreased by increasing the Powell Eyring fluid parameter values, whereas the temperature distribution depicts the opposite trend. The temperature profile increased with an increment of thermal conductivity parameter, whereas the opposite trends are found for Eckert number. The trend of the graph of temperature profile and nanoparticle concentration profile declined with an increment of the temperature slip parameter. Also, the nanoparticle concentration profile and density of microorganism profile decreased with an increment of activation energy parameter and chemical reaction parameter. The scope of the present investigation can be related to the advanced nanomechanical bioconvection energy conversion devices and bio-nanocoolant systems, among other relevant things.

ARTICLE HISTORY
Received 20 January 2023
Accepted 16 August 2023

KEYWORDS
Powell Eyring nanofluid; bioconvection; temperature dependent viscosity and thermal conductivity; activation energy and binary chemical reaction; inclined stretching sheet

1. Introduction

Most fluids used in industries are non-Newtonian (i.e. the relationship between shear stress and strain is nonlinear) because Newtonian fluids have some limitations in giving accurate predictions of flow formations and heat transfer. Some examples of non-Newtonian fluids are mud, ketchup, blood, toothpaste, lubricant, etc. Researchers are dedicated to investigating various patterns of non-Newtonian fluids. Several models have been proposed to understand and analyze this type of fluids (non-Newtonian fluids), such as the power-law model, the Casson fluid model, Maxwell fluid model, Jeffrey fluid model, Eyring-Powell fluid model, and so on. The Eyring-Powell fluid model has been employed for the present investigation. This model is proposed by Eyring and Powell [1]. Powell-Eyring fluid model is advantageous over the other non-Newtonian models because the Powell-Eyring fluid pattern is distinguished by following the same behavior as Newtonian fluid for low and high shear rates. Also, it was deduced from the kinetic theory of liquids rather than the experimental relationships in the case of the Power-law model (Malik et al. [2]). Several research articles have been devoted to comprehending this type of fluid and its applications in industries. Hayat et al. [3] explored Powell-Eyring fluid mixed convection unsteady flow under chemical reaction, thermal radiation, and non-uniform heat source/sink over an inclined stretching sheet. Reddy et al. [4] examined unsteady Powell-Eyring fluid heat and mass transfer over an inclined stretching sheet with a non-uniform heat source/sink, thermal radiation, and first-order chemical reaction effects.

Nanoparticles are tiny sized (diameter $< 100nm$) solid particles. These particles are mixed with base fluids such as water, kerosene, engine oil, ethylene glycol, and biofluid to enhance the heat transfer properties of the fluid. The

CONTACT Dulal Pal dulalp123@rediffmail.com Department of Mathematics, Institute of Science, Visva-Bharati University, West Bengal 731235, India
*Former Professor