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Impact of Iron Oxide Phases on the Magnetic Induction Heating Capacity of Mesoporous $45SiO_2-16.5CaO-24.5Na_2O-6P_2O_5-8Fe_3O_4$ Glass-Ceramics

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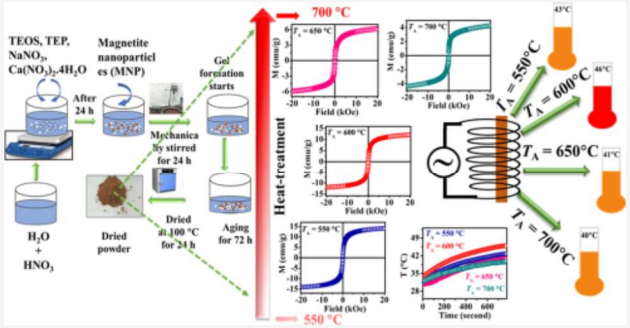
ABSTRACT: Sol−gel-based mesoporous $45SiO_2-16.5CaO-24.5Na_2O-6P_2O_5-8Fe_3O_4$ bioglass-ceramics were obtained by substituting magnetite nanoparticles for CaO in a $45SiO_2-24.5CaO-24.5Na_2O-6P_2O_5$ bioglass composition. To enhance the dissolution of the precursors and to vary the crystalline phases, the as-synthesized ceramic powders were processed for 1 h each at temperatures (T_A) between 550 and 700 °C. A gradual decline in the saturation magnetization with an increase in T_A was observed, which is linked to the gradual conversion of magnetite into hematite at different T_A > 550 °C. All of the processed samples indicated a hydroxyapatite surface layer formation in *in vitro* tests. Aqueous solutions of the ceramic processed at 600 °C exhibited superior magnetic induction capacity. Thus, the substitution of magnetite nanoparticles for CaO in the base composition, coupled with appropriate heat treatment, results in a promising bioactive glass-ceramic for magnetic hyperthermia treatment of deep-rooted cancer cells.



INTRODUCTION

Glass-ceramics exhibit a vast range of applications, including biomedical, owing to their inherent properties.[1,2] The advent of bulk bioglass-ceramic $45SiO_2-24.5CaO-24.5Na_2O-6P_2O_5$ (45S5) signaled a promising breakthrough in the realm of bone regenerative applications.[2] To extend the utility to magnetic hyperthermia treatment of cancer (MHT), attempts have been made to incorporate oxides of ferromagnetic elements such as Fe, Co, and Ni in the 45S5 ceramic.[3] Among these elements, Fe stands out due to its low toxicity and high biocompatibility, making Fe-substituted glass-ceramics suitable for MHT.[4] In MHT, the magnetic glass-ceramic experiences a temperature rise under an alternating magnetic field due to hysteresis loss.[5] Initial research on MHT dates back to 1957, when bulk maghemite (γ-Fe_2O_3) was tested at 1.2 GHz. Subsequent studies explored various methodologies, magnetic materials, and magnetic field conditions.[6,7] However, the lack of biocompatibility of maghemite raised concerns about post-MHT hazards on healthy cells and tissues. Achieving a delicate balance between bioactivity and magnetic properties is a significant challenge in synthesizing such materials.[8] In this context, considerable efforts have been made on bulk iron oxide-substituted glass-ceramics. A comprehensive review of the literature was conducted by Velasco et al. on bulk and nanopowder forms of magnetic glass-ceramics (MGCs).[8] The review emphasized the need for an organized investigation of both magnetic and bioactive properties of MGC for developing efficient thermoseeds for MHT.[7] The nanopowder form of MGC is preferred over the bulk counterpart due to the former's enhanced surface-related properties.[3,9] We have recently prepared and investigated the properties of Fe_2O_3 and Fe_3O_4 nanoparticles substitution for SiO_2 up to 15 wt % in the $45SiO_2-24.5CaO-24.5Na_2O-6P_2O_5$ glass.[3,10,11] Ur Rahman et al. also discussed the potential of the $7Fe_3O_4-51SiO_2-18CaO-20Na_2O-4P_2O_5$ ceramic containing magnetite phase.[12] Singh et al. identified three crystalline phases, viz., combeite, wollastonite, and magnetite, in the bulk $SiO_2-CaO-Na_2O-P_2O_5-Fe_2O_3$ glass-ceramic and found that their relative percentages varied with Fe_2O_3 concentration.[13,14] The available literature on the $SiO_2-CaO-Na_2O-P_2O_5-Fe_3O_4$ glass-ceramics, although profound, does not reveal the role of different magnetic phases present and their relative percentages on the interaction between the Fe ions in the ceramic network or their impact on their induction heating capacity. To explore this gap in the literature, we fabricated mesoporous $45SiO_2-$

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Zooplankton Communities of Three Wetlands of Nagaland, NE-India: Richness, Ecology and Abundance

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Abstract

The limnological studies was carried out in three selected wetlands viz., Noune, Madladijam and Bolfangdisa wetland in Nagaland from December 2014 to November 2016. A total of 269 species (S) of net plankton with zooplankton (181 species) > phytoplankton (88 species) revealed species-rich assemblage and thus affirmed environmental heterogeneity of the sampled habitats; ~50% are noted to occur in all the sampled wetlands. Zooplankton is characterized by biodiverse nature (181 species) with higher mean richness (139±22 species) in the three wetlands individually. The study indicates distinct monthly variations with higher richness in Bolfangdisa (27-69, 46±11 species) > Madladijam (25-60, 43±9 species) than in the 'semi-limnetic waters' of Noune (16-45, 29±9 species) wetlands, thereby, affirming habitat diversity amongst these lentic ecosystems. The abundance of zooplankton followed an oscillating monthly variation in the three wetlands. The density of zooplankton ranged between 63-186 (102±30) n/l in Noune wetland, 102-188 (3142±26) n/l in Madladijam wetland and 73-221 (135±39) n/l in Bolfangdisa wetland. ANOVA registered significant zooplankton richness variations amongst wetlands ($F_{2, 71}$=32.444, p =1.625E-09) and significant monthly variations ($F_{23, 71}$=2.345, p=0.006) between them. Rotifera formed the most important quantitative component of zooplankton of the sampled Nagaland wetlands. The present study records high species diversity and evenness and lower abundance and recorded limited density variations between wetlands. CCA asserted differential cumulative influence along first two axes of seventeen abiotic factors on zooplankton assemblages with high influence in Madladijam (84.2%) and Bolfangdisa (73.3%) and low influence in Noune (53.8%). The present study provides limited insight on the influence of individual abiotic parameters on zooplankton asserted generalist nature of majority of taxa in terms of general abiotic factors, with factors associated with microhabitat being more important.

Keywords: Density, Diversity, Abundance, Wetlands, Nagaland

Introduction

The zooplankton communities inhabiting wetland ecosystems plays a crucial role in nutrient cycling, food web dynamics, and overall ecosystem health. Freshwater ecosystems host a diverse range of aquatic organisms, with zooplankton playing a crucial role as primary consumers within aquatic food webs, thereby significantly impacting biological productivity (Steinberg & Robert, 2009). The smaller water bodies (wetlands and ponds smaller than 10 hectares in surface area) constitute over 90% of standing waters of our biosphere, and approximately 30% of the total surface area of lentic biotopes (Downing *et al.*, 2006). The small lentic ecosystems are integral components of freshwater ecosystems worldwide and are interconnected within the global network of metabolically active sites (Downing, 2010). They are increasingly recognized as biodiversity hotspots, encompassing diverse species compositions and biological characteristics (EPCN, 2008), thereby serving a crucial function in preserving biodiversity

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The Influence of Neural Behavior on Individuals' Financial Decisions

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ABSTRACT: To cope with the complexity of modern life, the need for better financial education is more crucial than ever. To make a good financial decision, a person needs to equip himself or herself with the knowledge and skills necessary to make an informed financial decision, manage debt effectively, plan for the future, and navigate a complex economic landscape. To exercise these complex economic decisions, the brain plays an important role in integrating information, assessing risk and reward, managing emotions, and executing strategies to achieve financial goals. As a result, an emerging field in the area of behavioral finance has emerged, which acts as a multidisciplinary field of study known as neurofinance. Neurofinance is a combination of fields of study like neurology, psychology, and finance and is an important tool for understanding an individual's behavior towards financial activity done through brain mapping. Thus, this paper constructs the concept of neurofinance in the life of an individual financial decision-maker. The present study demonstrates the available studies constructed by different researchers, authors, and organizations. After reviewing the existing literature, the researcher found a major gap in that there was not a single study conducted to determine the influence of neural behavior on financial decision-making among the private and government sector employees of a selected region. Therefore, it is imperative to know whether there is any association between neurofinance and the individual financial decision-making of the people in North-East India. Accordingly, it is anticipated that this review paper will facilitate forthcoming empirical research to examine individual financial decision-making in detail.

KEYWORDS: Neural Behavior, Behavioral Finance, Neurofinanace, Brain Mapping, Financial Decision

1. INTRODUCTION

In recent times, the study of brain have been highly appreciated to the extent that it has become one of the basic study like any of the normal subject in any course of studies. The study of brain and its functioning is normally known as 'neuroscience' which encompasses various subfields that examine different aspects of nervous system function of human body. Due to the development of the field of study, it has invariably attracted a huge crowd of researchers to do research in this field.Big countries have tended to make huge investments to explore the human brain through neural networks and model its structure and working mechanisms through the advanced technologies of computer science and artificial intelligence (Belabes, 2015).The curious minds, with an intention to explore the new field of research attracted researchers from various streams to try their luck to find something outstanding. With all the connection of interested parties coming from various field of study, neuroscience can now be called as an emerging interdisciplinary field of study.The neuroscience involves the study of brain parts, equally pointed out by Joshua & Michael that,"neural activity that represents immediate or remembered attributes of a sensory stimulus can be used as evidence" (Gold & Shadlen, 2007).Since the beginning of the twenty-first century, studies of the interaction between neuroscience and economics have developed remarkably (Belabes, 2015). The aim of the neuroeconomic enterprise is to integrate research from panoply of social and natural sciences: notably neurosciences, economics & finance, biology, cognitive and social psychology (Papa, 2018). Asabroader field of behavioral financial study, 'neurofinance' is an immerging field of study which collaborate multiple discipline came into existenceto study how the brain process the financial decision of individuals human. Neurofinance covers multidisciplinary fields like neurology, psychology and finance it is a tool for understanding an individual's behavior towards financial activity done through brain mapping(Singhraul & Batwe, 2022).Neurofinance emerged as a combined effort of Neurosciences and Finances in order to better understand the dynamics of decision making in normal times as well as crisis,

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Open Access Journal

Efficient Removal of Congo Red Dye Using Activated Carbon Derived from Mixed Fish Scales Waste: Isotherm, Kinetics and Thermodynamics Studies

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Key Words:
Activated carbon
Congo red dye removal
Regeneration
Mixed fish scales

ABSTRACT

The discharge of large quantities of organic dyes into the environment causes significant harm to humans and the environment. Thus, there is an urgent need to develop cost-effective adsorbents for removing these dyes. In the present study, the synthesis of activated carbon (AC) derived from mixed fish scale waste using KOH activation was investigated for Congo red (CR) dye removal. The finding shows that the obtained biocarbon has a fixed carbon of 42.9% with a crystallinity index of 15.01%. N_2 adsorption-desorption isotherm was found to be type IV, signifying mesoporous structure with a surface area and total pore volume of 150.049 $m^2\ g^{-1}$ and 0.119 $cm^3.g^{-1}$. Batch adsorption was carried out by various adsorbent doses, initial concentration, contact time, and pH to comprehend the effect of operating parameters on its removal efficacy. The isotherm studies fitted well for Freundlich with an R^2 of 0.99%. Adsorption kinetics was best fitted by the pseudo-second-order model and thermodynamic studies revealed the adsorption process to be exothermic and spontaneous. The efficiency of AC was also studied by an amount of sorption and desorption cycles which showed its potential for reusability up to the sixth cycle. Thus, the findings suggest that activated carbon derived from mixed fish scale waste is a promising adsorbent for removing Congo red dye from aqueous solutions.

INTRODUCTION

Dyes present in aqueous solutions are highly visible even at low concentrations and pose significant health and environmental risks due to their harmful effects on humans and ecosystems. It can be classed as cationic, anionic, or non-ionic depending on its properties and structure(Agarwal et al. 2023). The sources include industries like food, printing, textiles, leather, pulp/paper mills, plastics, cosmetics, and pharmaceuticals (Jasińska et al. 2019), which can lead to the creation of a hypoxic environment in water. Approximately 10,000 diverse dyes and pigments, totaling 700,000 tons, are used in industries each year out of which 10-15% end up in water bodies (Bhatia et al. 2017). Among them, congo red (CR) is a widely used anionic azo dye in textile and paper dyeing (Fig. 1) (Lade et al. 2015). Known for its six aromatic rings, this anionic diazo dye is highly toxic and mutagenic, also resistant to natural degradation. It can irritate the skin and gastrointestinal tract, and it decomposes into carcinogens, posing significant risks to both human health and environmental safety (Li et al. 2023). Additionally, it is often illicitly added to meat and meat products as a coloring agent due to its low cost, high stability, and excellent dyeing properties (Wang et al. 2023). According to Jain and co-workers (Jain & Sikarwar 2014), it is stable in the atmosphere and may also be used as an indicator. It can also be used in gamma-ray dosimeters since its color diminishes with radiation strength(Rajhans et al. 2020). Prolonged dye contact with the skin or eyes might cause severe irritability due to the dye's extreme toxicity and when consumed it can cause nausea, vomiting, and diarrhea (Lade et al. 2015). CR dye displays different types of toxic effects including skin-related, environmental, microbial, yeast, bacterial, algal, and protozoan toxicity that exhibits genotoxic and cytotoxic effects with the ability to produce genetic alterations and cancer (Rajhans et al. 2020).

Over the decades, wastewater has been treated using diverse approaches like photocatalysis(Jorfi et al. 2016, Khan et al. 2023b), ultrafiltration (Hoslett et al. 2018, Yin et al. 2019), electrochemical processes (Islam et al. 2023), adsorption (Ukanwa et al. 2019, Burchacka et al. 2021), etc.

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Morphometric Analysis of Chathe River Basin, In and Around Chumokukedima, Nagaland

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Abstract

Rivers are generally controlled by the geological nature of basins and their platforms, which equally influence channel slope and demonstrate erosional and depositional signs of the river. Morphometric analysis is carried out to estimate the altitude, volume, slope, and profiles of the surface and drainage basin characteristics. The present study aims to analyze the morphometric attributes of the Chathe River Basin in and around Chumoukedima, Nagaland, by detailed morphometric analyses. This study is attempted using morphometric techniques to gain insight into the geohydrological characteristics of the drainage basin to help in the identification of groundwater potential zones and overall management of the groundwater basin using GIS. The drainage network of the basin is extracted from the DEM of USGS earth explorer. Based on stream ordering, the drainage basin of the study area is designated as fifth-order basin. The total number of streams is 239, out of which 177 are first order, 46 are second order, 11 are third order, and 4 are fourth order; the main stream is fifth order. The large number of first order streams indicates that the region is undergoing the initial phase of erosion. The drainage density indicates that the subsurface is made up of permeable strata, which points to good groundwater potential. The significance of this study lies in the fact that it can help in watershed and hazard management It will also help in assessing the groundwater potential of the region and delineation of effective water-harvesting sites. Morphometric analysis thus, has a wide significance in watershed prioritization and management, soil erosion studies, groundwater potential assessment, and flood-hazard risk reduction.

Keywords:

Morphometric analysis, drainage density, permeability, groundwater potential.

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RESEARCH ARTICLE

Epigallocatechin Gallate (EGCG) Mitigates Oxidative Stress and Restores Histological Integrity in Streptozotocin-Induced Zebrafish Model of Diabetes

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Abstract:

Aims:

The primary aim of this study is to investigate the potential therapeutic effects of Epigallocatechin gallate (EGCG) in a zebrafish model of diabetes induced by streptozotocin.

Background:

Diabetes mellitus is characterized by chronic organ dysfunction and failure. Natural compounds, particularly polyphenols such as EGCG present in green tea, have garnered attention for their potential in managing various complications associated with diabetes owing to their antioxidant and anti-inflammatory properties.

Objective:

This study seeks to evaluate the influence of EGCG on oxidative stress markers, antioxidant levels, and histopathological alterations in the liver, kidney, and gills of zebrafish rendered diabetic through streptozotocin administration.

Methods:

Zebrafish subjects were allocated into four groups: control, diabetic, diabetic + EGCG, and control + EGCG. Superoxide dismutase (SOD) and catalase (CAT) activities were quantified, and histopathological assessments were conducted on day 21 of the experimental period.

Results:

Diabetic zebrafish exhibited pronounced reductions in SOD and CAT activities relative to control counterparts, coupled with notable histological changes indicative of organ impairment. Conversely, EGCG treatment attenuated oxidative stress bolstered antioxidant defenses and mitigated histopathological abnormalities in the liver, kidney, and gills of diabetic zebrafish.

Conclusion:

EGCG exhibits promising therapeutic potential in safeguarding multiple organs against diabetes-induced injury, underscoring its significance in ameliorating diabetic complications.

Other:

These findings emphasize the importance of investigating natural compounds such as EGCG as potential therapeutic agents for managing diabetes-related complications. Further elucidation of the mechanistic underpinnings and clinical applicability of EGCG in diabetes management warrants future research endeavors.

Keywords: Antioxidant enzymes, Diabetic complications, Epigallocatechin gallate, Histopathological examinations, Oxidative stress, Zebrafish model.

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1. INTRODUCTION

Diabetes mellitus (DM) is a global burden characterized by hyperglycemia resulting from abnormalities in insulin secretion, insulin resistance, or both. Individuals with DM are at a high risk of developing serious health problems that reduce their quality of life and increase mortality rates. The estimated prevalence of DM in adults aged 18-99 was 451 million, projected to reach 693 million by 2045 worldwide [1]. It is commonly associated with long-term dysfunction and failure of

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REVIEW

Recent advances in applications of animal biowaste-based activated carbon as biosorbents of water pollutants: a mini-review

Vevosa Nakro · Tsenbeni N. Lotha · Ketiyala Ao · Imkongyanger Ao · Vimha Ritse · Lemzila Rudithongru · Chubaakum Pongener · Merangmenla Aier · Dipak Sinha · Latonglila Jamir

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Abstract Advances in green engineering and technology have revealed a number of environmentally acceptable alternatives for water purification. In line with this, recent advances in biosorption of pollutants from aqueous solutions using animal biowaste-based activated carbon (AC) are reported herein. Apart from the fish scale-derived AC which is extensively documented, animal bones, among the rest others, have been studied most widely, followed by hair and feathers. Out of the various target water pollutants, removal of heavy metals has been mostly studied. Majority of the reports showed the Freundlich isotherm and pseudo second order as the best fit. Few investigations on the thermodynamics of the adsorption studies and reports on the Gibbs free energy change (ΔG°), enthalpy change (ΔH°), and entropy change (ΔS°) have also been discussed in this report. It has been concluded that while plant-based AC has gained wide interest, the same is not true for the animal-based counterpart albeit the latter's potential for high sorption efficiency as seen in the present report.

Keywords Activated carbon · Water pollutants · Animal biowaste · Biosorption · Heavy metals · Dyes

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Introduction

Freshwater scarcity is one of the most pressing challenges the world has been trying to tackle over the last few years. The already existing severe freshwater crisis is aggravated by population growth, unplanned rapid urbanization, technological advancements, and agricultural operations. Nowadays, wastewater pollution from diverse industrial activities has escalated into a global concern. Unchecked discharge of pollutants poses substantial dangers to aquatic habitats, contributing to acute and chronic toxicity for aquatic animals, ecosystem pollution biodiversity damage, habitat destruction, and human health problems (Palani et al., 2021). Toxic metal ions containing discharge from various sources such as industrial and sanitary wastes, domestic effluents, and agricultural runoff has added to the prevailing strain on usable freshwater supply (Mustafa et al., 2021). Long-term negative consequences in aquatic and human health have been seen to be directly related to consumption of polluted waters containing persistent metal ions or recalcitrant organic compounds. In addition, aesthetic

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Regular Article - Theoretical Physics

Restricted phase space thermodynamics of 4D dyonic AdS black holes: insights from Kaniadakis statistics and emergence of superfluid λ-phase transition

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Abstract We study the thermodynamics of $4D$ dyonic AdS black hole in the Kaniadakis statistics framework using the Restricted Phase Space (RPST) formalism. This framework provides a non-extensive extension of classical statistical mechanics, drawing inspiration from relativistic symmetries and presenting a fresh perspective on black hole thermodynamics. Our study analyzes how including Kaniadakis entropy modifies the phase transition of the dyonic black holes. We consider the central charge C and its conjugate chemical potential μ as the thermodynamic variable along with others except the pressure and volume. Due to the addition of the magnetic charge $\tilde{Q}_m$, the study of the phase transition becomes much richer by obtaining a non-equilibrium phase transition from an unstable small black hole to a stable large black hole along with the Van der Waals and superfluid phase transition with an extra unstable branch in the $T-S$ processes. In the $F-T$ plot, we get an extra Davies type with an extra branch phase transition. Including the deformation parameter κ introduces an unstable (ultra-large BH) branch seen in almost all the plots. Turning off the magnetic charge flips the direction of the phase transition seen during its presence. Also, in the plots varying κ match with the plot varying C which underlines some sort of correspondence in its meaning which is not possible to observe in Gibbs–Boltzmann statistics. As the entropy models change the homogeneity is not lost where mass is of the first order and the rest is zeroth order. The $\mu-C$ processes in quite similar across black hole systems and entropy formulation marking some kind of universality of this process. Our study shows that modified entropy, unlike in certain alternative gravity models, does not give rise to a new thermodynamic universality class but retains consistency with standard Einstein–Hilbert black hole behavior.

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1 Introduction

The exploration and study of black hole thermodynamics has performed a pivotal role in bridging classical gravity, quantum mechanics, and statistical mechanics offering a profound framework for understanding the microscopic nature of spacetime. This study began with the introduction of Hawking's temperature T and Bekenstein–Hawking entropy given as:

$$T=\frac{\hbar\kappa}{2\pi ck_B},\quad S=\frac{k_Bc^3A}{4\hbar G} \tag{1}$$

where κ is the surface gravity and A is the horizon area [1–4]. It has led to an active area of research [5–9]. AdS black holes hold a unique place in this discourse due to their thermodynamic property as seen by Hawking and Page as they observed a phase transition between a pure thermal AdS space and the Schwarzschild AdS black hole [10]. There are even more ways to study the various phase transitions [11–16] namely via the thermodynamic geometry [17–27] and topological studies [28–51].

A revolutionary leap made in the study of black hole thermodynamics in AdS spacetimes is the Extended Phase Space Thermodynamics (EPST) formalism by incorporating the (P, V) pair as variables where $P=-\Lambda/8\pi G$. This approach led to much research particularly focusing on $P-V$ criticality [52–61] also enabling it to be considered as heat engines [62,63]. With this, black hole was considered to have duality with other systems like QCD, CMP, and CFT [64–75]. Visser proposed further advancement in this framework [76], who was inspired by the AdS/CFT correspondence [77,78] and introduced a new parameter the central charge C and its conjugate chemical potential μ as variables replacing the $(P-V)$ with CFT-inspired $(\mathcal{P}-\mathcal{V})$ where $V\sim L^{d-2}$

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RESEARCH

Restricted phase space thermodynamics of dyonic AdS black holes: comparative analysis using different entropy models

Abhishek Baruah[1,2] · **Prabwal Phukon**[1,2]

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Abstract

Using the restricted phase space (RPST) formalism, we perform a comparative study of 4D dyonic AdS black hole thermodynamics in Gibbs–Boltzmann statistics and Rényi statistics. In RPST formalism, instead of pressure and volume, one considers central charge C and chemical potential μ as thermodynamic variables. Inclusion of the magnetic charge $\tilde{Q}_m$ gives rise to a richer phase structure of the study of thermodynamics by adding a non-equilibrium transition from an unstable small black hole to a stable black hole in the T–S processes and a Hawking–Page and Davies type phase transition in the F–T and specific heat plots on top of the Van der Waals and superfluid λ phase transitions. We study an extra mixed ensemble ($\tilde{\Phi}_e$, $\tilde{Q}_m$) due to the inclusion of $\tilde{Q}_m$ where we see Van der Waals phase transition and whose plots change as the entropy model changes meaning for isovoltage processes we see Hawking–Page transition in Bekenstein–Hawking entropy and absence of Hawking–Page in Rényi entropy construct. We observe an interesting phenomenon where changing the Rényi parameter λ, the T–S process changes the same way as when varying the central charge C underlining some similarity that is not seen in the Bekenstein Hawking entropy model. We observe a similarity between the plots when both charges are turned off relating to the Schwarzschild black hole and the grand-canonical ensemble. One can observe that as the entropy models are changed, the homogeneity is not lost where the mass as a function of extensive variables is of order one and the rest zero. We see a similarity in the μ–C process across the entropy models signally some universality across entropy models as well as different types of black holes studied before. Finally, we do not see a new universality class for modified entropy as it is seen in studies done for alternate gravity models.

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