

CHAPTER 45

PHYSICS AND ASTROPHYSICS

Doctoral Theses

01. ANITA

Studies on Zinc Oxide based Nanopowders and Radiation Induced Effects.

Supervisors : Dr. Vandna Luthra and Dr. Anant Pandey

Th25471

Abstract
(Not Verified)

Zinc Oxide (ZnO) as a semiconducting material with a wide direct band gap and high free exciton binding energy has excellent optical transparency in the visible range, which makes ZnO an admirable candidate for device applications. ZnO also has resistance towards radiation damage with high electron saturation velocity. ZnO is a green material useful in medical and environmental sciences. Doping with various dopants has widened its scope of applications due to significant changes in its physical and functional properties. Amongst many, aluminium (Al) has been regarded as promising dopant for the enhancement of electrical and optical properties in the visible range, but limited work is available on simultaneous enhancement of the electrical and magnetic properties on ZnO nanopowders. We have opted Nickel (Ni) as the transition metal (TM) ion dopant to investigate the induced changes in ZnO. Also, the co-doping of Ni with Al in ZnO has been studied to analyse the structural, electrical, optical and magnetic properties. The expected simultaneous occurrence of high conductivity and ferromagnetism at room temperature make these co-doped compounds promising candidate for spintronic applications. The rare earth (RE) elements are also the potential dopants because of their excellent optical and magnetic properties. Further, we have selected Gadolinium (Gd) as a RE element to study as a co-dopant with Al. The effect of gamma irradiation over undoped and doped ZnO has also been studied to analyse the modifications in optical, electrical and physical properties. In the present work, initially the Al doping concentration optimized to achieve high dc conductivity and further TM ion and RE metal ion have been co-doped within the limit of optimized concentration of Al doping. Further, the effect of irradiation has been studied over all samples and an extensive structural and electrical study has been made over selected samples.

Contents

1. Introduction. 2. Modulating structural, optical and electrical properties of Zinc Oxide nanopowders by aluminium doping 3. Investigations on aluminium doped, nickel doped and co-doped ZnO nanopowders 4. Investigation on aluminium and gadolinium doped and co-doped Zinc Oxide nanopowders 5. Effect of ionizing radiation on structural and electrical properties of undoped and doped ZnO.

02. ANSARI (Mohd Azaj)
Polymorphic Phase Boundaries and Light Upconversion effects in Er³⁺ and Sn⁴⁺ Modified BaTiO₃ Ceramics.
 Supervisor : Prof. K. Sreenivas
Th25589

Abstract
(Verified)

Polymorphic phase boundaries and the coexistence of phases at room temperature have been investigated in BaSn_xTi_{1-x}O₃. The coexistence of (Tetragonal + Orthorhombic) phases for $x = 0.05$, a pure rhombohedral (R) phase for $x = 0.1$, and coexisting (Rhombohedral + Cubic) phases for $x = 0.12$ are identified. Increasing Er content ($x = 0.1$ to 0.28) shows three distinct features (i) disorder-activated scattering, (ii) coexistence of two different octahedra (SnO₆ and TiO₆), and (iii) the formation of a defect-induced. The defect-induced semiconducting phase (BaSnO₃) evolves with increasing Sn content ($0 \leq x \leq 0.28$) and leads to a gradual transformation from a normal ferroelectric to diffused ferroelectric and ultimately to a relaxor-ferroelectric at high Sn content. The defect-infused BaSnO₃ phase is reinforced with increasing Sn content and tends to degrade the electrical resistivity. Substitution of Er in Ba_{1-y}EryTi_{0.94}Sn_{0.06}O₃ shifts the ortho to tetragonal phase transition (TO-T) to room temperature and exhibits coexistence of orthorhombic and tetragonal phases. The reduced tetragonal distortion affects the functional properties, and the defect chemistry of Er reduces the electrical resistivity. The usefulness of light upconversion technique as a non-contact optical probe for the detection of ferroelectric phase transitions is explored, and the sensitivity of the Er-doped Ba_{1-y}ErySn_{0.06}Ti_{0.94}O₃ for temperature sensing is investigated. The emission line intensity and integrated emission band intensity of show distinct changes around the TR-O, TO-T, and TT-C phase transition temperatures. An electrically poled surface is found to be more effective for observing the ferroelectric phase transitions by the luminescence method. The measured phase transition temperatures determined from the luminescence method are in good agreement with those determined from heat capacity and dielectric measurements. The application of light upconversion technique for ferroelectric phase transition detection can be developed as a rapid non-contact technique. The usefulness of light upconversion technique as a non-contact optical probe for the detection of ferroelectric phase transitions is explored, and the sensitivity of the Er-doped Ba_{1-y}ErySn_{0.06}Ti_{0.94}O₃ for temperature sensing is investigated. The emission line intensity and integrated emission band intensity of show distinct changes around the TR-O, TO-T, and TT-C phase transition temperatures. An electrically poled surface is found to be more effective for observing the ferroelectric phase transitions by the luminescence method. The measured phase transition temperatures determined from the luminescence method are in good agreement with those determined from heat capacity and dielectric measurements. The application of light upconversion technique for ferroelectric phase transition detection can be developed as a rapid non-contact technique.

Contents

1. Introduction to electro-ceramics and photoluminescence 2. Research problem formulation and thesis objectives 3. Sample preparation and characterization techniques 4. Disorder activated and growth of defectinduced phase in BaSn_xTi_{1-x}O₃ ($0 < x < 0.28$) ceramics 5. Er³⁺ substitution at site in Ba_{1-y}ErySn_{0.06}Ti_{0.94}O₃ ($0 < y < 0.9\text{mol}\%$) 6. Light upconversion effects in Er³⁺ and Sn⁴⁺ doped BaTiO₃.

03. CHANNEY (Kanwaljeet Singh)
Phenomenological Study of Fermion Masses and Mixings and Physics beyond Standard Model.
 Supervisor : Dr. Sanjeev Kumar Verma
Th25470

Abstract
(Not Verified)

One of the unresolved mysteries of the neutrino physics is the origin of the neutrino masses. If the three neutrino masses are distinct and non-zero, the mass and flavor eigenstates of neutrinos are not identical. The flavor eigenstates (ν_f) can be written as a linear combination of the mass eigenstates (ν_i). If the three neutrino masses (m_1, m_2 and m_3), three neutrino mixing angles (θ_{12}, θ_{23} and θ_{13}) and the three CP violating phases (α, β , and δ) are known, the neutrino mass matrix can be reconstructed as $M_\nu = U \cdot M_{\text{diag}} \cdot U^\dagger$ (1) where, $M_{\text{diag}} = \text{diag}\{m_1, m_2 e^{2i\alpha}, m_3 e^{2i\beta}\}$. The reconstruction of the neutrino mass matrix from the experimental observation of masses and mixing angles results into many possible structures. The experimental measurements of a non-zero θ_{13} ruled out many such structures. One such structure corresponded to the Tri-BiMaximal(TBM) mixing that predicts $\theta_{13} = 0$ and $\theta_{23} = \pi/4$. After the measurement of non-zero θ_{13} , the TBM scheme cannot be compatible with the neutrino data at the leading order. Yet, one can modify the mass matrix corresponding to the TBM mixing (MTBM) by adding some correction terms that break the underlying symmetry of MTBM. However, such modifications need not break the symmetry of MTBM completely. We can modify MTBM in such a manner that the resulting mixing matrix still has its first or second column identical to the TBM mixing matrix UTBM. Such mixing schemes can be called Tri-Maximal (TM) mixing of first and second kind (TM1 and TM2), respectively. In this thesis, we propose simple textures that can modify MTBM to have non-zero θ_{13} and non-maximal θ_{23} while preserving its first or second Eigen vector at their TBM values. We study the phenomenology of these textures and confront them with the experimental data. Our textures are testable at the future neutrino experiments like NOvA and T2K that aim to measure the octant of θ_{23} and CP-violating phase δ . We also present the predictions of these textures for the Majorana phases (α and β) and the neutrino masses as measured in the beta decay, the neutrino-less double beta decay and the cosmological experiments.

Contents

1. Introduction. 2. Two variants of the Tri-BiMaximal mixing: TM_1 and TM_2 mixing patterns 3. Two simple modifications of the Tri-BiMaximal mass matrix 4. Preserving magic symmetry in Tri-BiMaximal mass 5. Modifications of Tri-BiMaximal mass matrix: textures with TM_1 and TM_2 mixings 6. Conclusions.

04. CHOTHE (Hiyang Ramo)
Mimetic Torsion Gravity and its Cosmological Consequences.
 Supervisors : Dr. Sourav Sur and Dr. S. Somorendro Singh
Th25485

Abstract
(Not Verified)

The unsolved problems of dark sector in the standard cosmological set up have been addressed by various models based on modifications of General Relativity(GR), commonly referred to as the theories of modified gravity(MG). One such class is the

mimetic theory of gravity and a host of its extensions. We focus on formulating a mimetic-metric-torsion(MMT) theory, which is totally a new approach different from other extended mimetic theories. Any desired cosmic evolution can be reconstructed through coupling of mimetic field and torsion. The MMT theory is formulated within the purview of general Riemann-Cartan geometry. We take into account the conformal properties of the torsion through the Cartan transformation which is linked to the conformal transformation of the metric. We simultaneously reparametrize the physical metric and physical torsion in terms of the corresponding fiducial quantities and the mimetic field. The construction of equivalent Lagrangians are motivated by an explicit couplings of mimetic field Φ with the irreducible modes of the torsion. Setting a condition for a single coupling term $\beta(\Phi)$, we can get evolving dust-like mimetic fluid with a non-zero pressure. In FRW framework, taking $\beta(\Phi) \sim \Phi^2$ which gives Λ CDM and, showing how $\beta(\Phi)$ and trace mode of torsion evolve, we estimate their values at the present epoch using PLANCK data. Incorporation of higher derivative term of Φ for getting non-zero sound speed c_s at the perturbative level allow us to determine the bound on $\beta(\Phi)$. Again, we set the conditions for two coupling terms in the effective Lagrangian. The extra coupling term $\gamma(\Phi)$ is due to the coupling between the mimetic field Φ and the antisymmetric mode of the torsion. In this case by considering some mutual relationships between the coupling functions and with some approximation we can show phantom crossing phenomenon within the error bar.

Contents

1. Introduction 2. Mimetic-metric-torsion theoretical formulation 3. Mimetic-metric-torsion cosmology 4. Mimetic axial-torsion extension and cosmic super-acceleration 5. Conclusion. Bibliography.

05. CHOUDHARY (Siddharth)

Morphological Evolution in modified ZnO and α -Fe₂O₃ Hybrid Nanostructures for Gas Detection and Photodegradation Applications.

Supervisors : Prof. S. Annapoorni
Th25547

Abstract (Not Verified)

The main objective of this thesis is to find a solution of the existing environmental issues and human threats posed by the leakage of harmful gases and polluting dyes that cause air and water pollution. In the present work, ZnO and α -Fe₂O₃ based nanostructures have been used for gas (LPG, NO₂) detection and photocatalytic degradation of synthetic dyes (Methylene Blue). Chapter 1 is designed for defining the present work and the motivation behind the experiments. Chapter 2 presents the details of experimental setup for chemical route synthesis and also explains the experimental characterization techniques adopted in this study. Chapter 3 discusses the growth and evolution of ZnO nanorods synthesized using simple chemical colloidal method. The nanorods of different morphologies were exposed to low concentrations (below 100 ppm) of LPG and their sensing behavior was tested over a range of operating temperatures from 120 °C to 200 °C. Chapter 4 establishes ZnO@Ag nanocomposites with different concentrations of Ag as efficient photocatalysts. The photocatalytic behavior of pure ZnO and ZnO@Ag catalysts was investigated by degradation of methylene blue dye on exposure to UV-visible radiation. The optical properties were analyzed to understand the faster degradation using ZnO@Ag composites as compared to pure ZnO. Chapter 5 discusses about the interfacial charge transfer between Ag nanoparticles and shuttlecock-shaped ZnO nanostructures. Synchrotron based VUV-photoluminescence measurements

was performed to understand the optical properties of ZnO/Ag Hybrid Nanostructure (HNS) in the temperature range 10 K – 300 K. The impact of light illumination on the electronic structure of ZnO and the change in carriers density in ZnO/Ag system is evaluated using X-ray absorption spectroscopy. Chapter 6 demonstrates the synthesis of donut-shaped α -Fe₂O₃ nanoparticles for high performance LPG sensor. The donut-shaped structures exhibit high sensor response for detecting low concentration of LPG at a relatively low operating temperature of 170 °C.

Contents

1.Introduction 2. Experimental methods: synthesis, characterization and applications 3. Evolution and growth mechanism of hexagonal ZNO nanorods and their LPG sensing behaviour 4. Synthesis of ZNO@AG dumbbells for highly efficient visible-light photocatalysts 5. Photo generated charge transport studies of defect-induced shuttlecock-shaped ZNO/AG hybrid nanostructures for enhanced photo-response 6.Facile strategy to synthesize donut-shaped α -Fe₂O₃ naoparticles for enhanced gas detection 7. Summary and conclusions.

06. CHITRA

Electrical Properties of Modified Barium Titanate based Lead-free Piezoceramics.

Supervisor : Dr. K Chandramani Singh
Th25476

Abstract (Verified)

Recently discovered, (Ba,Ca)(Ti,Sn)O₃ (BCST) system is a potential lead-free alternative to substitute toxic lead-based PZTs. To optimize (Ba_{1-x}Ca_x)(Ti_{1-y}Sn_y)O₃ ceramics, where $0.06 \leq x \leq 0.18$ and $0.04 \leq y \leq 0.08$ were prepared by sintering method. Dielectric properties showed improvement along with the fall in Curie temperature T_c for the BCST ceramics with strengthening of the BST terminal. BCST₃ showing optimum piezoelectricity has primary pyroelectric coefficient (p₁) value of 0.488 C/m²K and hydrostatic electrostrictive coefficient (Q_h) value of 0.041 m⁴C⁻², which is higher than some of the lead-based materials. Optimized BCST nanopowders were synthesized via solid-state reaction route assisted by HEBM with milling time varying from 5 to 30 h at 175 rpm each. Remnant polarization (Pr), field-induced strain (S%) and converse piezoelectric coefficient (d₃₃*) upsurge with their peak values of 5 μ C/cm², 0.209% and 650 pm/V respectively for the 25 h milled sample. Later, BCST ceramic system in the range 100-400 rpm at fixed milling time of 5 h was studied. T_c increases by 60°C with a subsequent increase in Pr and d₃₃ by 77% and 60%. Conventional sintering method was employed to prepare BCST-xHo₂O₃ (x=0-2.0 mol%) ceramics. Evidence of Ho³⁺ substituting Ba²⁺ exists in the range 0-1.0 mol%, while Ti⁴⁺ sites were being replaced beyond it. Pr and d₃₃ increases and peaks at 1.0 mol%, while switching over to Ti-site greatly degrades these values. BCST ceramics doped with Dy³⁺ in the concentration range 0-2.5% were also studied. The perovskite structure of Dy doped BCST ceramics transforms from tetragonal to cubic phase above 2.0% Dy content due to the substitution of Dy³⁺ ions at Ba-site for concentrations less than 1.5% and Ti-site for more than 1.5%. Bimodal grain distribution was observed which transitioned from spherical to cubic at 2.5% Dy content. Addition of Dy in the BCST system degrades its electrical properties with rising dopant concentration.

Contents

1. Introduction. 2. Preparation and characterization 3. Compositional optimization of lead-free $(\text{Ba}_{1-x}\text{Ca}_x)(\text{Ti}_{1-y}\text{Sn}_y)\text{O}_3$ ceramics: a structural and electrical perspective 4. Effect of high energy ball milling on electrical properties of lead-free bcst piezoceramics 5. effect of holmium doping on electrical properties of lead-free bcst ceramics 6. Dysprosium doping on electrical properties of lead-free bcst ceramics 7. Conclusions and Future prospects.

07. DASTIDAR (Raya)

Study of Core-Collapse Supernovae and their Progenitors.

Supervisors : Prof. T. R. Seshadri and Dr. Brijesh Kumar

Th25492

Abstract

(Not Verified)

Supernovae are the cosmic fireworks marking the death of stars, wherein heavy elements are forged and dispersed, leading to the galactic enrichment of the Universe. In core-collapse supernovae, the collapse of the inert iron core in massive stars, paves the way for the catastrophic explosion. This gives rise to a range of observational signatures owing to the diverse nature of the pre-explosion star and its environment. Hence, decoding the properties of the progenitor and its immediate environment calls for a comprehensive study of these events. The hydrogen-rich core-collapse supernovae arise from progenitors which have managed to retain most of its hydrogen envelope prior to explosion. In this thesis, six hydrogen-rich core-collapse supernovae: 2014cx, 2014cy, 2015an, 2015ba, 2015cz, 2016B has been characterized for probing their progenitor properties and environment. Photometric and spectroscopic monitoring of these events was carried out from Indian and international telescopes. Analysis and modelling of the data have been performed to constrain progenitor properties and explosion parameters. Both light curve and spectral modelling indicate that circumstellar interaction is important in most hydrogen-rich core-collapse supernovae. The classification conundrum of the hydrogen-rich supernovae whether to be or not to be categorised into two subclasses: the plateau supernovae (IIP) and the linearly declining supernovae (IIL) during the recombination phase, has also been addressed in this thesis. The dilemma surrounding the low progenitor mass of type II supernovae from direct imaging, popularly known as the 'Red Supergiant Problem' has been explored in this thesis. In case of SN 2015ba, a progenitor mass of around 24-26 solar mass has been estimated, which is higher than the upper limit of 18 solar mass proposed from pre-explosion images, although, with insignificant levels of oxygen, otherwise expected from a massive progenitor. The implications of these results have been discussed in detail in the thesis.

Contents

1. Introduction. 2. Data acquisition and reduction 3. SN 2015ba: a type IIP supernova with a long plateau 4. SN 2016 B a.k.a Asassn- 16ab: a transitional type II supernova 5. SN 2015An: a normal luminosity type II supernova with low expansion velocity at early phases 6. The optical properties of three type II supernovae: 2014 cx, 2014cy and 2015cz 7. Summary, Conclusions and future prospects. Bibliography.

08. DAS (Susmita)
Light Curve Structure of Variable Stars and its Applications
 Supervisors : Prof. H.P. Singh
Th25546

Abstract
(Not Verified)

wavelengths, (ii) modelling observed pulsational properties of classical pulsators and thereby understanding the impact of composition and convective efficiency on the pulsation of these stars and (iii) probing the stellar structures to understand the microphysics of the outer envelopes of the pulsating variable stars. We found the observed Fourier parameters of RR Lyraes to be in reasonable agreement with those obtained from the models. We also probed the HIF-photosphere interaction from observational and theoretical aspects and included T2Cs for the first time to demonstrate that the theory holds true across a broad spectrum of variable stars in different evolutionary stages. Lastly, we computed a fine grid of BL Her models using MESA-RSP to study the theoretical PL and PR relations and the effect of metallicity and convection parameters. We found no significant metallicity effects for PR relations and significant effect of metallicity in UB-bands and negligible effect in infrared bands in PL relations.

Contents

1. Introduction. 2. Methodology 3. A multiwavelength light curve analysis of RR Lyrae models vs observations 4. The hydrogen ionisation front-stellar photosphere interaction theory 5. A new theoretical framework for BL Her stars 6. Conclusions and future prospects. Bibliography.

09. GOLA (Mohit)
New Look at Triple-GEM Detector and Dark Matter Search at Large Hadron Collider.
 Supervisor : Dr. Ashok Kumar
Th25480

Abstract
(Verified)

The research in this thesis is mainly based on the physics analysis and the upgrade of the muon system of the Compact Muon Solenoid (CMS) experiment at the Large Hadron Collider (LHC). In physics analysis, it consists of the associated production of the dark matter with Higgs boson decaying to pair of bottom quarks. The detector contribution includes the production and testing of Gas Electron Multiplier (GEM) detectors for the CMS upgrade. In addition to this, it includes the extensive R&D on India made GEM foils and advanced tests performed on these foils. Contents To extract the new physics at the LHC, it requires the upgrade of the detector elements to cope up with the harsh radiation environment. The LHC will be upgraded in several phases that will allow significant expansion of its physics program. To cope with the corresponding increase in background rates and trigger requirements, the installation of additional sets of muon detectors based on GEM technology, referred to as GE1/1, GE2/1, and ME0 has been planned. The details regarding detector production, Quality Controls (QCs), etc. have been discussed.

Contents

1. Introduction to gaseous detectors 2. CMS muon upgrade using GEMs 4. R & D on Indian GEM foils 5. Gain uniformity and induction gap thickness measurement 6. Dark matter search at LHC 7. Conclusions. Bibliography.

10. JAGANNATHAN (Sandhya)
Observable Imprints of Astrophysical Magnetic Fields.
 Supervisor : Prof. T. R. Seshadri
Th25490

Abstract (Not Verified)

Magnetic fields are important constituents of the universe and their generation and evolution has implications on various observables such as the Cosmic Microwave Background (CMB) radiation and the gas mass fraction of galaxy clusters. In this thesis, we have studied the imprints of helical magnetic fields on the CMB through their dissipation via ambipolar diffusion and decaying turbulence after recombination. Compared with non-helical magnetic fields, the dissipation of helical magnetic fields leads to lesser temperature and ionization fraction considering the effect of both ambipolar diffusion and decaying turbulence, where the former dominates the evolution for magnetic field power spectrum spectral index, $n_B=2.0$, and the latter dominates for the spectral index, $n_B = 2.9$. This translates to a difference in CMB temperature and polarization anisotropies, where we find, that the presence of helicity relaxes the constraint on the magnetic field strength obtained for $n_B=2.0$, and tightens the constraints for $n_B = 2.9$ in the case of non-helical magnetic fields. In the second part, we have studied the effect of magnetic field on the gas mass fraction of galaxy clusters. In the central regions of galaxy clusters, the magnetic fields can achieve high strengths. We find that the gas mass fraction, which is defined as the ratio of the gas mass to the total mass, experiences a small decrease in the presence of magnetic field where the effect of the same has been considered in the distribution of the gas density. This decrease is more for higher values of magnetic field strength and lower values of the parameter, which relates the gas density distribution with the magnetic field distribution. Our results indicate that the effect of magnetic field on the gas mass fraction is very minute for the present constraints on the magnetic field strength.

Contents

1. Introduction. 2. Post-recombination dissipation of non-helical magnetic fields 3. Post-recombination dissipation of helical magnetic fields 4. Impact of magnetic field on the gas mass fraction of galaxy clusters 5. Conclusions. Bibliography.

11. JARWAL (Bharti)
Signals of Quark Gluon Plasma Formation.
 Supervisor : Prof. S. Somorendro Singh
Th25590

Abstract (Not Verified)

The Quark gluon plasma, QGP is a state of matter which is obtained during the early universe phase transition. The matter is considered to be transformed to hadron with its subsequent cooling process of the universe. It is also believed to

exist in the interior of massive neutron stars, and possibly in the early phase of big bang model of universe. The study of compact remnants such as neutron star can provide information about the QGP phase. Like neutron star, boson star also formed and in this work boson star are chosen as signals of qgp formation. So on the aspect of the probable signature of QGP formation, we consider that BS formation is also one probable signature as they are highly compact objects like neutron star. As they are highly compact their density is very large and it is comparative with the formation of QGP at high nuclear density. Therefore we focus on the oscillation of boson star by using a different phenomenological models. The oscillations of the boson star are studied through these models in this research work. These models include perturbation terms in the potential (Coulombic term, chemical potential) and by the introduction of cosmological parameter and coupling terms with curvature of the universe. The results are analyzed. It is found that these oscillating states of BS indicates that there is formation of compact objects in the universe after the supernova explosion the probable signatures of quark gluon plasma formation. So they can be a good candidate to represent the QGP formation.

Contents

1. Introduction to signals of QGP 2. Oscillation of boson star in Newtonian approximation 3. Effect of chemical potential on rotation of boson star 4. Cosmological constant effect on boson star 5. Curvature coupling effect on boson star 6. Conclusion.

12. JOSEPH (Abhilash Joshua)
Processing and Characterization of Lead Based Binary/Ternary (BF-PMN-PT)/Quaternary (BNT-BT-PMN-PT) Perovskite Ceramic systems and Flux Grown PMN-PT Crystals.
 Supervisor : Prof. Binay Kumar
Th25483

Abstract *(Not Verified)*

Chapter 1 introduces various concepts of ceramic synthesis and single crystal growth. Chapter 2 describes the experimental techniques used for crystal growth and ceramics synthesis and their various characterizations. Chapter 3 presents synthesis and die-/piezo-/pyro-/ferroelectric characterizations of a near MPB composition of pure (1-x)PMN-xPT (x = 0.36). The synthesis was carried out using solid state reaction technique. Chapter 4 describes synthesis of a MPB composition of 0.37BF-0.31PMN-0.31PT ceramic by solid-state reaction method. Chapter 5 describes the synthesis of a new quaternary ceramic 0.16(Bi_{0.5}Na_{0.5})TiO₃-0.04BaTiO₃-0.5Pb(Mg_{1/3}Nb_{2/3})O₃-0.3PbTiO₃ (BNT-B PMN-PT) via solid state reaction method. Chapter 6 describes the flux growth of single crystals of 0.64PMN-0.36PT. Compared to its ceramic counterpart, a higher value of T_c (190 °C) was exhibited by the 0.64PMN-0.36PT crystals authenticating its applicability in high temperature ferroelectric applications. Chapter 7 summarizes the important results of the thesis work. The piezoelectric, ferroelectric and pyroelectric properties of three types of ceramic were compared. Further these properties of PMNPT were compared in its ceramic and single crystal form. Based on the results of the present work scope of future work is also discussed.

Contents

1. General Introduction & literature survey 2. Experimental techniques 3. Synthesis and di-/piezo-/pyro-/ ferroelectric characterizations of pure (1-x) PMN-xPT ceramic

4. Synthesis and characterization of a ternary 0.37BF-0.31PMN-0.32PT ceramic
5. Ferro-/piezo-/pyroelectric characterizations of quaternary BNT-BT-PMN-PT ceramic
6. Growth and characterizations of flux grown PMN-PT
7. Conclusions and Future Scope.

13. KAMALESH

Morphology Controlled Au and Au-Ag Nanostructures: Synthesis, Plasmonic Features and Applications.

Supervisor : Dr. P. Senthil Kumar

Th25478

Abstract
(Not Verified)

Present thesis work provides versatile, single-step colloidal synthesis protocols for different anisotropic shaped gold nanostructures such as decahedra, hexagon, triangle and star under ambient conditions itself. Further, in the synthesis of hollow Au-Ag nanoparticles utilizing Ag seeds as sacrificial template in galvanic replacement reaction at 100° C. Core to cavity ratio, elemental composition, thickness and porosity of resultant hollow nanostructures is controlled by redesigning the Turkevich method in the presence of excess NaCl, which monitors the reduction of HAuCl₄ through galvanic replacement. Particularly, star shaped Au NPs provide LSPR in the NIR region owing to its sharp tips, which is very useful in sensing applications. In this regard, star shaped Au NPs with different number of tips, tip length and tip sharpness are synthesized by varying the pH of reduction medium under ambient conditions. These star shaped Au nanostructures are stable for long period of time as well as in different surrounding medium due to the capping of long chain length polymer, PVP [mw 40k]. The performance of all synthesized Au, Au-Ag nanostructures were checked diligently for different applications such as in refractive index sensitivity, SEIRA, catalysis and SERS. Contents A completely complementary trend is observed in the corresponding SERS applications, wherein solid spherical and hollow Au NPs demonstrated detection up to nM concentration of MB dye molecules with corresponding enhancement factor of 106. Whereas, meticulous detection up to even < 25 pM concentration with corresponding enhancement factor of 109 with ease, in star shaped Au NPs. A completely complementary trend is observed in the corresponding SERS applications, wherein solid spherical and hollow Au NPs demonstrated detection up to nM concentration of MB dye molecules with corresponding enhancement factor of 106. Whereas, meticulous detection up to even < 25 pM concentration with corresponding enhancement factor of 109 with ease, in star shaped Au NPs

Contents

1.Introduction 2. Materials and methods techniques 3. Chloride ion induced formation of monodisperse hollow Au-Ag nanostructures 4. Modulating the shape and size of anisotropic gold nanostructures 5. Mechanistic studies of Au and Au-Ag nanostructures for catalysis and SERS applications 6. Summary and Scope for Future Study. References.

14. MALIK (Chirag)

Study of thermo-and Photo-Luminescence Properties of Some Potassium Calcium Based Sulfate, Phosphate and Borate Phosphors Irradiated with Ionizing Radiations.

Supervisor : Dr. Anant Pandey

Th25481

Abstract
(Verified)

In the present study, mainly four luminescent materials have been studied namely co-doped $\text{K}_2\text{Ca}_2(\text{SO}_4)_3:\text{Eu,Cu}$ prepared by co-precipitation method; $\text{KCaPO}_4:\text{Dy}$ prepared by solid-state diffusion and combustion methods; $\text{Ca}_3(\text{PO}_4)_2:\text{Dy}$ prepared by co-precipitation method and $\text{KCaBO}_3:\text{Dy}$ prepared by solid-state diffusion method. All these phosphors were investigated for their TL and PL properties and were characterized via techniques like XRD, FE-SEM, TEM, FTIR, and DRS in order to get compound confirmation, surface morphology, internal structure, band-gap determination and utility features of the materials. Phosphors were further irradiated using gamma-rays, UV-rays and ion-beams to note their TL sensitivity and thus study the effect of different types of ionizing radiations on the phosphors. The co-doped phosphor $\text{K}_2\text{Ca}_2(\text{SO}_4)_3:\text{Eu,Cu}$ showed more TL sensitivity than the singly doped phosphors and the standard TLD-100. It was found that the co-doped phosphors exhibited enhanced TL emission due to positive energy transfer. $\text{KCaPO}_4:\text{Dy}$ showed good TL sensitivity towards gamma rays and UV rays. The phosphor also showed good linear dose response for gamma (with linearity ranging from 10 Gy to 2 kGy) and UV rays irradiation. The same phosphor prepared by combustion method showed linear dose response from 10 Gy to 2 kGy. Another phosphate phosphor $\text{Ca}_3(\text{PO}_4)_2:\text{Dy}$ also exhibited decent TL properties. The borate phosphor $\text{KCaBO}_3:\text{Dy}$ showed good TL characteristics for ionizing photon-beam. However, in case of ion-beams, the dose response of the phosphor was good only for the low energy oxygen ion-beam. All phosphors mentioned above were *having acceptable value of repeatability (for gamma and UV rays) and fading (for gamma rays only). Furthermore, decent PL properties in case of Dy doped phosphors with an overall emission lying very near to white region were observed through the chromaticity index of Commission Internationale de l'Eclairage (CIE).*

Contents

1. Introduction 2. Experimental and characterization techniques 3. Potassium calcium based sulphate phosphors 4. Potassium calcium based phosphate phosphors 5. Potassium calcium based borate phosphor 6. Conclusion and future prospects.

15. MALIK (Sunil)
Study of Astrophysical Magnetic Field at High Redshift and Some of its Consequences.
 Supervisors : Prof. T. R. Seshadri and Prof. Hum Chand
Th25491

Abstract
(Verified)

Magnetic fields are ubiquitous in our universe. Astrophysical magnetic fields affect the galactic dynamics and evolution, star formation, and cosmic ray confinement. To gauge the effects that magnetic fields could have on these processes, we need to study the strength and morphology of the magnetic fields at different scales. We used the rotation measure of quasars to explore the magnetic fields in intervening normal galaxies and clusters of galaxies. We constrained the average strength of the magnetic field in high redshift galaxies to be around $1.3 \pm 0.3 \mu\text{G}$ at a median redshift of 0.92. From this analysis, we can conclude that the high-redshift galaxies also have magnetic fields of significant strength which can play a crucial role in galaxy dynamics. At larger scales cosmic magnetic fields can also affect the

structure formation in the universe and have a significant impact on the thermal and ionization history of the universe. We investigate the combined effect of the cosmic magnetic field and a possible non-standard interaction between baryons and dark matter on the temperature and the ionization state of the intergalactic medium. This manifests in terms of the thermal Sunyaev-Zel'dovich (tSZ) effect. We note that the spectral distortions (y -parameter) of Cosmic Microwave Background radiation can be significantly enhanced with the inclusion of magnetic field and baryon-dark matter interaction as compared to the case when these are absent. The enhancement depends on the strength of the magnetic field. The study of magnetic fields over different length scales done in this thesis further advances our understanding of the role of magnetic fields in the astrophysical processes and their signature and strength. With upcoming and operating observational facilities like Square Kilometer Array (SKA), LOFAR, MeerKat etc, the study of astrophysical magnetic fields holds enormous promise as a probe of the universe.

Contents

1. Introduction. 2. Diagnostics of astrophysical magnetic field 3. Magnetic field in high redshift galaxies 4. Implications of magnetic field on tSZ effect 5. Conclusions and Future Work. Appendix. References.

16. MISHRA (Sapna)
Probing Environment of AGNs Based on their Feedback Processes.
 Supervisors : Prof. T. R. Seshadri and Prof. Hum Chand
Th25475

Abstract (Verified)

The presence of a supermassive black hole (SMBH) at the core of an Active Galactic Nucleus (AGN) may predict the final evolution of its host galaxy. Energy generation via accretion in the form of outflows/jets, known as AGN feedback, can cause heating or compression of gases around the host galaxy. This occurs via two modes, (i) radiative and (ii) kinetic. In the first part, to probe whether the number density (dN/dz) of intervening (with offset velocity > 5000 km/s relative to the background) MgII absorbers are background dependent or not, we computed dN/dz towards 191 blazars and found that it statistically matches with the dN/dz of normal quasars. Besides, we showed that the associated MgII absorbers towards blazars can contribute to dN/dz up to $0.2c$. We extended our analysis to the high ionization CIV BAL quasars to explore the leading cause of their extreme variations. We presented a sample of 94 BAL quasars exhibiting appearing CIV BAL troughs and contrasted their properties with the disappearing BAL quasars. We found appearing BAL quasars are brighter and shallower compared to the disappearing BAL quasars with BAL trough appearance being followed by continuum dimming and vice versa. Our analysis supports the 'bluer when brighter' trend, fluctuating ionizing radiation model while rule out the intrinsic dust model. In the last part, we unprecedentedly searched 10 blazar-like BAL quasars with flat-spectrum and high linear-polarisation to inquire for a blazar-subset among BAL quasars and performed intra-night optical variability (INOV) analysis. Our analysis yielded zero INOV in this new sample, which being uncharacteristic of blazars implies physical conditions in BAL-blazars are less conducive for powerful INOV. Evidence in support of this is drawn from a comparison sample of 9 blazars (non-BAL) matching in magnitude-redshift with BAL-blazars.

Contents

1.Introduction 2. Data acquisition and reduction 3. Probing AGN environment using the kinetic-mode feedback 4. Probing AGN environment using the radiative-mode feedback 5. The relative role of kinetic-mode and radiative-mode of AGN feedback 6. Summary, conclusions and future prospects. Bibliography.

17. MITTAL (Shreya)

Synthesis and Characterization of Barium Titanate Based Piezoceramics.

Supervisor : Dr. K. Chandramani Singh

Th25494

Abstract

(Verified)

For more than a decade, the global piezoelectric market has been monopolized by lead-based material, particularly, lead zirconium titanate (PZT) due to its remarkable properties and commercial viability. PZT is an extremely toxic substance due to the presence of lead amounting to 60 wt% in its composition. U. S. ATSDR (Agency for Toxic Substances and Disease Registry), in 1999, listed lead as one of the hazardous substances to the environment and people. The RoHS (Restriction of Hazardous Substances) and the WEEE (Waste Electrical and Electronic Equipment) also restricted the use of lead-based materials in many developed countries. The ban in the electronic industry was exempted due to deficit of any alternative to PZT. This provided the impetus for research in lead-free piezoelectric material worldwide. In 2009, in a major breakthrough, Liu et al. discovered a new lead-free piezoelectric ceramic system, $(1-x)\text{Ba}(\text{Ti}_{0.8}\text{Zr}_{0.2})\text{O}_{3-x}(\text{Ba}_{0.7}\text{Ca}_{0.3})\text{TiO}_3$ (BCZT) exhibiting large piezoelectric constant. This present work is also an endeavour to synthesize lead-free piezoceramics by employing the conventional solid-state sintering method through (a) investigating the influence of dopant on the electrical properties of BCZT ceramic system and (b) studying the effect of BCZT-based piezoceramics prepared from nanocrystalline powders. On the basis of remarkable results obtained with other Nd-doped systems reported by other research groups, Nd was doped in the present study to form $\text{Ba}_{0.85-x}\text{Nd}_x\text{Ca}_{0.15}\text{Zr}_{0.1}\text{Ti}_{0.9}\text{O}_3$. Nanocrystalline powders of $\text{Ba}_{0.85}\text{Ca}_{0.15}\text{Zr}_{0.1}\text{Ti}_{0.9}\text{O}_3$ (BCZT) were prepared by traditional solid-state method along with high energy ball milling for 20 h fixed at the speeds of 100 rpm, 150 rpm, 200 rpm, 250 rpm, 300 rpm and 350 rpm of the sun-wheel. In the subsequent study, the influence of Yttrium content on transition temperature, microstructural and electrical properties of BCZT ceramics has been scrutinized profoundly. BCZT- $x\text{Y}_2\text{O}_3$ ($x = 0-0.10$ mol%) piezoceramics were prepared. Further study of another dopant Antimony (Sb) in BCZT system was performed.

Contents

1.Introduction 2. Experimental and characterization techniques 3. Neodymium doping in $\text{Ba}_{0.85}\text{Ca}_{0.15}\text{Zr}_{0.1}\text{Ti}_{0.9}\text{O}_3$ lead- free piezoceramics 4. Effect of ball-milling in $\text{Ba}_{0.85}\text{Ca}_{0.15}\text{Zr}_{0.1}\text{Ti}_{0.9}\text{O}_3$ ceramics 5. Yttrium doping in $\text{Ba}_{0.9}\text{Ca}_{0.1}\text{Zr}_{0.07}\text{Ti}_{0.93}\text{O}_{3-x}\text{Y}_x$ ($x=0,0.02, 0.04, 0.06,0.08,0.1$) lead-free piezoceramics 6.Yttrium doping in $\text{Ba}_{0.9-x}\text{Y}_x\text{Ca}_{0.1}\text{Zr}_{0.07}\text{Ti}_{0.93}\text{O}_3$ ($x=0,0.005,0.01,0.015,0.02, 0.025, 0.03, 0.035$) 7. Antimony doping in $\text{Ba}_{0.9}\text{Ca}_{0.1}\text{Zr}_{0.07}\text{Ti}_{0.93-x}\text{Sb}_x\text{O}_3$ lead-free piezoceramics 8. Conclusions and future prospects.

18. NEELAM

Study of the Transitional ^{134}Ba and ^{132}Xe ($N=78$) Nuclei using In-Beam Gamma-Ray Spectroscopy.

Supervisor : Dr. Suresh Kumar

Th25469*Abstract
(Not Verified)*

This thesis focus on an extension of the level scheme in the ^{134}Ba and ^{132}Xe nuclei using the In-beam gamma-ray spectroscopy and reports results on these nuclei populated in the three experiments carried out using the INGA facility. In the present thesis, the intermediate and high-spin states of the ^{134}Ba nucleus have been investigated up to spin $I = (20^-)$ via $^{124}\text{Sn}(^{13}\text{C}, 3n)^{134}\text{Ba}$ and $^{130}\text{Te}(^9\text{Be}, xyn)$ reactions at 48 MeV. Three negative parity ($\Delta I = 2$) bands were studied above the 1985.9 keV level and based on the systematics of the Ba (Even-N) isotopes and similarity in the behavior of signature splitting and $B(M1)/B(E2)$ ratios, two quasiparticles configuration has been assigned for these bands. Further, two ($\Delta I = 1$) dipole bands namely Band D1 and Band D2 have also been observed at the 5284.5- and 5677.9 keV level, respectively. The TAC calculations and systematic studies of similar structures in the neighboring $N = 78$ isotones suggest that the dipole band i.e, Band D1 observed at 5677.9 keV level may have the Magnetic Rotation (MR) character. Further, the reactions $^{130}\text{Te}(\alpha, 2n)^{132}\text{Xe}$ and $^{130}\text{Te}(^9\text{Be}, xyn)$ at 28- and 48 MeV, respectively were utilized to investigate the nuclear structure of the ^{132}Xe nucleus. Three negative parity ($\Delta I = 2$) bands namely Band A, Band B and Band C above the $I = 5^-$ isomeric state and the extension of the gamma-vibration band beyond the 1440.3 keV level were observed the first time in the ^{132}Xe nucleus. The shell model calculations with *SN100PN effective interaction provide insight into the structure established in this nucleus. The shell model calculations compare the experimental band structure remarkably well and corroborate most of the spin and parity assignment.*

Contents

1. Introduction 2.Theoretical models 3. Experimental setup and data analysis techniques 4. Investigation of dipole ($\Delta I=1$) bands in the transitional ^{134}Ba nucleus 5. In-beam gamma-ray spectroscopy of the transitional ^{132}Xe nucleus 6.Conclusion and future outlook.

19. NITISH

Some Aspects of Non-Perturbative Quantum Gravity in a Two form Gauge Theory.

Supervisors : Dr. Supriya K. Kar

Th25479*Abstract
(Verified)*

I consider a dynamical Kalb-Ramond two form and a constant Neveu-Schwarz two form to modify the covariant derivative in Einstein gravity. The modified gravity has been shown to be described by the torsion connections in the framework. Alternately a geometric torsion (three form) has been constructed in the modified theory which interestingly reflects a propagating Neveu-Schwarz two form in the modified gravity. Furthermore for a propagating geometric torsion the modified gravity has been shown to be described by a four form in the framework which was

constructed for an on-shell Neveu-Schwarz two form. Interestingly the Poincaré dual of four form, i.e. an axionic scalar dynamics, has been exploited to provide some clue to the quintessence cosmology. It may provide clues to unfold some aspects of quantum gravity. Furthermore the geometric torsion in the framework is explored to generate a mass term for an one and a two form gauge field without the established Higgs mechanism. In the context the dynamics of Neveu-Schwarz two form in a quantum theory has been argued to govern a graviton in a $(3 + 1)$ dimensional emergent gravity underlying a correspondence in local degrees of a massless two form gauge theory in the bulk and a boundary gravity theory. In addition the Killing symmetries underlying a Schwarzschild black hole in GTR were analyzed to reveal a non-Newtonian potential which in turn has been shown to describe a mass dipole in the framework. It is shown to incorporate a topological (quantum) correction to the GTR. The topological correction is argued to be sourced by a four form underlying a propagating geometric torsion in the bulk theory.

Contents

1. Introduction 2. Two form gauge theory 3. Generalized Riemann duals and four form 4. Quintessence in emergent gravity 5. Mass generation from a non-perturbative correction 6. Perihelion precession in torsion modified gravity 7. Quantum gravity with gravitational pairs 8. Concluding remarks.

20. PHOGAT (Aman)
Development of Resistive Plate Chambers and Front-end Electronics for ICAL Experiment.
 Supervisor : Dr. Md. Naimuddin
Th25484

Abstract (Verified)

The proposed 51 kton magnetized Iron Calorimeter (ICAL) detector at the India-based Neutrino Observatory (INO) is intended to measure atmospheric neutrino parameters precisely, and solve the neutrino mass hierarchy problem. Almost 29,000 Resistive Plate Chamber (RPC) detectors will be deployed in the ICAL detector to detect charged particles. Before stationing such a large number of chambers, it is necessary to closely examine each of its parameters. RPCs are parallel plate detectors that operate on the principle of gas ionization. RPC detectors have been fabricated and were tested for efficiency, cluster size, count rate, time resolution and charge spectra under different R134a(Freon)/Isobutane/SF₆ gas compositions. Materials used in the construction of RPCs are tested for any outgassing. An indigenous leakage station is also designed and fully assembled RPC detectors were tested with this leak station. A complete readout of the ICAL detector would require about 3.7 million electronic readout channels. A new front-end electronics HARDROC (Hadronic RPC Detector ReadOut Chip) has been tested as an alternative electronics for ICAL-RPCs. Features such as multichannel readout, low power consumption, and compactness make HARDROC an attractive option as a front-end data acquisition system. The HARDROC ASIC can read 64 channels and implements amplification, shaping, and digitization. Its various parameters and working readout modes were calibrated and tested. Later the HARDROC electronics was integrated with RPC detectors. Then, the performance results of single gap glass-based RPC using HARDROC as front end electronics are presented. Uniformity of response of large size detectors in terms of cluster size, efficiency and count rate has been studied across $1\text{m} \times 1\text{m}$ glass RPC detectors by dividing the

detector into 32 zones. The satisfactory results achieved with HARDROC make it an alternative front-end readout for ICAL RPCs.

Contents

1.Introduction 2. Resistive plate chamber 3. Characterisation of ICAL RPC 4.Outgassing and leak rates 5. Electronics development for ICAL RPCs 6. Conclusion & Outlook. Bibliography.

21. Sachin Kumar
Investigations on Yttrium and /or Tin Doped Barium Titanate for Ferroelectric Applications.
 Supervisor : Dr. Vandna Luthra
Th25472

Abstract *(Not Verified)*

Barium Titanate (BT) based ceramics are widely used for scientific and industrial applications such as MLCC, FeRAM etc. It is a lead-free material that doesn't show any ill effect on human health or the environment. BT is of specific importance because of its ferroelectric nature. There are continuous efforts to modify the ferroelectric properties of barium titanate by doping with different elements or by adopting several synthesis techniques. Yttrium is a rare-earth element that is used for several applications in modern electronics. Yttrium in BT could densify the material at lower processing temperatures. The yttrium doping concentration and synthesis conditions were optimized to enhance the ferroelectric properties of barium titanate using the solid-state route of material preparation. Besides, tin doping in barium titanate is known for reducing its Curie temperature, which is the region of high dielectric constant. Moreover, it also enhances the dielectric properties of the native BT-based perovskite material. Some of the most favourable processing conditions and doping compositions were observed and utilized for the co-doping of these dopants in barium titanate. The simultaneous doping of yttrium and tin in barium titanate showed an increase in the ferroelectric properties of barium titanate. A dense microstructure and high dielectric constant at its transition temperature as well as near room temperature were observed for co-doped samples. The sol-gel method is a wet chemical synthesis route that can be cast into thin films as well. The bulk powders prepared through the sol-gel route also showed high dielectric constant at its Curie and room temperature. The doping induced compensation mechanism was established by Raman and FTIR spectroscopies. The correlated behaviour of the optimum values is observed in density, dielectric constant and other ferroelectric properties which can be explored further for various applications.

Contents

1. Introduction 2. Synthesis and characterization techniques 3.Yttrium Doping at A-site of barium titanate 4. Tin doping at B-site of barium titanate 5. Investigation of yttrium and tin co-doping in barium titanate 6. Investigations on sol-gel synthesized yttrium and /or tin doped barium titanate 7. Conclusion and Future Plan.

22. SARIN (Neha)
Synthesis, Characterization and Gas Sensing Applications of Undoped & Fe-/Co-Substituted Strontium Titanate Ceramics.
 Supervisor : Dr. Vandna Luthra
Th24635

Abstract
(Not Verified)

Strontium titanate (ST) is a wide band gap material that has been studied due to its usage in multitude of applications such as sensing, spintronics, photocatalysis and microelectronics amongst many more. On doping with appropriate dopants like transition metals (TM), ST gives rise to interesting physical and chemical properties suited for various applications. In the present work, a comprehensive investigation of the incorporation of TM ions into SrTiO_3 is reported. $\text{SrM}_x\text{Ti}_{1-x}\text{O}_{3-\delta}$ ($M = \text{Fe}/\text{Co}$) ($x = 0 - 0.4$) powders were prepared via solid state route. The dopant-induced changes in structural, electrical, magnetic and gas sensing properties were investigated. X-ray diffraction, Raman and Fourier transform infrared spectroscopic techniques were used to analyze the structure, phase formation and lattice dynamics while Scanning electron microscopy was employed to investigate the surface morphology of the samples. The X-ray photoelectron spectroscopy was performed to study the surface chemistry, electronic structure, and the impact of ambient environment on synthesized samples. The results indicated presence of dopant and titanium ions in mixed valence states along with considerable increase in oxygen vacancies. Moreover, a downward shift in Fermi level was observed with an increase in doping level suggesting a transition from n-type to p-type behavior. The electrical and magnetic properties were studied to explore the effect of TM substitution on current conduction and magnetic phase. The DC conductivity was studied at room temperature (RT) and as a function of temperature. The magnetic studies were performed at RT and to substantiate magnetic phase transition, Zero field cooled and Field cooled studies were carried out. To probe the gas sensing properties, resistive sensors were made using screen printing technique. The corresponding properties were investigated in dry and humid environments (50% RH) for various reducing and oxidizing gases in range 5-50 ppm at different operating temperatures to obtain optimum response.

Contents

1. Introduction 2. Experimental techniques 3. Structural investigations of the undoped, Fe- and Co-substituted SrTiO_3 4. X-Ray photoelectron studies of the undoped, Fe and Co-substituted SrTiO_3 5. Investigating the electrical and magnetic properties of the undoped, Fe- and Co-substituted 6. Gas sensing properties of the undoped, iron and cobalt substituted SrTiO_3 7. Conclusion and future work. Conclusion. List of publications.

23. SETHI (Varun)
Studies of Phases in Holographic Nuclear Matter.
 Supervisors : Dr. Swarnendu Sarkar and Dr. Alok Laddha
Th25476

Abstract
(Verified)

We consider a holographic QCD model based on Sakai-Sugimoto approach with intersecting D8-branes in bulk. Boundary has strong coupling QCD with large number of colours and flavours and in presence of chemical potential for baryon number and isospin. For $2N_f$ D8-branes, gauge symmetry is $U(2N_f) \equiv U(1)_B \times SU(2N_f)$. Sources for $U(1)_B$ and $U(1)_3$ (diagonal subgroup of $SU(2N_f)$) fields on 8-branes are D4-branes wrapped on S^4 part of background [1] (for two flavour branes). Charge corresponding to $U(1)_3$ acts differently on the 8-branes making them separate. The tachyonic instability of intersecting 8-branes configuration discussed in [1] was

proposed to be the dual of pairing instability in superconductors. In this thesis, we first study behaviour of intersecting brane configuration at finite temperature. We consider a simplified configuration of intersecting D3-branes in flat background and analyse one loop finite temperature two-point tachyon amplitude in Yang-Mills approximation. We then extend this model to calculate the corresponding tachyon amplitude for intersecting stacks of D3-branes. We show that tachyon two point amplitude is ultraviolet finite owing to the cancellations between terms involving bosonic and fermionic modes in the loop. For intersecting D3-branes problem, we numerically compute the transition temperature at which tachyon becomes massless. For two intersecting stacks, we show that the results of previous problem can be generalised to this setup. We further discuss the issues involved in computation of two point amplitude in case of multiple intersecting stacks. Finally we consider the setup [1] and show various brane configurations in both confined and deconfined phases along with phases of the gauge theory they correspond to. We also explore the possibility of phase transition between the phases.

Contents

1. Introduction 2. A pair of intersecting D3-branes 3. Stacks of intersecting D3-branes 4. Holographic QCD: a study of phases 5. Discussion

24. SHARMA (Ekta)
Investigation of the Evolution of Dark Clouds.
 Supervisors : Prof. T. R. Seshadri and Prof. Maheswar Gopinathan
Th25493

Contents

1. Introduction 2. Observations & data reduction 3. Dynamical state of Gas surrounding herbig be star HD 200775 4. Interplay of magnetic field and gas dynamics in LDN 1172 5. Distance, magnetic field and kinematics of a filamentary cloud LDN 1157 6. Molecular line study of the cloud complex LDN 1147/L1158 complex 7. Kinematics of star-forming molecular clouds in Cepheus flare region 8. Core orientations and magnetic fields in molecular clouds showing asymmetric morphology 9. Summary and Future Work. References.

25. SHARMA (Rahul)
Study of Transient X-ray Binaries in the Time and Energy Domains.
 Supervisor : Prof. Anjan Dutta
Th25474

Abstract (Verified)

The Low Mass X-ray Binaries (LMXBs) are astrophysical systems that consist of a compact object, either a black hole or a Neutron Star (NS) and a low mass companion star. This thesis presents results from the transient LMXBs hosting a NS, which show the outbursts after a long period of quiescence, where the X-ray luminosity increases by a factor of ~ 10 - 10^4 , and therefore, can be studied over a wide range of X-ray luminosities. A detailed study of two such sources, MXB 1658-298 and SAX J1748.9-2021, were performed in the time and energy domains. The mid-eclipse timing record of MXB 1658-298 is found to be quite unusual. The long-term evolution of mid-eclipse times indicates an overall orbital period decay with a time-scale of $-6.5(7) \times 10^7$ years. Over and above this orbital period decay, the Observed-Calculated residual curve also shows a periodic residual on shorter time-

scales, indicative of the presence of a third body around the compact X-ray binary with a mass of 16-20 Jupiter mass. For the first time, we have reported a detailed comparison of the soft and hard spectral states during an outburst in MXB 1658-298. We have also found a link between the spectral state of the source and the Fe K absorber, observed only in the soft state. SAX J1748.9-2021, an accreting millisecond X-ray pulsar, showed the spectral features of the reflected emission from the accretion disc. The AstroSat data revealed the presence of pulsations at spin frequency of 442.361098(3) Hz and the pulse profiles obtained from 3-7 keV and 7-20 keV energy bands suggest constant fractional amplitude ~0.5% for fundamental components, contrary to previously observed energy pulse profile dependence. Both sources are known X-ray bursters and showed the radius expansion during the bright bursts.

Contents

1. Introduction 2. X-ray observations and data analysis 3. Eclipse timing of MXB 1658-298 4. Spectral properties of MXB 1658-298 5. SAX J1748.9-2021 6. Conclusion and Future Work. Bibliography.

26. SINGH (Madhav Kumar)
Studies on Electron Dynamics and Quantum Optical Properties of Semiconductor Microcavities : Possible Device Application.
 Supervisor : Dr. Pradip K. Jha
Th25488

Abstract (Not Verified)

The spin and tunneling dynamics as a function of magnetic field in one dimensional double QD with spin orbit coupling is studied. The dynamics is investigated in the presence of Dresselhaus and Rashba Spin orbit coupling. The probability to find the electron in the right quantum dot along with expectation value of spin components are calculated, which is useful to describe quantum transport. Calculations showed that z- component of spin is irregular in behaviour when the spin-up and spin-down state have identical width (ID). Similarly the dynamics of probability density in right dot is irregular for the identical width. This showed that for small magnetic fields, a small spin polarization can be achieved in tunneling under ID case. A strong magnetic field suppresses the tunneling from left to right well. While the dynamics for non-identical width (NID) case, is more regular. For NID case no spin polarization is achieved in tunneling from left to right QD. The investigation is carried out for two QDs optically coupled to semiconductor microcavities, which are shown to be perfect system to explore the field of cavity quantum electrodynamics. Strong interactions between QDs and microcavities allow us to generate non-linear optics near the single photon level. Photon statistics with the strong antibunching effect have been observed in the zero time delay second order correlation by optimizing the relative phase between the applied laser field of microcavity and one QD, and rabi coupling strength. We also theoretically investigated optical bistability/multistability for all optical switching signature in a hybrid semiconductor microcavity system comprising a quantum well and a Kerr nonlinear substrate. The switching between bistable and multistable behaviour is found to be influenced by the modulated pump laser, Kerr nonlinearity and the optical coupling between the two microcavities.

Contents

1. Introduction 2. Methodologies used in this thesis 3. Spin and tunnelling dynamics in an asymmetrical double quantum dot with spin orbit coupling: selective spin transport device 4. Photon blockade induced tunable source of one/two photon in a double quantum dot-semiconductor microcavity system 5. Optical switching and normal mode splitting in hybrid semiconductor microcavity containing quantum well and kerr medium driven by amplitude modulated field 6. Bibliography. Concluding remarks.

27. SINGH (Kuldeep)

Study of Astrophysical Magnetized Flows.

Supervisors : Prof. Patrick Das Gupta and Dr. Indranil Chattopadhyay
Th25482

Abstract (Verified)

A detailed study of magnetized astrophysical flows has been carried out in the magnetohydrodynamic and special relativistic magnetohydrodynamic regime. We have considered the thermodynamics of the flow to be described with a fixed as well as, a variable adiabatic index equation of state (EoS). As examples of MHD flow, we have studied (i) funnel accretion on to neutron stars and white dwarfs, (ii) magnetized equatorial outflows from around a compact magnetized star, and (iii) magnetized relativistic outflows about the axis of symmetry from compact objects like black holes. We obtained semi-analytical magnetized accretion solutions on to compact objects with hard surface such as neutron stars which satisfies the inner boundary condition, where the accreting matter gently settles onto the surface of the star. We also compared these solutions in Newtonian & pseudo-Newtonian regimes. We have found that cyclotron cooling and bremsstrahlung cooling are necessary to obtain a consistent accretion solution i.e., a solution which connects the flow from the accretion disk to the star surface. We studied the effect of plasma composition on the equatorial wind outflow with variable adiabatic index EoS in Newtonian & pseudo-Newtonian regimes. We have found that terminal velocity and flow variables depend upon the plasma composition. Lepton dominated winds with higher values of Bernoulli parameter have high terminal speeds. We also explored the case of collimated outflows or jets in special relativistic magnetohydrodynamic regime with variable adiabatic index EoS. From our analysis, we inferred that plasma composition mainly affects the velocity and the temperature of the jet but the collimation of jet and fast critical point location appears to have no dependence on plasma composition.

Contents

1. Introduction 2. Mathematical structure and methodology to solve equations of motion 3. The study of magnetized accretion flow onto compact objects 4. Effect of composition on magnetized outflows 5. Study of relativistic magnetized outflows with relativistic equation of state 6. Conclusions.

28. SUJIT KUMAR

2D-MoS₂ Grown by Pulsed Laser Deposition Technique for Environmental Monitoring and Energy Harvesting.

Supervisor : Prof. Vinay Gupta
Th25489

Abstract
(Not Verified)

MoS₂ is the most prevalent and widely explored two dimensional material for various application. Pulsed laser deposition (PLD) is a powerful bottom-up technique which is highly promising for growing stoichiometric and continuous 2D materials with great controllability. This dissertation is an attempt to address the key challenges faced in growing high quality controlled growth of MoS₂ layers along with realization of optimized MoS₂ layers for various device applications. MoS₂ layers were grown using PLD and good quality was confirmed using XRD, AFM, PL, RAMAN, HR-TEM, XPS. Different contact electrodes (Platinum (Pt)/Titanium (Ti), Silver (Ag)/Gold (Au) and Indium Titanium oxide (ITO)) were exploited with MoS₂ layers for the fabrication of efficient UV photodetectors. For the demonstration of FETs using MoS₂ layer as semiconducting channel, various metal contacts were deposited using thermal evaporation (Au/Ag, Al and Ni) and rf sputtering (Pt/Ti) techniques over the surface of trilayer MoS₂ using a shadow mask and two probe measurements were performed. Effect of dielectric (SiO₂ and Si₃N₄) thickness in fabricated FETs were studied in detail. To demonstrate the efficacy of optimized FET geometry, NO₂ gas sensor based on 90 nm thin Si₃N₄ as gate dielectric and Au/Ag (50/50 nm) as source drain contact and different number of MoS₂ layers as semiconducting channel were employed. Sensitivity of the devices were calculated from the conductance value obtained from the output curve of the transistor when exposed to 10 ppm of NO₂ gas. Fabricated FET based gas sensor showed the sensing response of 165.3% towards 10 ppm concentration of NO₂ gas and limit of detection (LOD) of 1 ppm. Finally, optimized MoS₂ layers were exploited for triboelectric energy harvesting applications based on motion of NaCl droplet on its surface. Various substrates, Si₃N₄ (300 nm)/Si, c-plane sapphire and thermally grown SiO₂ (300 nm)/Si were exploited for optimum performance.

Contents

1. MoS₂ a 2D material: introduction 2. Growth and characterization of MoS₂ layers using pulsed laser deposition (PLD) 3. Fabrication UV photodetector using MoS₂ layers grown by pulsed laser deposition (PD) 4. High-performance FETs using MoS₂ layers as channel 5. MoS₂ FET based room temperature NO₂ gas sensor 6. Development of novel MoS₂ turboelectric nanogenerators from moving NaCl droplet

29. SUDHISHT KUMAR

Growth of ZnO Nanostructured Thin Films: Their Properties and Applications.

Supervisor : Prof. P. D. Sahare

Th25487

Abstract
(Not Verified)

The work in hand presents the growth of ZnO nanostructured thin film, their properties, and applications. A comparative study of different growth techniques reveals pronounced differences in the properties of grown nanostructures. The understanding of growth mechanism and dynamics provides strong control over the growth parameters for the growth of nanostructures with desired morphology and physical properties. The major portion of work is dedicated to practical applications of grown nanostructures such as UV sensing nano diodes, light-emitting diodes, spintronics, and field emission devices.

Contents

1. Introduction 2. Experimental techniques 3. Morphological control of ZnO nanostructured film grown by hydrothermal method 4. Optimizing the CVD parameters for ZnO nanorods growth: its photoluminescence and field emission properties 5. Morphological transformations induced by Co impurity in ZnO nanostructures prepared by RF magnetron sputtering and their physical properties 6. N-ZnO/p-Si heterojunction nanodiodes based sensor for monitoring UV radiation 7. Summary and Conclusions 8. Publications 9. Conference contributions.

30. VARSHNEY (Vaibhav)

Emergence of Novel Dynamics in Counter-rotating Coupled Oscillators.

Supervisors : Dr. Awadhesh Prasad and Prof. Bibhu Biswal

Th24639

Abstract (Not Verified)

Second, we report bifurcation delay and chimera-like states in a network of FitzHugh-Nagumo oscillators, where each oscillator can rotate either clockwise or anticlockwise. Slow variation of the time-dependent parameter of oscillator near the bifurcation point leads to a delay in the bifurcation. The delay in the bifurcation is independent of the direction of rotation of the system. When the FHN oscillators are coupled via dissimilar variables, then bifurcation delay in the anticlockwise rotating oscillator changes, creating chimera-like structures and also travelling waves. Bifurcation preonement is also observed for other range of coupling strengths. Finally, we study the emergence of extreme events and their propagation in a network of coupled nonlinear oscillators, where counter-rotating oscillators play the role of malfunctioning agents. We observe that the extreme events occur only in the counter oscillating pair of oscillators through the saddle-node bifurcation. We present a detailed study of the propagation and destruction of the extreme events. Extreme events travel only when nearby oscillators are in synchronized states.

Contents

1. Introduction 2. Oscillation death and revival by coupling with damped harmonic Oscillator 3. Bifurcation delay, travelling waves and chimera-like states in a network of coupled oscillators 4. Travelling of extreme events in network of nonlinear oscillators 5. Summary, Conclusion and Future works. Bibliography.

31. VISHNU KUMAR

Synthesis, Characterizations and Physical Properties of Perovskite Oxide and Oxy-nitride: An Investigation by Synchrotron-based Techniques.

Supervisors : Prof. S. Annapoorni and Dr. Asokan Kandasami

Th25496

Abstract (Not Verified)

The present thesis focuses on the SrTiO₃ (STO) and possible enhancement in dye degradation efficiency of a photocatalytic material for the elimination of pollutants present in water and to study their structural and optical properties. Correlations of these properties with the electronic structure of STO were investigated using synchrotron-based techniques. Chapter 1 provides a brief introduction to basic properties, crystal structure, and applications of perovskites with special reference

to STO. Chapter 2 presents the experimental details of the synthesis of STO nanoparticles and thin films for introducing defects in the system. It also describes the different laboratory and synchrotron-based techniques used to characterize the samples. In Chapter 3, the photocatalytic degradation of methylene blue dye using ball-milled STO powders is described. The particle size of STO decreases after increasing the time of ball-milling. Smaller particles provide a shorter path to the photo-generated charge carriers which decrease their recombination probability. Chapter 4 is divided into two sections. The optimization of experimental parameters to fabricate STO films using RF magnetron sputtering is presented in the first section. The second section illustrates the evolution of optical blue-green emission in STO thin films implanted by 100 keV nitrogen ions at different ion fluences. The modification in local surroundings of Ti ions results in the alterations of its coordination geometry and valency. Chapter 5 describes the bandgap engineering of STO films with swift heavy Ag ions. An appropriate fluence of Ag ion beam results in the bandgap of STO close to the visible light necessary for several applications. The presence of nitrogen in N ion implanted STO single-crystals was confirmed by X-ray absorption near-edge structure spectra at N K-edge and is presented in Chapter 6. The modified electronic structure was studied by analyzing the angle-dependent XANES spectra at Ti K-, L-, and O K-edges.

Contents

1. Introduction 2. Experimental methods 3. Enhanced photo catalytic activity of ball-milled SrTiO₃ powder 4. Intense blue-green emission by N Ion implanted SrTiO₃ films 5. Bandgap engineering in SrTiO₃ films by electronic excitations 6. X-ray nano diffraction and X-ray absorption spectroscopy studies on N Ion implanted SrTiO₃ single-crystals 7. Summary and future perspectives.

32. YADAV (Neetu)

Gel Polymer Electrolytes for Application in Quasi-Solid-State Carbon Super capacitors.

Supervisor : Prof. S. A. Hashmi
Th25486

Abstract (Not Verified)

Electrical energy storage and delivery using batteries and supercapacitors is a necessity of the future due to the dwindling fossil fuel supplies and unreliable power delivery from renewable sources such as wind and sun. Supercapacitors are the promising energy storage devices that can meet the demands of high power density and high cycle life. However, supercapacitors, in general, possess low energy density, hence, have limited applicability as power sources in various applications. In order to achieve high energy density supercapacitors (particularly, electrical double layer capacitors, EDLCs), ionic liquid as electrolyte and activated carbon (derived from biomass) as electrodes are frequently reported. The present thesis presents the details to preparation and characterization of two types of EDLC electrode materials, preparation and characterization of Mg-ion conducting gel polymer electrolytes (GPEs), and various types of redox-active GPEs; fabrication and characterization of EDLCs using Mg-ion and redox-active GPEs and AC-electrodes. The multiwalled carbon nanotube (MWCNTs), and graphene nanoplatelets (GNPs) have also been used to prepare EDLC-electrodes for comparison. The comparative performance studies have been presented on EDLCs, fabricated with peanut-shell derived activated carbon electrodes (prepared by two processes) and ionic liquid incorporated Mg-ion conducting GPE films.

Contents

1. Introduction 2. Experimental techniques 3. Quasi-solid-state supercapacitors with peanut-shell-derived porous carbon and Mg^{2+} ion conducting gel polymer electrolyte 4. Quasi-solid-state carbon supercapacitors with ionic liquid incorporated redox-active blend polymer electrolyte 5. Non-aqueous redox-active gel polymer electrolyte incorporated with ionic liquid for high performance supercapacitor 6. Redox-active gel polymer electrolyte incorporated with plastic crystal and ionic-liquid for high energy density quasi-solid-state carbon supercapacitors 7. High energy density quasi-solid-state supercapacitor based on non-aqueous dual redox-additive gel polymer electrolyte 8. Overall summary and conclusions.

33. Yeluripati (Rohin Kumar)

Studies in Alternative Cosmologies.

Supervisors : Prof. Daksh Lohiya and Prof. Amitabha Mukherjee

Th25473

Abstract (Not Verified)

The purpose of this thesis is to explore alternative cosmologies, especially linearly coasting models - a cosmology model in which scale factor increases linearly with time. The scope of such class of cosmologies, their theoretical limitations and observational constraints etc. are studied in sufficient detail. There is growing interest in extending cosmology beyond the standard Λ CDM model, motivated by a range of apparently serious theoretical issues. Novelty of this work approaching alternative cosmologies is primarily in two areas - study of linear coasting cosmologies using $f(R)$ gravity and study of large scale structures using redshift surveys assuming an alternative cosmology of choice. $f(R)$ gravity is a simple metric theory extension of general relativity. Instead of assuming a form of $f(R)$, we reconstruct gravity models from scale factor evolution. Gravity models obtained for linear coasting models are then evaluated based on the theoretical viability conditions. In the second part of the thesis, large scale structure observations are studied from redshift surveys. We generally obtain clustering statistics of galaxies such as the two-point correlation function (2pCF) using distances calculated from their redshifts assuming a fiducial cosmology model as a prior. All the existing codes that calculate 2pCF assume standard Λ CDM model with flat geometry by default. To be able to calculate these clustering statistics for any arbitrary model of cosmology with geometry of one's choice, a code is developed from scratch using Python named 'correlcalc'. Using machine learning algorithms for faster calculation of nearest neighbors the developed code can be used to quickly calculate 2pCF for any alternative model. A quick comparison of results is done to verify validity of *galaxy clustering in alternative models. A case study of constraining gravity models from large scale structure growth rates using redshift space distortions is also done.*

Contents

1. Introduction 2. Study of some alternative gravity models 3. Gravity models for linearly coasting cosmologies 4. Large scale structure of the universe 5. Galaxy clustering from redshift surveys 6. Summary & Future Work. References. Appendix.