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Published: February 13, 2015

A multisymplectic approach to defects in integrable classical field theory

V. Caudrelier and A. Kundu

Abstract:
Real materials as a rule exhibit defect structures, which however is usually avoided in theoretical studies due to difficulty in handling them. In recent years, the question of integrable defects in classical field theories was considered actively with some major success. However, there are some crucial gaps in these investigations, which we intend to bridge, by reconciling different approaches and getting rid of their limitations by proposing a significantly new idea, through the concept of multisymplectic formalism. The new Poisson bracket associated to the space coordinate, that we introduce taking the nonlinear Schroedinger equation as an example, completely bypasses all the known problems associated with the presence of a defect in integrable systems and allows to implement the crucial r- matrix formalism for proving the Liouville integrability of the system with such a defect.

Journal Reference: *10.1007/JHEP02(2015)088*

Number of coauthors outside SINP: 1
(V. Caudrelier, Department of Mathematics, City University London)

Journal Impact Factor:(2013) : 6.220

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Physics Letters B

www.elsevier.com/locate/physletb

Published : 6th March, 2015

Low energy gamma ray excess confronting a singlet scalar extended inert doublet dark matter model

Amit Dutta Banik and Debasish Majumdar

Abstract

Recent study of gamma rays originating from the region of galactic centre has confirmed an anomalous γ-ray excess within the energy range 1-3 GeV. This can be explained as the consequence of pair annihilation of a 31-40 GeV dark matter into $b\bar{b}$ with thermal annihilation cross-section $\sigma v \sim 1.4 - 2.0 \times 10^{-26}$ cm^3/s. In this work we revisit the Inert Doublet Model (IDM) in order to explain this gamma ray excess. Taking the lightest inert particle (LIP) as a stable DM candidate we show that a 31-40 GeV dark matter derived from IDM will fail to satisfy experimental limits on dark matter direct detection cross-section obtained from ongoing direct detection experiments and is also inconsistent with LHC findings. We show that a singlet extended inert doublet model can easily explain the reported γ-ray excess which is as well in agreement with Higgs search results at LHC and other observed results like DM relic density and direct detection constraints.

Journal Reference :Physics Letters B 743 (2015) 420

Number of coauthors outside SINP: 0

Journal Impact Factor : 6.019

Journal of Cosmology and Astroparticle Physics
An IOP and SISSA journal

A possible explanation of low energy γ-ray excess from galactic centre and Fermi bubble by a Dark Matter model with two real scalars

Kamakshya Prasad Modak,[a] **Debasish Majumdar**[a] **and Subhendu Rakshit**[b]

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Published : 9th March, 2015

Abstract. We promote the idea of multi-component Dark Matter (DM) to explain results from both direct and indirect detection experiments. In these models as contribution of each DM candidate to relic abundance is summed up to meet WMAP/Planck measurements of $\Omega_{\rm DM}$, these candidates have larger annihilation cross-sections compared to the single-component DM models. We illustrate this fact by introducing an extra scalar to the popular single real scalar DM model. We also present detailed calculations for the vacuum stability bounds, perturbative unitarity and triviality constraints on this model. As direct detection experimental results still show some conflict, we kept our options open, discussing different scenarios with different DM mass zones. In the framework of our model we make an interesting observation: the existing direct detection experiments like CDMS II, CoGeNT, CRESST II, XENON 100 or LUX together with the observation of excess low energy γ-ray from galactic centre and Fermi bubble by Fermi Gamma-ray Space Telescope (FGST) already have the capability to distinguish between different DM halo profiles.

Journal Reference : JCAP03(2015)011

Number of coauthors outside SINP: 1
(S. Rakshit, Discipline of Physics, IIT Indore)

Journal Impact Factor:5.877

Stacking Geometry for Non-Canonical G:U Wobble Base Pair Containing Dinucleotide Sequences in RNA: Dispersion-Corrected DFT-D Study

Manas Mondal, Sanchita Mukherjee, Sukanya Halder and Dhananjay Bhattacharyya

Non-technical summery:

DNA double helices are stabilized by the canonical A:U and G:C Watson-Crick type base pairing and stacking interaction between the base pairs, which involve interactions between aromatic pi-electrons of successive base pairs. Structures of different RNA molecules, on the other hand, are seen to have various other types of base pairs, G:U is one of the most common one. In this paper we tried to understand stacking interactions between the G:U base pairs and other canonical ones.

Abstract:

Emergence of thousands of crystal structures of non-coding RNA molecules indicates its structural and functional diversity. RNA function is based upon a large variety of structural elements which are specifically assembled in the folded molecules. Along with the canonical Watson-Crick base pairs, different orientations of the bases to form hydrogen-bonded non-canonical base pairs have been observed in the available RNA structures. Frequencies of occurrences of different non-canonical base pairs in RNA indicate their important role to maintain overall structure and functions of RNA. There are several reports on geometry and energetic stabilities of these non-canonical base pairs. However their stacking geometry and stacking stability with the neighboring base pairs are not well studied. Among the different non-canonical base pairs, the G:U wobble base pair (G:U W:WC) is most frequently observed in the RNA double helices. Using quantum chemical method and available experimental data set we have studied the stacking geometry of G:U W:WC base pair containing dinucleotide sequences in roll-slide parameters hyperspace for different values of twist. This study indicates that the G:U W:WC base pair can stack well with the canonical base pairs giving rise to large interaction energy. The overall preferred stacking geometry in terms of roll, twist and slide for the eleven possible dinucleotide sequences is seen to be quite dependent on their sequences. This article is protected by copyright. All rights reserved.

Biopolymers 2015, Feb 4. DOI: 10.1002/bip.22616

All authors are from SINP.

RNABP COGEST: a Resource for Investigating Functional RNAs

Swati Panigrahi, Rahul Paul, Sukanya Halder, Dhananjay Bhattacharyya

Ribonucleic acid (RNA) structures are known to have nucleotide base – base interactions, commonly called as base pairs and most of the base pairs as found in the structures are similar to those found in DNA double helix, also known as Watson-Crick base pairs. Analysis of the available structures of RNA also indicated presence of various other non Watson-Crick base pairs. Many groups, across the world, studied stabilities of these base pairs from different aspects – by experimental as well theoretical approaches. This database of base pairs in RNA was created compiling all such studies.

Abstract

Structural bioinformatics of RNA has evolved mainly in response to the rapidly accumulating evidence that non-(protein)-coding RNAs (ncRNAs) play critical roles in gene regulation and development. The structures and functions of most ncRNAs are however still unknown. Most of the available RNA structural databases rely heavily on known 3D structures, and contextually correlate base pairing geometry with actual 3D RNA structures. None of the databases provide any direct information about stabilization energies. However, the intrinsic interaction energies of constituent base pairs can provide significant insights into their roles in the overall dynamics of RNA motifs and structures. Quantum mechanical (QM) computations provide the only approach toward their accurate quantification and characterization. 'RNA Base Pair Count, Geometry and Stability' (http://bioinf.iiit.ac.in/RNABPCOGEST) brings together information, extracted from literature data, regarding occurrence frequency, experimental and quantum chemically optimized geometries, and computed interaction energies, for non-canonical base pairs observed in a non-redundant dataset of functional RNA structures. The database is designed to enable the QM community, on the one hand, to identify appropriate biologically relevant model systems and also enable the biology community to easily sift through diverse computational results to gain theoretical insights which could promote hypothesis driven biological research.
Database URL: http://bioinf.iiit.ac.in/RNABPCOGEST

Authors from SINP: 4

Complete reference:

Sohini Bhattacharya, Shriyaa Mittal, Swati Panigrahi, Purshotam Sharma, Preethi S. P., Rahul Paul, Sukanya Halder, Antarip Halder, Dhananjay Bhattacharyya,*and Abhijit Mitra* Database, 2015, 1–9
doi: 10.1093/database/bav011

PHYSICS OF PLASMAS 22, 022307 (2015)

Investigation and quantification of nonlinearity using surrogate data in a glow discharge plasma

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(Received 21 November 2014; accepted 28 January 2015; published online 12 February 2015)

Detection of nonlinearity has been carried out in periodic and aperiodic floating potential fluctuations of DC glow discharge plasma by generating surrogate data using iterative amplitude adjusted Fourier transform method. We introduce "delay vector variance" analysis (DVV) for the first time, which allows reliable detection of nonlinearity and provides some easy to interpret diagram conveying information about the nature of the experimental floating potential fluctuations (FPF). The method of false nearest neighbourhood is deployed on the FPF's to find a good embedding so as to be acquainted with the precise knowledge of m, which is desirable for carrying out DVV analysis. The emergence of nonlinearity with increase in discharge voltage has been ensured by taking into consideration the total energy present in different band of frequencies excited due to nonlinear processes. Rejection of null hypothesis has been verified by performing the rank test method that confirms the presence of nonlinearity quantitatively. © *2015 AIP Publishing LLC*. [http://dx.doi.org/10.1063/1.4907796]

Journal reference Phys. Plasmas 22(2015)022307

No of authors outside SINP : 0

PHYSICS OF PLASMAS 22, 033702 (2015)

Stabilization of Rayleigh-Taylor instability in a non-Newtonian incompressible complex plasma

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The stabilization of Rayleigh-Taylor (RT) instability is investigated in a non-Newtonian unmagnetized dusty plasma with an experimentally verified model of shear flow rate dependent viscosity. It has been found that non-Newtonian property has also a significant role in stabilization of RT instability along with velocity shear stabilization in the short wavelength regime. The effect of the non-Newtonian parameters is more profound in the higher velocity shear rate regime. A detailed study is reported on the role of non-Newtonian effect on RT instability with conventional dust fluid equations using standard numerical eigenvalue analysis. © *2015 AIP Publishing LLC*.
[http://dx.doi.org/10.1063/1.4916126]

Journal Reference Phys. Plasmas 22(2015)033702

No. of authors outside SINP : 1

Photoacoustic Imaging of Nanoparticle-Containing Cells Using Single-Element Focused Transducer: A Simulation Study

Madhusudan Roy and Ratan K. Saha
Surface Physics and Material Science Division

A new theoretical approach for photoacoustic (PA) image simulation of an ensemble of cells with endocytosed gold nanoparticles is presented. Each cell was approximated as a fluid sphere and suspended in a nonabsorbing fluid medium. It was assumed that the cellular optical absorption coefficient changed greatly because of endocytosis of nanoparticles; however, thermophysical parameters remained unchanged because nanoparticles occupied negligible intracellular volume. A frequency-domain method was used to obtain a PA signal from a single cell and resultant signal detected by a focused single-element transducer was evaluated by convolving signals from many cells with the spatial impulse response function of the receiver. The proposed model was explored to simulate PA images of numerical phantoms. It was observed that features of the phantoms are retained precisely in those simulated images. Also, speckles in PA images are significantly suppressed because of strong boundary buildup when cells are bounded to a region. Nevertheless, speckle visibility increases when cells are not bounded to a region. This approach may be developed as a realistic simulation tool for PA imaging of tissue medium utilizing its cellular feature.

Full Journal reference:

IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control, vol. 62, no. 3, March 2015

No of authors from outside SINP: 1

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ScienceDirect

Physics Procedia 61 (2015) 107 – 111

Physics Procedia

Searching For Dark Matter With PICASSO

The Project In CAnada to Search for Supersymmetric Objects (PICASSO) at SNOLAB searches for Weakly Interacting Massive Particle (WIMP) interactions with 19F. It is particularly sensitive to spin-dependent particle interactions. It uses a droplet technique, based on the principle of a bubble chamber, in which phase transitions in superheated liquids can be triggered by WIMP induced nuclear recoils. The detection process allows a highly efficient suppression of backgrounds from cosmic muons, γ rays and electrons. Recent results and progress are presented and future plans to scale this technique to large masses with the PICO collaboration are briefly discussed. Research and development using bulk superheated liquid detectors continues, exploring condensation and bubble chambers in the framework of the PICO collaboration.

Physics Procedia 61 (2015) 107-111.

Authors : Susnata Seth, Mala Das, Pijushpani Bhattacharjee, APC Division, SINP + 36 authors

Work credit to SINP authors : detector fabrication (det nickname ‘Joy ho’), R & D (bulk target with condensation chamber) , data analysis (time correction).

Structure of Cr monolayer on Ag(001): A buried two-dimensional $c(2 \times 2)$ antiferromagnet

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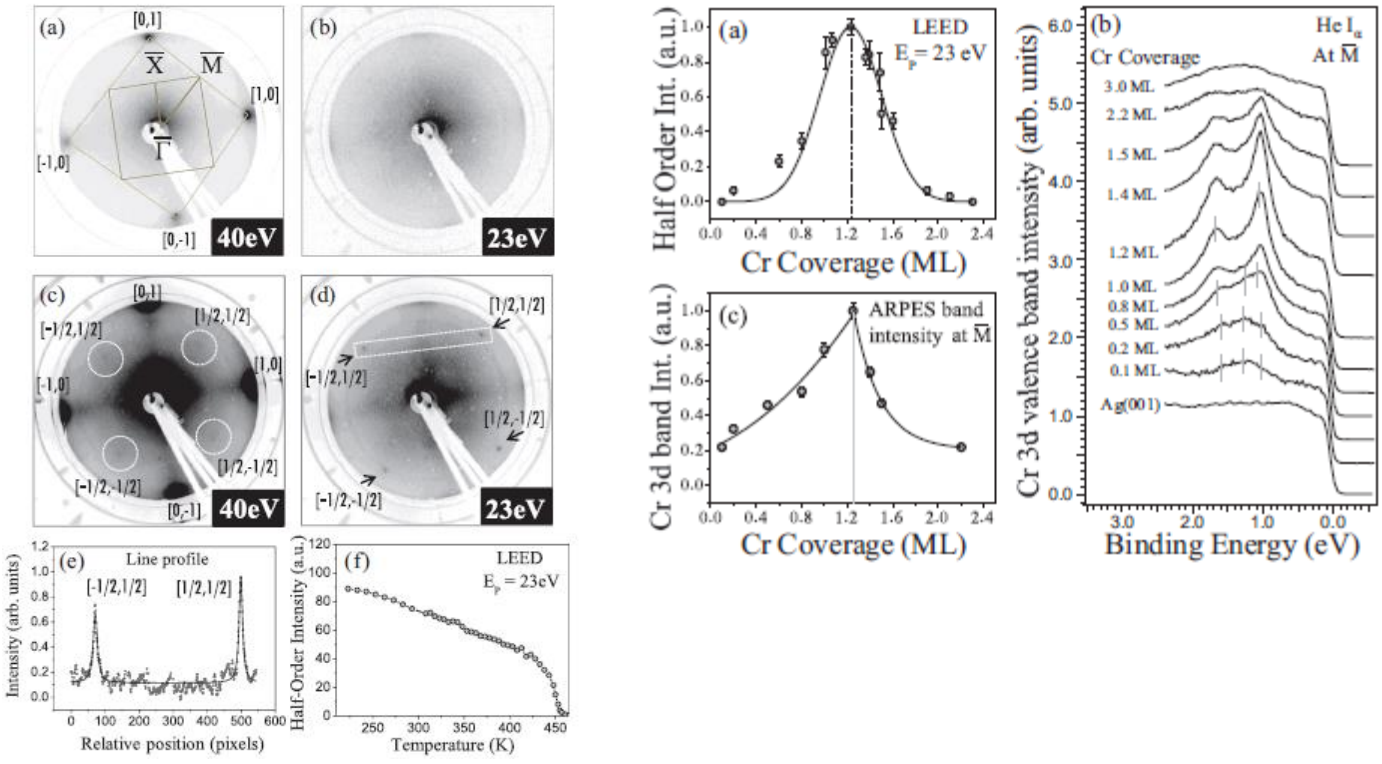
(Received 7 January 2015; published 27 March 2015)

The growth, morphology, and magnetic structure of ultrathin Cr films grown on a Ag(001) substrate are studied using low-energy electron diffraction (LEED), angle-resolved photoemission spectroscopy (ARPES), and *ab initio* density functional theory (DFT) calculations. The presence and temperature dependence of $c(2 \times 2)$ half-order spots in the LEED pattern, for low electron energies, along with the presence of characteristic Cr 3*d* bands in the ARPES spectra, confirm the existence of antiferromagnetic ordering for the Cr monolayer case. Our experiments are also consistent with the presence of a $p(1 \times 1)$ Ag overlayer on top of the Cr layer, suggesting the existence of a Ag/Cr/Ag(001) sandwich structure at the surface. Our DFT calculations confirm that this is the most favored geometric and magnetic structure of the system. The Cr layer is found to retain a "two-dimensional" character with enhanced Cr 3*d* magnetic moments, despite being buried below a Ag monolayer, due to the absence of significant hybridization between Cr 3*d* and Ag 4*d* electronic states. The coverage dependence of the magnetic ordering indicates a maximum ordering above the expected monolayer coverage, possibly due to intermixing between Ag and Cr atoms in the overlayer.

DOI: 10.1103/PhysRevB.91.125435 PACS number(s): 75.70.Rf, 68.55.−a, 68.43.Bc, 79.60.−i



Journal Reference: Phys. Rev. B 91, 125435 – Published 27 March 2015

http://dx.doi.org/10.1103/PhysRevB.91.125435

Authors from outside SINP: 2

J. Plasma Physics: page 1 of 6. © Cambridge University Press 2015
doi:10.1017/S0022377815000057

Longitudinal dust acoustic solitary waves in a strongly coupled complex (dusty) plasma

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(Received 13 November 2014; revised 5 January 2015; accepted 6 January 2015)

The dynamics of the weakly nonlinear and weakly dispersive low frequency longitudinal dust acoustic waves (LDAWs) in a strongly coupled complex (dusty) plasma are investigated using generalized hydrodynamic (GH) model. In presence of strong correlation, the nonlinear wave is shown to be governed by a Korteweg–de Vries (KdV) equation with a nonlocal nonlinear forcing and a linear damping terms. This novel equation is solved numerically to show the competition between nonlinear forcing and dissipative damping in the formation of the localized structures.

No of author outside SINP is 1

JOURNAL OF APPLIED PHYSICS **117**, 095304 (2015)

A comprehensive secondary ion mass spectrometry analysis of ZnO nanowalls: Correlation to photocatalytic responses

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We report on the visible light induced photocatalytic responses of zinc oxide (ZnO) nanostructures in the form of nanowires and nanowalls grown on aluminum substrates. Morphological and microstructural characteristics of these nanostructures have been analyzed using scanning electron microscopy (SEM) and high resolution electron microscopy (HRTEM). The presence of surface-adsorbed H^+, O_2^-, and OH^- species on ZnO nanostructures has been established through secondary ion mass spectrometry (SIMS). The relative change in substrate coverage under varying reaction time has also been evidenced through SIMS and is in agreement with SEM observation. Compared to nanowires, oxygen adsorption on ZnO surfaces and subsequent oxygen in-diffusion are found to be prominent for the nanowall-like structures and are seen to be highest for nanowalls grown in lower reaction time. In contrast to nanowires, nanowalls are found to exhibit higher photocatalytic activity and this can be attributed to higher adsorption of oxygen. The photocatalytic activity of the samples under visible light is originated from the native defect-states and the photocatalytic efficiency is largely influenced by the surface-adsorbants. Control of surface adsorption characteristics of the nanowalls upon tuning wall thicknesses can lead to the development of futuristic efficient photocatalytic devices. © *2015 AIP Publishing LLC*.

[http://dx.doi.org/10.1063/1.4914047]

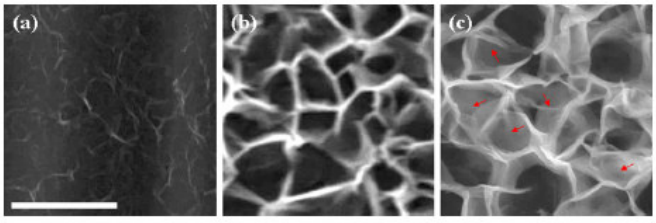

FIG. 1. SEM images of the ZnO nanostructures grown on Al substrates for 20 min (a), 45 min (b), and 2 h (c). The scale bar measures 4 μm in all cases.

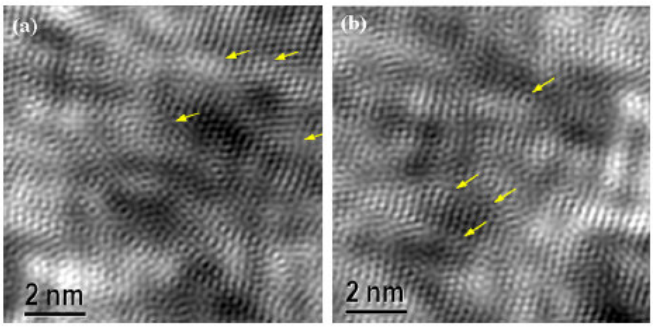

FIG. 3. (a) and (b) HRTEM image of the nanowalls captured from two different areas.

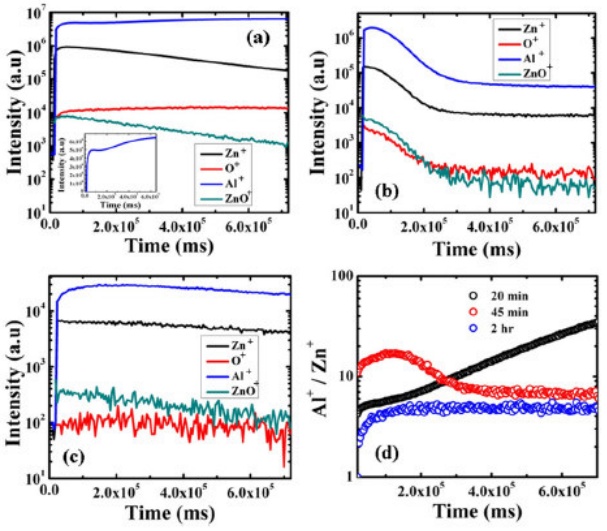

FIG. 6. SIMS depth profiling under O_2^+ ion bombardment for the ZnO nanostructured samples grown in 20 min (a), 45 min (b), and 2 h (c). The inset of (a) represents the variation of Al^+ ion emission in linear scale.

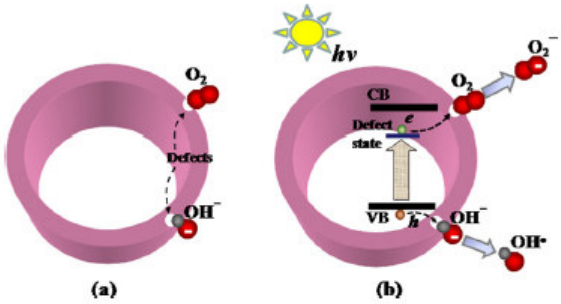

FIG. 11. (a) Schematic representation of a nanowall with surface-adsorbed species. (b) Mechanism of ongoing photocatalytic activity of the nanowalls under visible light irradiation.

Study of inelastic mean free path of metal nanostructures using energy filtered transmission electron microscopy imaging

T. GHOSH, M. BARDHAN, M. BHATTACHARYA & B. SATPATI*
Saha Institute of Nuclear Physics, 1/AF Bidhannagar, Kolkata 700064, India

We report a simple method for measuring the inelastic mean free path (IMFP) of nanostructures of known geometry using energy filtered transmission electron microscopy (EFTEM) imaging. The mean free path of inelastic electrons were measured by using systems having known symmetry like cylindrical or cubic combined with Poisson statistics without employing the knowledge of the microscope parameters namely the convergence angle and the collection angle. Having inherent symmetry of this type of systems, their absolute thickness can be measured from their two-dimensional (2D) projection images. We have calculated mean free path of inelastic scattering of electrons in gold, silver, and nickel as case studies by employing gold nanorod, silver nanocube and nickel nanorod lying on a carbon coated TEM grid at two different electron energies (viz., 200 keV and 300 keV) following this alternative approach. Results obtained using such alternative approach were verified using microscope parameters.

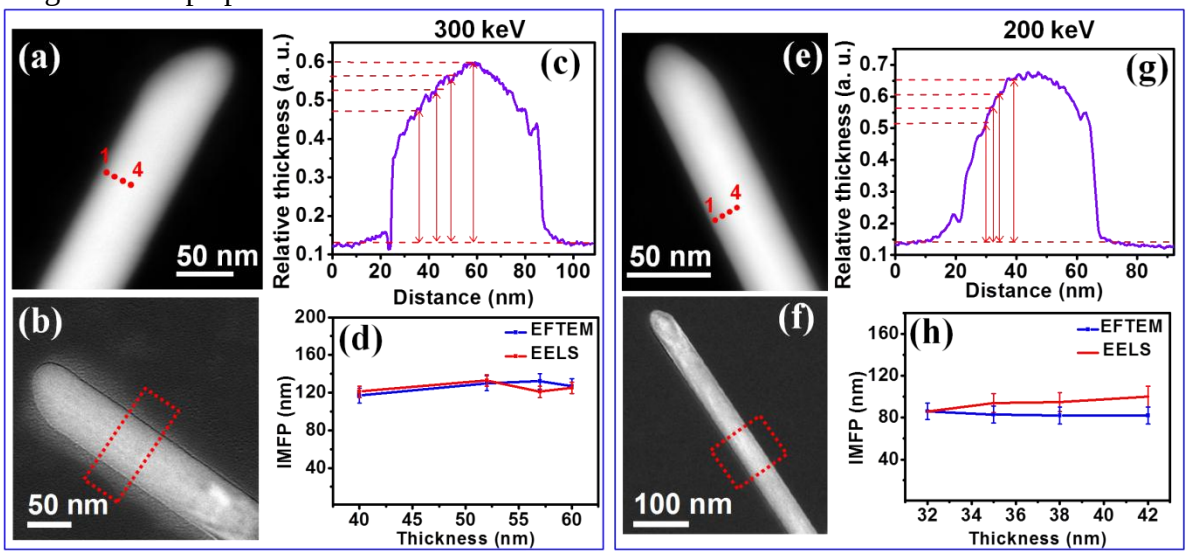

Figure: (A) and (E) STEM-HAADF images, (B) and (F) relative thickness maps, (C) and (G) relative thickness profiles, (D) and (H) IMFP vs. thickness graphs for two different measuring techniques, of an Au nanorod at 300 keV and 200 keV, respectively. Red color spots on STEM-HAADF images with numbering 1..4 indicate the four probe positions. The dotted rectangular box on images indicates the integration width. Red lines in (C) and (G) indicates the four different thicknesses obtained using EEL spectroscopy technique and corresponding relative thickness values obtained using EFTEM imaging technique.

Full Journal Reference: ***Journal of Microscopy*, 2015, doi: 10.1111/jmi.12240**

No of authors from outside SINP: 0

Structural interpretation, growth mechanism and optical properties of ZnO nanorods synthesized by a simple wet chemical route.

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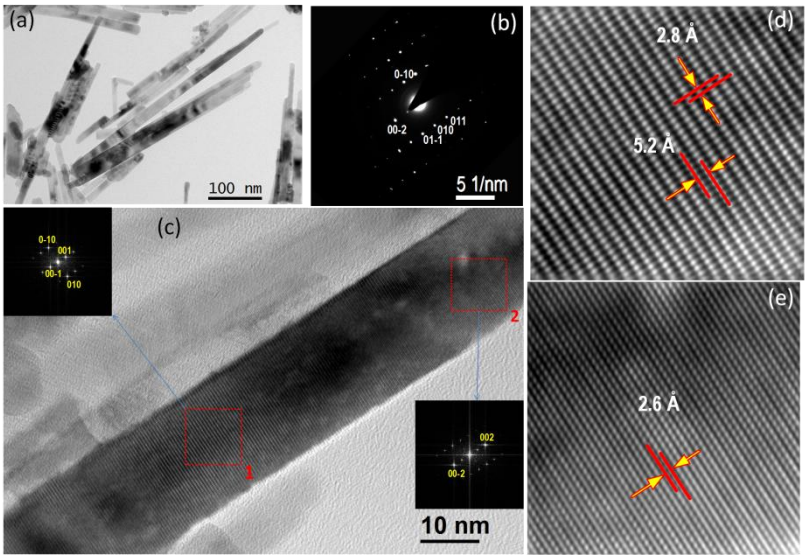
ZnO nanorods are synthesized at room temperature through a simple chemical process without using any template or capping agent. ZnO nanopowders used in this synthesis are synthesized by mechanical alloying the ZnO powder. Here, we report primarily the crystal structure and microstructure interpretations of ZnO nanorods by analyzing X-ray diffraction patterns employing Rietveld refinement, field emission scanning electron microscopy (FESEM) and high resolution transmission electron microscopy (HRTEM) with energy dispersive X-ray (EDX) spectroscopy techniques. Uniform-shaped pure ZnO nanorods with different lengths and diameters are synthesized within 5h of reaction time. The Rietveld refinement and HRTEM images ascertain the growth of ZnO nanorods along <002>. STEM-HAADF images and EDX spectra and imaging of nanorods confirm the chemical composition and reveal the uniform elemental distributions of Zn and O over the entire nanorod. UV-visible spectra analyses of ZnO nanopowder and nanorod reveal a small decrease in optical band gap of nanorods due to morphological change. Photoluminescence (PL) spectra of both powder and rod shaped ZnO reveals the presence of excess oxygen in nanorods. Rietveld analysis corroborates the findings of PL and quantifies the content of oxygen in ZnO nanorods.



Full Journal Reference: ***RSC Adv.*, 2015, 5, 23101**

No of authors from outside SINP: 3

हीरक जयंती वर्ष का हर्षोल्लास - 66 वीं गणतंत्रता दिवस परेड 2015 में राजपथ, नई दिल्ली पर परमाणु ऊर्जा विभाग की झांकी

Celebrating the spirit of Diamond Jubliee Year - Department of Atomic Energy Tableau in the 66th Republic Day Parade 2015 at Rajpath, New Delhi