CURRICULLAM VIATE

Dr. Hempal Singh

Official Address
Assistant Professor, Physics Department
Central University of Haryana
Jant-Pali, Mahendergarh
Haryana, India
Email: physics.hempal@gmail.com
M. No - 9719616207

Permanent Address
Murari Nagar Colony Gali No-3
Siddeshwar Road Khurja,
Khurja-203131, Bulandshahr
Uttar Pradesh, India.
Email: hem07dph@gmail.com
M. No- 7082576184

Objective:

To obtain a challenging career as a **"RESEARCH AND DEVELOPMENT"** , in an environment that provide me challenging tasks which encourages and helps me to build my career to explore the boundaries of science and technology as well as to give my best to the research work and teaching.

Education:

Ph. D. 2016

- Institute: Indian Institute of Technology (IIT) Roorkee
- Department: Department of Physics
- Title of Thesis: Optical Properties of High T_c Superconductors
- Supervisor: Prof. B. D. Indu, Department of Physics, IIT Roorkee.
- Awarded: 09 May 2016
- Ph.D. Course work from IIT Roorkee, India
- Advanced Classical Physics PH-785 with Grade Point 7.
- Advanced Quantum Physics PH-786 with Grade Point 8.
- Self-Study Course on "Dynamics of Phonons and Many Body Theory" PH-SS1 with Grade Point 9

M. Sc. 2007

- University: CCS University Meerut
- College: NREC College Khurja
- Department: Department of Physics
- Marks: 60.66%

B. Sc. 2005

- University: CCS University Meerut
- College: JV Jain College Saharanpur
- Marks: 65.45%

10+2 2002

- Board: UP Board Allahabad
- College: MD Inter College Saharanpur
- Marks: 70.60%

Professional Experience:

- **Assistant Professor**
  September 07, 2016-present, Department of Physics, Central University of Haryana, Jant-Pali, Mahendergarh, Haryana Pin: 123031

- **Teaching Assistant**

- B. Tech. tutorial classes, Department of Physics, Indian Institute of Technology Roorkee from 2009-2014.

- **Practical Labs**

- B. Tech. Practical Labs, Department of Physics, Indian Institute of Technology Roorkee.

Course Taught and Responsibllites:

- Mathematical Mathods in Physics
- Engineering Physics-1
- Electormagnetic Theory
- M. Sc., Practicle Lab
- B. Tech, Practical Lab

Contribution in the corporate life of University:

- **Member**, Board of Studies, Department of Physics, Central University of Haryana (CUH) (Session 2016-2017).
- **Member,** NAAC Coordination Committee
- **Member**, Departmental purchase committee, Department of Physics CUH.
- **Office In charge**, Department of Physics CUH.
- **Student Advisor**, M. Sc. 1st year students, Department of Physics, CUH.

- **Member**, Departmental Library committee, Department of Physics, CUH.
- **Member**, Departmental Activity Committee, Department of Physics, CUH.
- **Exam Coordinator**, End-Semester Examination, Dept. Of Physics, Dec 2016, CUH
- **Member**, Time Table Committee, Department of Physics, CUH.
- **Internal Examiner,** M.Sc. I (Physics) End Term Practical Examination, Department of Physics, CUH.

Technical Skills:

General skills in computing. Specific expertise and interests in:

- Computing platforms: Windows 98/7/XP/Vista
- Programming languages: Mathematica 6/7/8
- Simulation of mathematical equation using Mathematica
- High level computational programming using Mathematica
- Text formatting and Graphics: LaTeX, MS Word, PowerPoint, Get Data Digitizer

Honors and Awards/Fellowships:

- GATE (Graduate aptitute test for engineering) 2009.
- JRF (Junior research fellow, MHRD) July 2009 to July 2011.
- SRF (Senior research fellow, MHRD) from July 2011 to July 2014.
- Funding provided by The Abdus Salam International Centre for Theoretical Physics (ICTP) to participate and present a research paper in a conference at Trieste, Italy during 28 Sep-2 Oct 2015.

Research Interest:

Major Research Area:

- Theoretical Condensed Matter Physics

Specialized Area of Research:

- Theoretical Study of High Temperature Superconductors,
- Study of the Effects of Defects, Impurities and Anharmonicities on Dynamical Properties of High Temperature Layered Superconductors; namely, Optical Properties of High Temperature Superconductors,
- Role of Interacting Potentials in High Temperature Superconductors.

Research done so far:

The Born-Mayer-Huggins potential found to be the best potential to describe the dynamical properties of high temperature superconductors (HTS). In earlier work many physicists have taken Born-Mayer parameters as constant to explain the various properties of HTS. But we have developed a new theory in which the Born-Mayer parameters are not constants but show their complicated dependency upon various physical quantities like charges, distances, bulk modulus, pressure and Gruneisen parameter. Gruneisen parameter is nothing but the measure of the

strength of anharmonic effects in HTS. Therefore, the expressions for bulk modulus, pressure and Born-Mayer parameters a_{ij} and b_{ij} have been derived with in a new framework. This theory is applied to a basic superconductor $YBa_2Cu_3O_{7-\delta}$ (YBCO) and also applicable to other high temperature and cuprate superconductors. Various responses to this end have been depicted successfully.

Taking the effects of defects, impurities and anharmonicities simultaneously, the study of dynamical properties of high temperature superconductivity have been the most complex and tedious research problem in the theoretical condensed matter physics. We have critically analysis this problem with a new approach of Green's function formalism with the complete crystal Hamiltonian which has almost all effects like unperturbed electron, unperturbed phonon, impurity, defects and anharmonicities (without taking BCS type of Hamiltonian). Adopting the equation of motion technique of Zubarev via complete crystal Hamiltonian and some tedious algebraic simplifications, the expressions for phonon frequency shift, phonon line widths, electron frequency shift and electron line widths have been derived. The frequency line width is responsible for various dynamical properties of high temperature superconductors.

The expressions of phonon density of states (PDOS) have been established by using the line width in Lehmann's expression. The PDOS can be further resolved in diagonal and non-diagonal parts. The deeper insights reveal that PDOS is very sensitive physical quantities which is not only depend upon energy, impurity concentration, electron-phonon coupling parameter but also on temperature via various distribution functions, and provide us a track to study the dynamical properties of a system in the superconducting and normal regimes, which appears as the special feature of the present theory. Now the YBCO superconductor has been taken to analyze the PDOS of the various contributions like defect, anharmonicity, electron-phonon, interaction of cubic anharmonicity with defect, diagonal, non-diagonal and total contribution for PDOS for superconducting and normal regimes. Strong temperature dependence (non-superconducting region) is observed with the emergence of a number of peaks in PDOS, which emerged as the salient and main feature of the theory. The computed results for PDOS of YBCO show fair agreements with experimental results establishing that this theory is successfully applicable to the other high temperature superconductors. The results thus obtained for PDOS for YBCO are in fair agreements with experimental results establishing that this theory is successfully applicable to the other HTS. The 3D depiction for PDOS shows the various peaks more live in above said two regions. The automatic appearance of pairons without considering the BCS Hamiltonian is the main breakthrough of the present theory.

The impurity induced anharmonic electron-phonon problem is taken up as state of art and the *ab-initio* formulation of electron density of states (EDOS) via perturbation free approach. The expressions of EDOS has been developed in a new frame work (without considering BCS Hamiltonian) for impurity, cubic anharmonicity and electron-phonon contribution. The EDOS are found to be influenced heavily by temperature, electron-phonon coupling and impurity concentration and emerges as new feature of this theory. Numerical computations have been done for YBCO with the large number of peaks for EDOS which is to be established experimentally. 3D depictions of EDOS also refreshed the theory within a new framework.

The study of infrared absorption with the effects of defects, electron-phonon interactions and Anharmonicity has been a very long pending and intricate problem in solid state physics. We have successfully done this study with the above formalism. The expressions of infrared

absorption coefficients have been derived which can be separated in two parts diagonal and non-diagonal. The non-diagonal contribution appears only in impure crystals and become extinct in pure crystals. The absorption coefficients depend on temperature via various distribution functions (addressing as main feature) provides a platform to critically analyze a system in superconducting and normal regions. This has been numerically analyzed for YBCO superconductor for diagonal, non-diagonal, defect, anharmonicity, electron-phonon and total contributions. The results thus obtained are highly sensitive in nature and in well agreements with experimental results. 3D depictions also refreshed this theory. This theory is also applicable for other cuprate, high temperature superconductors.

Research Publications:

Papers in Journals

(1) Theory of Electron Density of States of Impurity Induced Anharmonic High Temperature Superconductors.
Hempal Singh, Anu Singh, Vinod Ashokan and B.D. Indu
Advances in Materials Physics and Chemistry, Vol.2, pp.249-254, 2012.

(2) Theory of Electronic Heat Capacity of High Temperature Superconductors.
Anu Singh, **Hempal Singh** and B.D. Indu
International Journal of Science and Advanced Technology, Vol.2, pp.51-55, 2012.

(3) Signature of Anharmonicities in High Temperature Superconductors.
Hempal Singh, Anu Singh, Vinod Ashokan and B.D. Indu
Indian Journal of Applied Research, Vol. 3, pp.35-38, 2013.

(4) Anharmonicity and Impurity Effects on Infrared Absorption in High Temperature Superconductors
Hempal Singh and B.D. Indu
International Journal of Physics, Vol. 4, pp.43-49, 2016.

(5) Electrons and Phonons in High Temperature Superconductors.
Anu Singh, **Hempal Singh**, Vinod Ashokan and B.D.Indu
Journal of Materials, Vol. 1, pp.1-4, 2013.

(6) The Born-Mayer-Huggins Potential in High Temperature Superconductors
Hempal Singh, Anu Singh and B.D. Indu
Modern Physics Letters B, Vol. 30, pp. 1650283.1-1650283.10, 2016.

(7) The Electronic Heat Capacity of $YBa_2Cu_3O_{7-\delta}$ Superconductor
Anu Singh, **Hempal Singh**, and B. D. Indu
AIP Advances, Vol. 6, pp. 075102.1-075102-9, 2016.

(8) Effects of Defects and Anharmonicity on Electron-Phonon States and Infrared Absorption in $YBa_2Cu_3O_{7-\delta}$
Hempal Singh, Anu Singh and B. D. Indu
Physica Scripta (Submitted).

(9) The Effects of Defects and Anharmonicities on Electron Density of States in High Temperature Superconductors
Anu Singh, **Hempal Singh** and B. D. Indu
International Journal of Modern Physics B (Under Review).

(10) Lattice Heat Capacity of $YBa_2Cu_3O_{7-\delta}$ Superconductor
Anu Singh, **Hempal Singh**, and B. D. Indu
The European Physical Journal-Plus (Under Review).

Paper Presented in Conferences:

International Conferences in Abroad:

- New Frontiers of Born-Mayer-Huggins Potential in High Temperature Superconductors
  Hempal Singh, B. D. Indu and Anu Singh
  International Conference on Frustration, Disorder and Localization: Statics and Dynamics at The Abdus Salam International Center for Theoretical Physics (ICTP), Trieste, Italy, 28 September - 2 October, 2015.

International Conference in India:

- Anharmonicity and Disorder Effects on Electron Density of states of High Temperature Superconductors.
  Vinod Ashokan, B.D. Indu, Anu Singh and **Hempal Singh**
  International Conference on Theoretical and Applied Physics., IIT-Kharagpur, 1-2 December, 2011.

- Role of Anharmonicities in High Temperature Superconductors.
  Hempal Singh, Anu Singh, Vinod Ashokan and B.D. Indu
  International Conference on Material Science and Technology,
  St. Thomas College Pala Kerala, 10-14 June, 2012.

- The Electron-Phonon Interactions in High Temperature Superconductors.
  Anu Singh, **Hempal Singh**, Vinod Ashokan and B.D.Indu
  International Conference on Material Science and Technology,
  St. Thomas College Pala Kerala, 10-14 June, 2012.

National Conference in India:

- A New approach to Electron Density of states of High Temperature Superconductors.
  Hempal Singh, Anu Singh, Vinod Ashokan and B.D. Indu
  National Conference on Advances in Physics, IIT-Roorkee, 25-26 Feb, 2012.

Work Shop, Short Course, Mini-Colloquium attended:

- QIP workshop on "Novel correlated electronic materials" on 8th March 2014 at IIT Roorkee, India.

- Short course on Nanoelectronics on "Nanotechnology Journey from Quantum Physics to Nanoengineering" on 2nd April 2014 at IIT-Roorkee, India.

- IEEE-ED Mini-Colloquium on "Nanoscale Device Physics and Reliability" schedule on 19th Sept., 2014 at IIT-Roorkee, India.

- A Workshop on "Checking of Plagiarism in Scientific Writing using Turnitin Software" Organized by IIT-Roorkee, held at IIT-Roorkee on April 17, 2015.

- Participated in the Indian Physics Association (IPA) Lecture Series and Delivered a talk on "Theory of Electronic Heat Capacity of High Temperature Superconductor" Held at the Department of Physics IIT-Roorkee, August 31, 2012.

Professional Memberships:

- Life Time Member of Indian Physics Association (IPA).
- Life Time Member of International Association of Computer Science and Information Technology (IACSIT).
- Life Time Member of Asia-Pecific Chemical, Biological & Environmental Engineering Society (APCBEES).
- Membership of Institute of Research Engineers and Doctors (IRED).
- Life Time Member of International Association of Engineers (IAENG).
- Life Time Member of Science and Engineering Institute (SCIEI).

Administration:

President of Physics Association Department of Physics Indian Institute of Technology (IIT) Roorkee 2012-2013.

Extra Co-Curricular Activities:

- I have organized various events like Fresher's party, Farewell Party and Departmental Games.
- I have successfully participated in Departmental Games (Physics) of IIT Roorkee and won various positions in Cricket, Table Tennis, Carrom.

Languages Efficiency:

English: Read, Write, Speak
Hindi: Read, Write, Speak

Personal Details:

Father's Name	Shri Sher Pal Singh
Mother's Name	Smt. Ramvati Devi
Date of birth	19th October 1984
Nationality	Indian
Gender	Male
Maritial status	Single

References:

Prof. B. D. Indu
Department of Physics, Indian Institute
of Technology (IIT) Roorkee,
Roorkee, Uttarakhand
Email: drbdindu@gmail.com

Prof. G.D.Verma
Department of Physics, Indian Institute
of Technology (IIT) Roorkee,
Roorkee, Uttarakhand
Email: gdvarfph@gmail.com

Dr. Praveen Malik
Department of Physics, Dr. BR Ambedkar
National Institute of Technology (NIT) Jalandhar,
Jalandhar-144011, Punjab, India.
Email: malikp@nitj.ac.in

Declaration:

I hereby declare that, the above mentioned data are true to the best of my knowledge.

Place: Department of Physics, CUH.

(Hempal Singh)