Rakshit Jain

CONTACT INFORMATION

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RESEARCH INTERESTS

Experimental solid state physics and Photonics

EDUCATION

Indian Institute of Technology Bombay, Mumbai, India *July 2014 – Present*

Final Year (Bachelor of Technology in Engineering Physics with honors), Department of Physics

- **Major CGPA:** 9.30/10 (Detailed List of Courses)
- **Minor Degree:** Department of Electrical Engineering

PUBLICATIONS AND PREPRINTS

- **Jain R.**, Poonia V.S, *Sensitive Magnetic Compass in prescence of decoherening nuclear environment* . To be submitted for publication in *Physical Review E.*

TEST SCORES

- **GRE Physics**: Under evaluation
- **TOEFL**: Reading: 29/30, Listening: 29/30, Speaking: 28/30, Writing 28/30
- **GRE General Test**: Quantitative :169/170, Verbal: 155/170, Writing 3.5/6

KEY RESEARCH WORK

Quantum Sensing Lab, University of Basel, Department of Physics

Fully Tunable Fano Resonances in strain driven NV center in Diamond

Guide: Prof. Patrick Maletinsky *Summer 2017*

In this study, we proposed an experimental scheme to implement a sequence to realize fano lineshapes in magnetic resonance with a strain driven ∇ system. We create a pseudo continuum by controlling the level splittings of the NV system while maintaining a three photon like resonance. And realized the dependence of the asymmetry factor of the resonance with the phase difference between strain driving and magnetic fields. Thus leading to dependence on coherent nature of the strain drive and no asymmetry in case of an incoherent drive.
Currently, the group is in the process of realizing the scheme experimentally in diamond cantilevers.

Side Project: Using DD pulses to probe the depth of NV centers

Guide: Prof. Patrick Maletinsky and *James Wood* *Summer 2017*

The distance between the sample and NV center is an important parameter for determining the sensitivity to stray fields. One way to determine this distance is to sense surface spins and determine the depth by fitting a known function[1]. In this project, firstly I built a single spin confocal setup from scratch and obtained optimal counts from a single NV center. Then I implemented a CPMG pulse in order to probe the nearby spins. We could detect signal from C-13 spin by aligning the field and measuring the refocusing frequency from the precision of nearby spins. The group is now implementing the DD pulses on a diamond pillars to determine the NV depth by sensing the surface spins.

Photonics And Quantum Enabled Sensing Technology Lab, Indian Institute of Technology Bombay

Sensing Radical Pair by single defect centers in Diamond

Guide: Prof. Kasturi Saha, with Vishvendra Singh Poonia *May 2017 -*

A direct probe to sense the spin dynamics and decoherence in chemical compass of avian magnetoreception is necessary for understanding the avian compass. By appropriately controlling the dynamics of Radical Pair and single spin in diamond, we could propose sensing of spin transitions of electron spins in radical pair using diamond NV center probe . The spin of the NV center is driven by both dipolar and electric field[2] components of the chemical reaction. The dipolar interactions cause a different phase gain for spin states of NV center compared to the

[1] https://journals.aps.org/prb/abstract/10.1103/PhysRevB.93.045425
[2] https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.118.200402

electric field. Thus by suitably controlling the NV one can gain both the aspects of the reaction. The dipolar couplings lead to an AC phase gain due to spin state transitions would actually correspond to the how long does the molecule actually remains coherent in presence of environmental dephasing. On the other hand, the electric fields only correspond to the recombination time scales. Thus electron spin in NV could act as an effective sensor of dephasing time of the Radical pair.
The manuscript of this work is under preparation.

Hybrid Gyroscope based on NV centers and a BAW gyroscope

Guide: Prof. Kasturi Saha; Research and Development Project *July 2017 -*

I worked on investigating how a MEMS BAW gyroscope can be coupled with a NV center in diamond to ensure stability and sensitivity. We proposed coupling the NV with the degenerate modes of a disc via AC strain and detecting gyroscopic action by sensing excitation of these modes via Coriolis transfer.
We realized that the sensitivities are limited by thermal noise of the disc in the case of ensemble detection and deviation from non-linearity due to strong coupling. In future, we plan to realize a better gyroscope by using a feedback between a nuclear spin gyroscope[3] and the sensing mechanism we proposed.

Quantum Biology and Biomimetics Group, Indian Institute of Technology Bombay

Sensitivity and Coherence in a Realistic Radical Pair model

Guide: Vishvendra Singh Poonia; Junior Thesis *July 2016 - May 2017*

The radical pair model is the most accepted hypothesis to explain the navigational capability of certain migratory birds. I worked on identifying whether the spin dynamics of the radical pair exploits coherence in its functioning. Firstly, by modifying the existing techniques, I found an effective way to simulate dynamics of a realistic radical pair model which involves very large Hilbert space. Moreover, in this case the system closely resembles to singlet-triplet spin dynamics in the Double Quantum Dots(DQD). Since, decoherence in DQDs is rather well understood[4], we were able to correlate results. We concluded from our studies that the compass can still function in a parameter regime where in spite of fast decoherence due to nuclear environment, sensitives are still significant.
Can give the link of arxiv once the manuscript is prepared and uploaded on arxiv.

Hybrid Optoelectronics Lab, Indian Institute of Technology Bombay

Scanning PL and PC studies on Perovskites

Guide: Prof. Dinesh Kabra ; Senior Thesis *August 2017 -*

Inorganic-Organic hybrid perovskites are emerging materials for solar cell and light emitting sources. They are marked by their distinguishing properties of low cost and relatively easier processing making them leading candidates for next generation solar cell and light emitting applications. In the phase one of this project, I worked on probing the transport of carriers on a device by spatial excitation using a laser and scanning piezo stage. By scanning over the interfaces we were able to extract the diffusion length of hole and electron carriers using a lock-in detection.
I am currently working on extracting the phase delay from these measurements as it related to the diffusion parameters and one can extract both recombination times and mobility for both the carriers from such a measurement.

Other Research Projects

Photodetectors based on a few layer ReS_2 devices

Guide: Prof. Saurabh Lodha ; Indian Institute of Technology Bombay *August 2016- Dec 2016*

I worked on measurements of few layer ReS_2 based photodetector devices. By using a optical chopper we were able to measure response time of the order of few ms. I also reviewed optical properties of several devices based on various 2D materials.

miRNA regulation of Gene expression.

Guide: Prof. Amitabha Nandi ; Indian Institute of Technology Bombay *Summer 2016*

I modeled gene regulation in the gene expression network by forming a complex between miRNA and mRNA. I analytically calculated fano-factors and various moments involved in gene regulation by analyzing master equation of the set of reactions. I also simulated the reaction kinetics using Gillespie algorithm to analyze steady state behaviour.

Prototype Spark Chamber for detecting Cosmic rays.

Guide: Prof. Pradeep Sarin, Indian Institute of Technology Bombay *Winter 2015*

[3] https://journals.aps.org/pra/abstract/10.1103/PhysRevA.86.062104
[4] https://journals.aps.org/prb/pdf/10.1103/PhysRevB.72.125337

In this winter project, we made a prototype spark chamber for detection of cosmic rays from PCB copper plates placed in helium chamber. We designed etched PCB plates in order to reduce corona. Report can be found here

Key Course Seminars/ Term Papers

Electromagnetically Induced Transparency *PH 440: Atomic and Molecular Physics*
Instructor: Prof. Gopal Dixit, Course Seminar, IITB
Presented coherent population trapping and effect of strongly coupled laser field to induce transparency to a probe field. Slides here

Spin Hall effect *EP503: Advanced Magnetic Materials*
Instructor: Prof. Avinash Mahajan, Course Seminar, IITB
Presented Spin Hall effect and its detection by optical and electrical means. Slides here

Integer Quantum Hall effect *PH308: Introduction to Condensed Matter Physics*
Instructor: Prof. P.P. Singh, Term paper, IITB *Autumn 2015-16*
We studied landau levels formation due to presence of an magnetic field which leads to quantified hall voltage. Report here

Random Number Generation and Sampling *Microprocessor Lab*
Instructor: Prof. Pradeep Sarin, Course Projects, IITB *Spring 2014-15*
Generated a true random signal by utilising diode noise and then sampled it using a microprocessor to make an interface with a computer. We then used it as random number to perform stochastic gillespie algorithm. Report here

Modelling of Migration Dynamics *PH542 Non-Linear Dynamics*
Instructor: Prof. Amitabha Nandi, Course Seminar, IITB *Autumn 2014-15*
Used coupled logistic equation to show the Effects of Migration over Population Dynamics. Slides here

Achievements and Awards

- DAAD WISE Scholarship for 10 weeks internship in Germany. (Declined)
- Purdue Undergraduate Summer Experience(PURE) Scholarship for 8 weeks Summer Internship at Purdue.(Declined)
- Received **AP grade** for **exceptional performance** in 3 courses done at IITB - Introduction to Condensed Matter Physics, Introduction to Renewable Technologies and Electronic Devices and Circuits
- Awarded Hostel Technical Color for enhancement of Technical activities and culture of the Hostel.
- Selected for National Mathematics and Physics Olympiads on the basis of performance at state level in high school
- All India Rank 746 in JEE Advanced among 121,000 overall participants for entrance to the IITs
- Refered for Scholarship for Higher Education scholarship by Department of Science and Technology India (Declined)
- Awarded with Medhawi Vidyarthi Protsahan Scholarship and Certificate of merit for being among the top candidates in Madhya Pradesh in Higher School Certificate Exam

Key Talks and Seminars

Scanning Photocurrent Measurements *Bachelor's Thesis Talk*
Department of Physics, Indian Institute of Technology Bombay *November 2017*
I presented results from the first stage of my bachelor degree thesis.

Fano Resonances with strain driven NV centers *Group Talk*
Quantum Sensing Lab, Uni Basel *July 2017*
I presented results of summer internship at Unibas. The talk included description of the scheme I proposed to observe fano lineshapes in magnetic resonance with NV centers.

Decohernece in Avian Magnetoreception *Junior Thesis' Talk*
Department of Physics, Indian Institute of Technology Bombay *November 2017*
In this talk I presented my work in the Junior thesis. The talk included the major results of my work regarding decoherence due to nuclear spins in the radical pair mechanism.

Key Coursework

Physics
Advanced Magentic Materials, Applied Solid State Physics, Photonics, Quantum Information and Computing, Electromagntic Theory, Quantum Mechanics I and II, Introduction to Condensed Matter physics

Electrical Engineering and Energy
Electronic Devices, Analog Circuits, Digital Systems, Introduction to Renewable Technologies

Technical Skills

Programming	Mathematica, C/C++, Python, Matlab, HTML/CSS,LaTeX
Software Packages	COMSOL, T-CAD
Science Software	Python packages: QuTip, NumPy, SciPy and Matplotlib

Extra-Curricular Activities

Positions of Responsibility

- **Teaching Assistant** *PH108: Electricity and Magnetism* *May 2016 - June 2016*
  I served as a teaching assistant for freshman course of Electricity and Magnetism . My duties included solving and explaining tutorial problems to over 50 students. It also included answer sheets evaluation and invigilation during exams.
- **Manager, Tinkerers Laboratory** *April 2016 - January 2017*
  In my junior year I worked as a manager of makers lab inside my institute. My duties included ensuring the funding and inventory maintenance of the lab.
- **Hostel technical Secretary** April 2015 - March 2016
  I served as a technical secretary of hostel. My duties included maintaining Hostel Tech Room, organizing various events and representation in various technical general championships. I was awarded Hostel technical color for enhancing technical culture of the hostel.

Technical Activities

- **General Championships**: I participated in various general championships during my second and third year. In these competitions, we made a hydrofoam which is a robot that could work on all terrains and a tesla coil from mosquito rqcquet.
- **Hostel Technical Events** - I organized various hostel events during my tenure as technical secretary of the Hostel. Various events included intra-hostel logic competitions, dissembling various electronics around like DLP projector, transformers and analyzing how they work.

Sports

- I completed Advanced Training Course in Tennis organized by Tennis Club of IIT Bombay
- I completed a basic swimming course at LCH Fitness, Indore in my first year summers.

References

Available upon request.