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Atul Singh Arora
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Objective

short term Get a PhD position to explore Quantum Gravity.

general Contribute to expanding our knowledge of nature.

Education

Present **BS-MS Dual Degree**, *Indian Institute of Science Education and Research*, Mohali, CPI: *9.3/10*.

Semester I: (8.5/10) Mechanics, Chemistry of elements and chemical transformations, Cellular basis of life, Symmetry, Language Skills B, Introduction to Computers, Physics Lab I, Chem Lab I, Bio Lab I

Semester II: (8.6/10) Electromagnetism, Atoms Molecules and Symmetry, Gene expression and development, Analysis in one variable, Hands-on electronics, History of science, Physics Lab II, Chemistry Lab II, Biology Lab II

Semester III: (8.8/10) Waves and optics, Spectroscopic and other physical methods, Genetics and evolution, Curves and surfaces, Introduction to Astrophysics, Workshop Training, Physics Lab III, Chemistry Lab III, Biology Lab III

Semester IV: (9.7/10) Thermodynamics and statistical physics, Energetics and dynamics of chemical reactions, Behaviour and ecology, Probability and statistics, Introduction to Quantum Physics, Philosophy of science, Physics Lab IV, Chemistry Lab IV, Biology Lab IV

Semester V: (10/10) Classical Mechanics, Quantum Mechanics, Electrodynamics, Advanced Optics Lab, Reason and Rationality

Semester VI: (9.6/10) Statistical Mechanics, Atomic and Molecular Physics, Quantum Computation, Advanced Electronics and Instrumentation Lab, Quantum Field Theory

Semester VII: (9.4/10) Solid State Physics, Nuclear and Particle Physics, Nuclear Physics Lab, Physics of Fluids, Quantum Principles and Quantum Optics, Radiative Effects and Renormalization Group in Relativistic Quantum Field Theory

Semester VIII: (9.5/10) Nonlinear Dynamics, Chaos and Complex Systems, Condensed matter Physics Lab, Computational Methods in Physics, Standard Model and beyond, Selected topics in classical and quantum mechanics

Semester IX (current): Ethics, MS Thesis - Research Project I

2010 **CBSE 10+2**, *Sardar Patel Vidyalaya*, New Delhi, *80%*.
Physics, Chemistry, Math, Computer Science, English

2008 **CBSE X**, *Sardar Patel Vidyalaya*, New Delhi, *93%*.
Science, Maths, Social Science, English, Hindi, Information Technology

Experience (Academic)

Summer 2015 **Intern**, *University of Siegen*, Siegen, Germany.
I had worked under the guidance of Dr. Ali Asadian and Prof. Otfried Guehne. We proposed a test of local realism based on correlation measurements of continuum valued functions of positions and momenta, known as modular variables. The Wigner representations of these observables are bounded in phase space and therefore, the associated inequality holds for any state described by a non-negative Wigner function. This agrees with Bell's remark that positive Wigner functions, serving as a valid probability distribution over local (hidden) phase space coordinates, do not reveal non-locality. We constructed a class of entangled states resulting in a violation of the inequality and thus truly demonstrate non-locality in phase space. These states were realized through grating techniques in space-like separated interferometric setups. The non-locality is verified from the spatial correlation data that is collected from the screens.

Summer 2014 **Intern**, *Indian Institute of Science Education and Research*, Mohali.
The objective was to device ways of using a universal quantum computer to perform simulations of quantum phenomena itself, with 'practical' resource requirements. The project involved reading of books and papers, followed by reproducing the results of a paper using a quantum computer simulator, which was written from scratch and an independent discovery of a simple quantum algorithm to simulate mixed states (this result was however already known). I was guided by Prof. Arvind and had helpful discussions with Dr. Sudipta Sarkar and Dr. Abhishek Choudhury.

Winter 2013 **Intern**, *Indian Institute of Science Education and Research*, Mohali.
Studied Mechanics from Landau's first volume (excluding the last chapter) and covered parts of Mathematical Methods from a book on the said topic by Dennery and Krzywicki. I was guided by Prof. Jasjeet Bagla and Prof. Sudeshna Sinha.

Monsoon 2013 **School**, *National Centre for Biological Sciences*, Bangalore.
Participated in a Monsoon School on Physics of Life where we treated selected biological phenomena with physical rigour, headed by Dr. Mukun Thattai

Summer 2013 **Intern**, *National Physical Laboratory*, New Delhi.
Worked on setting up an experiment to study dynamics of a two dimensional magnetic dipole lattice, with Dr. Ravi Mehrotra.

Winter 2012 **Intern**, *Indian Institute of Science Education and Research*, Mohali.
Studied Quantum Mechanics from J.J. Sakurai, under the guidance of Prof. Jasjeet Bagla and created a corresponding report.

Summer 2012 **Intern**, *Indian Institute of Science Education and Research*, Mohali.
Studied Group Theory and Linear Algebra for understanding Symmetry, under Prof. Kapil Hari Paranjape.
A brief introductory understanding of the Knot Theory was also undertaken. LaTeX was learnt during this period, to be able to efficiently communicate via the internet.

Summer 2011 **Intern**, *Indian Institute of Technology*, Bombay.
Worked on Image Recognition techniques using OpenCV, for Yarn Fault detection under the supervision of Prof. Anirban Guha.
This was an extension to an IIT alumni's Masters thesis. The work was done using Visual Studio, C++ and involved understanding of OpenCV and the idea behind various algorithms, to be able to solve the problem at hand.

Publication (Academic)

2015 A. S. A, A. Asadian. *Proposal for a macroscopic test of local realism with phase-space measurements.* Phys. Rev. A **92**, 062107

Teaching

2015 **TA**, Classical Mechanics for undergraduates.

Projects

Sem VI 2014 **Drawdio**, What is Drawdio: "Imagine you could draw musical instruments on normal paper with any pencil (cheap circuit thumb-tacked on) and then play them with your finger. The Drawdio circuit-craft lets you MacGuyver your everyday objects into musical instruments: paintbrushes, macaroni, trees, grandpa, even the kitchen sink... ". This project was originally created at the MIT Media Lab; I simply reproduced a version of this for the National Science Day, 2014.

Summer 2013 **Nazar Band**, A face recognition system built using OpenCV with the aim of automating the locking and unlocking of doors, eliminating the need of keys.

Sem III 2012 **Opportunity Cell Website**, Team Project, A centralized web portal for the Opportunity Cell of IISER Mohali.

Sem III 2012 **Fly Count Assister**, For easing the task of counting flies (Biology experiment), this application was written in Python and used extensively. With just two buttons on the keyboard, and the voice support, the counting process was made much more efficient.

Sem III 2012 **NaveenTantra**, Team Project, An Online Election system, based on a novel fraud prevention technique, created using Javascript, PHP and mySQL.

Summer 2012 **Telescope**, Team Project, Newtonian Reflection Telescope for observing Transit of Venus.

Sem II 2012 **Capacitive Touch Sensor**, Sensitive enough to measure changes in PicoFarads, developed for the Science Day.

2010-11 **Chatur Chaalak**, Developed with the aim of application in robotics, this project was designed to control the torque and speed of stepper motors, with precision, independently. This was implemented using C as the language and Atmel AVR as the platform.

2010 **Live GSM**, This was an attempt at controlling a phone using a microcontroller, to be able to remotely control devices, using DTMF communication protocol over voice calls.

Class XII 2010 **3D Modelling and Animation**, Imitated the '21st Century FOX' animation and customized it to read 'XII class presents', for a class presentation, using the popular 3D cinema creation software, Maya.

Class XI-XII 2009-10 **Space Race**, This game was developed using OpenGL to ensure cross-platform support and as a transition to the open world. Apart from the 3D-graphics, this game had Newtonian physics implemented using a point particle approach, derived from an open-source game.

Class XI 2009 **Robotic Rescue Vehicle (RRV)**, It was designed using auto-mobile parts such as bicycle chains and sprockets, wiper motors, car batteries, a web-camera, and an ordinary PC, which gave it a unique look. It could be moved around wirelessly using a laptop which gave a live video feed from the robot, ideal for rescue operations.

Class X 2008 **Math Project**, A calculator built using micro-controllers, to verify the property $(a+b)(a-b) = a^2 - b^2$. It was a battery operated device, with an LCD screen and used an 89S52 to process.

Class IX 2006 **ALive City 2 - DirectX 9.0**, My second attempt at game making; this was developed without using any game engines, while the game itself was controlled using a USB steering wheel, built by me, based on an open-source application.

Class VIII 2005 **Motion Detection - Image Processing**, This program was developed to save frames of a video feed, only when motion is detected, ideal for surveillance.

Class VIII 2005 **ALive City - DirectX 8.0**, My first computer graphics 3D project, a simple racing game where the player could put his/her own picture, right on the car.

Class VII 2004 **Edge Detecting Robot**, Built using stepper motors and a microprocessor, this vehicle was programmed to detect edges of a table using infra red sensors and turn to avoid falling.

Class VII 2004 **AT Keyboard Interface**, Built using the 8051 series of Microcontrollers and an LCD, this device was developed to serve as a low cost portable typing tutor for kids. It was programmed using Bascom, a basic compiler.

Class VII 2004 **School Bell Scheduler 2**, This application was re-written in Visual Basic.NET to automate ringing of school bells, given the schedule, like it's first version. It used UART for securer communication and was installed in Srijan School, Model Town, New Delhi.

Class VI 2003 **School Bell Scheduler**, A program, written in Visual Basic 6, for automating the ringing of school bells. The user simply needs to specify the schedule.

Recognition

2015 Awarded a Certificate of Merit for the best academic performance in the second semester of the academic session 2014-15

2015 Was awarded the DAAD WISE fellowship for a summer internship in Germany

2015 Amongst the highest scorers in the first semester of the academic session 2014-15

2014 Amongst the highest scorers in the second semester of the academic session 2013-14

2014 Awarded a Certificate of Merit for the best academic performance in the first semester of the academic session 2013-14

2012 Capacitive touch won the Best Physics Demonstration, at the Science Day 2012, organized by IISER Mohali

2011 Was awarded the KVPY fellowship, for my work on Stepper Motor control, Chatur Chaalak

2010 Was awarded the First position in Senior programming, with my Team member, in an inter-school programming competition, a part of Access, an annual Computer Symposium, Access, organized by Modern School

2010 I was selected as one of the participants for attending the Bright Green Youth, Denmark, an international climate summit for the youth, on the basis of my performance in the National Science Fair and a personal interview. In DK, our team made it to the top 14 projects

2009 The Robotic Rescue Vehicle was awarded the first position in the Delhi region and second position in the Northern region, at the National Science Fair, held at the National Science Centre, New Delhi

2005 ALive City won the first place in the open Software Display, at an inter-school Computer Symposium, Access, an annual event organized by Modern School, Barakhamba Road, New Delhi

2004 ALive City qualified the open Software Display, at the inter-school Computer Symposium, Access

2004 Displayed the Robotic Rescue Vehicle at an interschool competition and secured the third position, even though due to a component failure, the robot failed to work when it was judged

2003 Displayed the School Bell Scheduler at the National Convention 2003, Computer Society of India, IIT-Delhi

Languages

Native **Punjabi**

Fluent **English** *Formally studied till Sem I, BS-MS*

Fluent **Hindi** *Formally studied till class X*

Computer Skills

Familiar OSs Windows: XP, Vista, 7, 8; Linux: Ubuntu, OpenSuse, Slackware

Languages Basic, C, C++, C#, Fortran, Python, Javascript, SQL, HTML, PHP, LaTeX, Octave/Matlab, Mathematica

Applications Visual Studio, Emacs, Sublime Text, Microsoft Office (Word, Powerpoint, Outlook, OneNote, Excel), CorelDraw, Inkscape, Git, Sony Vegas, Autodesk Maya, GNU plot, SolidWorks, FL Studio, Sony Sound Forge, Cinelerra

Extra-Curricular Activities

Playing the Guitar

Programming and Electronics

Playing the Tabla

Red I in Taekwondo

Statement of Purpose

Atul Singh Arora

Fascinated by the idea that the laws of nature are discovered by people, as a child I wanted to become a scientist. Upon growing up, my interest shifted to building simple robots that can help do everyday chores. The construction involved programming, electronics and assembling mechanical parts. Upon learning physics and doing questions from books like Irodov, I became interested in physics again. It was however only after coming to IISER, my second home, that I took seriously the idea of becoming a scientist.

Initially we're taught all the basic sciences plus pure math. I developed a taste for abstract mathematics during that time. My first subject for exploration was group theory and symmetry. I also looked at knot theory at the time and was surprised to learn its relation to quantum computation and elementary physics. I learnt eventually that while mathematics was fascinating in its own right, I missed physics, the connection to reality. That *my equations describe nature*, I realised was rather important for me.

I spent the following summer constructing an experiment whose objective was to study the dynamics of spins on a lattice. Having enough experience with robotics, this project wasn't all that challenging in terms of novelty and learning, even though it took a lot of effort. By the end of it, I was convinced that while constructing physics experiments, there's not too much focus on physics itself. I learnt that I really *wish to explore theoretical physics* in my future projects.

By this time, I had chosen physics as my major. Physics had never ceased to surprise me, but with solid state physics, fluid mechanics, quantum computation, quantum field theory (QFT) and gauge theories, the standard model & beyond, the excitement pinnacled.

In my major years, I spent the first summer exploring the simulation of quantum physics on a quantum computer. This was fascinating for I had independently discovered a small simulation protocol, that extended the pure state simulation to that of a mixed state. That for me, was the first novel construction of its type. However towards the end of it, I felt that I wasn't doing physics. I wanted to work on *finding new laws of nature*.

In the next summer, I was awarded the DAAD-WISE scholarship to work in Germany. While applying, I was confused between quantum gravity and quantum optics & foundations. I chose the latter for I felt it is experimentally more accessible, that our results could at least be verified within our lifetime. I was able to make some progress and construct a new extension of the Bell test[1]. In addition to this, I learnt about Bohmian Mechanics (BM) which is a deterministic theory that describes the same phenomena that Quantum Mechanics does. While I was not disappointed with my progress and had learnt about exciting research directions such as the No-Signalling principle/PR-box and information causality, I somehow *missed the richness of the remaining physics*.

For my master's thesis, I decided to explore BM, a theory in which observers play no fundamental role. This I felt might eventually make interpretation of 'quantum spacetime' more meaningful as a concept. For the thesis though, I'm focusing on a more specific problem, viz. seeing how BM could be consistent with contextuality; more precisely, I want to see how a theory deterministic in position & momentum (q,p) can be consistent with a quantum mechanics' test that says (q,p) must be contextual, if at all they're deterministic. This would show the relation between non-locality and contextuality in the continuous variable regime, which isn't yet properly understood and is of considerable interest. The larger goal is to see how spin like discrete degrees of freedom are fundamentally different from (q,p). Perhaps this would suggest an appropriate understanding of it's extension to QFTs and quantum gravity (QG).

I haven't had any formal courses in QG but I am confident that I can pick up the essentials in a few months before joining the programme. Perhaps naively so, but I'm more inclined towards the loop quantum gravity (LQG) approach, as opposed to string theory. I have gleaned that the dynamics of LQG is the current active area of research with hamiltonian formulations and the spin foam alternative being among the studied approaches. I don't suppose I can formulate a research problem at the moment for my lack of knowledge about the area, however I hope that my past work supports my application to a PhD in this exciting field. The known applications to cosmology could perhaps be a starting point. Interestingly, recently BM was applied to cosmology as a test to distinguish it from QM.

Friedrich-Alexander Universität Erlangen-Nürnberg (FAU) has a vibrant group, consisting of various erudite researchers, such as Prof. H. Sahlmann and Prof. K. Giesel who're exploring QLG and its semi-classical limit, a regime that's criticized for not being able to produce flat space time. With mavericks working in important and diverse fields, both within and outside QG, I believe, FAU will be an ideal place, for such a pursuit.

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[1] A. S. Arora, A. Asadian. *Proposal for a macroscopic test of local realism with phase-space measurements.* Phys. Rev. A **92**, 062107.

INDIAN INSTITUTE OF SCIENCE EDUCATION AND RESEARCH MOHALI
(Established by Ministry of Human Resource Development, Govt. of India)
Sector 81, Knowledge City, SAS Nagar, 140306, Punjab, India

Five year BS-MS Dual Degree Programme
Interim Grade Card

Name of the student : **Atul Singh Arora**
Registration No. : **MS11003**
Year & Month of Completion : (*Programme not complete*)
Cumulative Performance Index (CPI) : **9.3**

Code	Title of the Course	Cr	Gd
	Semester I		
BIO101	Cellular basis of life	3	A
BIO111	Biology Lab I	1	B
CHM101	Chemistry of elements & chemical transformations	3	D
CHM111	Chemistry Lab I	1	B
HSS101	Language Skills	2	B
IDC101	Introduction to computers	2	A
MTH101	Symmetry	3	A
PHY101	Mechanics	3	A
PHY111	Physics Laboratory I	1	B
	Semester III		
BIO201	Genetics & Evolution	3	A
BIO211	Biology Laboratory III	1	A
CHM201	Spectroscopic & other physical methods	3	B
CHM211	Chemistry Laboratory III	1	A
IDC201	Astronomy & Astrophysics	2	B
IDC211	Workshop Training	1	A
MTH201	Curves & Surfaces	3	A
PHY201	Waves & Optics	3	C
PHY211	Physics Laboratory III	1	A
	Semester V		
HSS632	Philosophy of Rationality	4	A
IDC351	Seminar (attending)	1	A
PHY301	Classical Mechanics	4	A
PHY302	Quantum Mechanics	4	A
PHY303	Electrodynamics	4	A
PHY311	Adv Optics & Spectroscopy Lab	4	A
	Semester VII		
IDC451	Seminar	1	A
PHY401	Nuclear & Particle Physics	4	A
PHY402	Solid State Physics	4	B
PHY411	Nuclear Physics Lab	4	A
PHY638	Physics of Fluids	4	B
PHY656	Quantum Principles & Quantum Optics	4	A
PHY658	Radiative effects & REnormalization Group in Relativistic Quantum Field Theory	4	A

Code	Title of the Course	Cr	Gd
	Semester II		
BIO102	Gene expression & development	3	B
BIO112	Biology Lab II	1	B
CHM102	Atoms molecules & symmetry	3	B
CHM112	Chemistry Lab II	1	B
HSS102	History of science	2	B
IDC102	Hands-on electronics	2	A
MTH102	Analysis in one variable	3	B
PHY102	Electromagnetism	3	A
PHY112	Physics Laboratory II	1	A
	Semester IV		
BIO202	Behaviour & ecology	3	B
BIO212	Biology Lab IV	1	A
CHM202	Energetics & Dynamics of Chemical Reactions	3	A
CHM212	Chemistry Lab IV	1	A
HSS202	Philosophy of Science	2	A
IDC206	Quantum physics for scientists	2	A
MTH202	Probability & Statistics	3	A
PHY202	Thermodynamics & Statistical Physics	3	A
PHY212	Modern Physics Lab	1	A
	Semester VI		
IDC352	Seminar (attending)	1	A
PHY304	Statistical Mechanics	4	A
PHY305	Atomic & Molecular Physics	4	A
PHY312	Advanced Electronics & Instrumentation Lab	4	B
PHY631	Quantum Computation & Quantum Information	4	A
PHY646	Field Theory	4	A
	Semester VIII		
IDC402	Nonlinear dynamics, chaos & complex systems	4	A
IDC452	Seminar (delivering)	1	B
PHY412	Condensed matter physics lab	4	A
PHY422	Computational methods in physics	4	A
PHY659	Gauge Theories, the standard model & beyond	4	B
PHY661	Selected topics in classical & quantum mechanics	4	A

Date of Issue: **August 18, 2015**

Dean Academics

Meaning of Grades: A=Excellent, B=Good, C=Average, D=Pass, F=Fail.
Points for Grades: A=10, B=8, C=6, D=4, F=0
CPI is the credit weighted average of points earned.

Cr: Credits; Gd: Grade

$$\text{CPI}=\frac{\text{Total of(Credits}\times\text{Points)}}{\text{Total Credits}}$$

Chanchal Kumar
Dean of Academics
Indian Institute of Science Education & Research (IISER) Mohali