

Atul Singh Arora

ætul siŋh ərəʊrɑː

was born on November 20, 1991
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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 **Intern**, *University of Siegen*, Siegen, Germany.
2015 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 **Intern**, *Indian Institute of Science Education and Research*, Mohali.
2014 The objective was to devise 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 **Intern**, *Indian Institute of Science Education and Research*, Mohali.
2013 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 **School**, *National Centre for Biological Sciences*, Bangalore.
2013 Participated in a Monsoon School on Physics of Life where we treated selected biological phenomena with physical rigour, headed by Dr. Mukun Thattai
- Summer **Intern**, *National Physical Laboratory*, New Delhi.
2013 Worked on setting up an experiment to study dynamics of a two dimensional magnetic dipole lattice, with Dr. Ravi Mehrotra.
- Winter **Intern**, *Indian Institute of Science Education and Research*, Mohali.
2012 Studied Quantum Mechanics from J.J. Sakurai, under the guidance of Prof. Jasjeet Bagla and created a corresponding report.
- Summer **Intern**, *Indian Institute of Science Education and Research*, Mohali.
2012 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 **Intern**, *Indian Institute of Technology*, Bombay.
2011 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. Arora, A. Asadian. "[Towards a macroscopic test of local realism](#)". In: *arXiv*.
Accepted: *Physical Review A*

Teaching

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

Projects

- Sem VI **Drawdio**, What is Drawdio: “Imagine you could draw musical instruments on normal
2014 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 **Nazar Band**, A face recognition system built using OpenCV with the aim of au-
2013 tomatizing the locking and unlocking of doors, eliminating the need of keys.
- Sem III **Opportunity Cell Website**, Team Project, A centralized web portal for the Oppor-
2012 tunity Cell of IISER Mohali.
- Sem III **Fly Count Assister**, For easing the task of counting flies (Biology experiment), this
2012 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 **NaveenTantra**, Team Project, An Online Election system, based on a novel fraud
2012 prevention technique, created using Javascript, PHP and MySQL.
- Summer **Telescope**, Team Project, Newtonian Reflection Telescope for observing Transit of
2012 Venus.
- Sem II **Capacitive Touch Sensor**, Sensitive enough to measure changes in PicoFarads,
2012 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 **3D Modelling and Animation**, Imitated the ‘21st Century FOX’ animation and
2010 customized it to read ‘XII class presents’, for a class presentation, using the popular
3D cinema creation software, Maya.
- Class XI-XII **Space Race**, This game was developed using OpenGL to ensure cross-platform
2009-10 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 **Robotic Rescue Vehicle (RRV)**, It was designed using auto-mobile parts such
2009 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 **Math Project**, A calculator built using micro-controllers, to verify the property
2008 $(a + b)(a - b) = a^2 - b^2$. It was a battery operated device, with an LCD screen and
used an 89S52 to process.

- Class IX **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 **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 **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 **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 **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 **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 **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 S. Arora

Fascinated by the idea that laws of nature are discovered by people, as a child I wanted to become a scientist. Upon growing up, my interest shifted to constructing machines (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.

The following summer, I spent on constructing an experiment whose objective was to study the dynamics of spins on a lattice. Having enough experience with programming, electronics and simple mechanical designs, this project wasn't all that challenging in terms of novelty and learning. It took a lot of effort however; 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 entered my masters and chosen physics as the 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 had peaked.

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 second summer, I got a scholarship to work in Germany. While applying to Germany I was confused between quantum gravity and quantum optics and foundations. I chose the latter for I felt it is experimentally more accessible, that our results can at least be verified within our lifetime. I was able to make some progress and construct a new extension of the Bell test. 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, learnt about exciting research directions such as the 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 its 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.

An opportunity to work with one of the founders of LQG will be a very fortunate one. I needn't describe how conducive being with the group at CPT Marseille would be to research, especially since their interests, viz. quantum gravity and foundations, are almost identical to mine.

क्रमांक

S.No. SSE/2008/

803146

ALL INDIA

केन्द्रीय माध्यमिक शिक्षा बोर्ड

65851/00096

CENTRAL BOARD OF SECONDARY EDUCATION

अंक विवरणिका MARKS STATEMENT

सेकण्डरी स्कूल परीक्षा, 2008

SECONDARY SCHOOL EXAMINATION, 2008

नाम Name ATUL SINGH ARORA

अनुक्रमांक Roll No. 6186416

माता का नाम Mother's Name TAJINDER ARORA

पिता का नाम Father's Name ASSA SINGH ARORA

जन्म तिथि Date of Birth 20TH NOVEMBER NINETEEN HUNDRED NINETY ONE

विद्यालय School 65851 SARDAR PATEL VIDYALAYA LODI ESTATE NEW DELHI

विषय कोड SUB. CODE	विषय SUBJECT	प्राप्तांक MARKS OBTAINED				स्थितीय ग्रेड POSITIONAL GRADE
		लि. TH	प्रे/आ.मू PR/IA	योग TOTAL	योग शब्दों में TOTAL IN WORDS	
101	ENGLISH COMM.	091	XXX	091	NINETY ONE	A1
002	HINDI COURSE-A	083	XXX	083	EIGHTY THREE	A2
041	MATHEMATICS	075	018	093	NINETY THREE	A1
086	SCIENCE	053	038	091	NINETY ONE	A1
	PRAC.-INTERNAL 020					
	PRAC.-SKILLS EXT 018					
087	SOCIAL SCIENCE	076	016	092	NINETY TWO	A1
165	INTRODUCTORY I T	039	060	099	NINETY NINE	A1

संक्षिप्तियों का अर्थ : Abbreviations

AB : विषय में अनुपस्थित Absent in the Subject

PR : प्रयोगात्मक Practical

IA : आंतरिक मूल्यांकन Internal Assessment

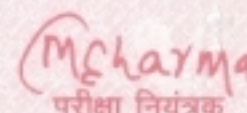
दिल्ली Delhi

दिनांक Dated

27-05-2008

परिणाम Result

PASS


परीक्षा नियंत्रक
Controller of Examinations

क्रमांक
S.No. SSCE/2010/

केन्द्रीय माध्यमिक शिक्षा बोर्ड
CENTRAL BOARD OF SECONDARY EDUCATION

65851/00114

अंक विवरणिका MARKS STATEMENT

सीनियर स्कूल सर्टिफिकेट परीक्षा, 2010

735326

SENIOR SCHOOL CERTIFICATE EXAMINATION, 2010

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नाम Name ATUL SINGH ARORA

अनुक्रमांक Roll No.

6278725

माता का नाम Mother's Name TEJINDER ARORA

पिता का नाम Father's Name ASSA SINGH ARORA

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विषय कोड SUB. CODE	विषय SUBJECT	प्राप्तांक MARKS OBTAINED				स्थितीय ग्रेड POSITIONAL GRADE
		लि. TH	प्र. PR	योग TOTAL	योग शब्दों में TOTAL IN WORDS	
301	ENGLISH CORE	090	XXX	090	NINETY	A1
041	MATHEMATICS	062	XXX	062	SIXTY TWO	B2
042	PHYSICS	050	030	080	EIGHTY	A2
043	CHEMISTRY	050	028	078	SEVENTY EIGHT	B1
083	COMPUTER SCIENCE	060	030	090	NINETY	A2
500	WORK EXPERIENCE					A1
502	PHY & HEALTH EDUCA					B1
503	GENERAL STUDIES					A2

संक्षिप्तियों का अर्थ : Abbreviations

AB : विषय में अनुपस्थित Absent in the Subject

परिणाम Result

PASS

EX : छूट - प्राप्त Exempted

FP : प्रयोगात्मक में असफल Fail in Practical

FT : लिखित में असफल Fail in Theory

दिल्ली Delhi

दिनांक Dated

21-05-2010

M Sharma
परीक्षा नियंत्रक

Controller of Examinations



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	Code	Title of the Course	Cr	Gd
<i>Semester I</i>				<i>Semester II</i>			
BI0101	Cellular basis of life	3	A	BI0102	Gene expression & development	3	B
BI0111	Biology Lab I	1	B	BI0112	Biology Lab II	1	B
CHM101	Chemistry of elements & chemical transformations	3	D	CHM102	Atoms molecules & symmetry	3	B
CHM111	Chemistry Lab I	1	B	CHM112	Chemistry Lab II	1	B
HSS101	Language Skills	2	B	HSS102	History of science	2	B
IDC101	Introduction to computers	2	A	IDC102	Hands-on electronics	2	A
MTH101	Symmetry	3	A	MTH102	Analysis in one variable	3	B
PHY101	Mechanics	3	A	PHY102	Electromagnetism	3	A
PHY111	Physics Laboratory I	1	B	PHY112	Physics Laboratory II	1	A
<i>Semester III</i>				<i>Semester IV</i>			
BI0201	Genetics & Evolution	3	A	BI0202	Behaviour & ecology	3	B
BI0211	Biology Laboratory III	1	A	BI0212	Biology Lab IV	1	A
CHM201	Spectroscopic & other physical methods	3	B	CHM202	Energetics & Dynamics of Chemical Reactions	3	A
CHM211	Chemistry Laboratory III	1	A	CHM212	Chemistry Lab IV	1	A
IDC201	Astronomy & Astrophysics	2	B	HSS202	Philosophy of Science	2	A
IDC211	Workshop Training	1	A	IDC206	Quantum physics for scientists	2	A
MTH201	Curves & Surfaces	3	A	MTH202	Probability & Statistics	3	A
PHY201	Waves & Optics	3	C	PHY202	Thermodynamics & Statistical Physics	3	A
PHY211	Physics Laboratory III	1	A	PHY212	Modern Physics Lab	1	A
<i>Semester V</i>				<i>Semester VI</i>			
HSS632	Philosophy of Rationality	4	A	IDC352	Seminar (attending)	1	A
IDC351	Seminar (attending)	1	A	PHY304	Statistical Mechanics	4	A
PHY301	Classical Mechanics	4	A	PHY305	Atomic & Molecular Physics	4	A
PHY302	Quantum Mechanics	4	A	PHY312	Advanced Electronics & Instrumentation Lab	4	B
PHY303	Electrodynamics	4	A	PHY631	Quantum Computation & Quantum Information	4	A
PHY311	Adv Optics & Spectroscopy Lab	4	A	PHY646	Field Theory	4	A
<i>Semester VII</i>				<i>Semester VIII</i>			
IDC451	Seminar	1	A	IDC402	Nonlinear dynamics, chaos & complex systems	4	A
PHY401	Nuclear & Particle Physics	4	A	IDC452	Seminar (delivering)	1	B
PHY402	Solid State Physics	4	B	PHY412	Condensed matter physics lab	4	A
PHY411	Nuclear Physics Lab	4	A	PHY422	Computational methods in physics	4	A
PHY638	Physics of Fluids	4	B	PHY659	Gauge Theories, the standard model & beyond	4	B
PHY656	Quantum Principles & Quantum Optics	4	A	PHY661	Selected topics in classical & quantum mechanics	4	A
PHY658	Radiative effects & RENormalization Group in Relativistic Quantum Field Theory	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
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