

Atul Singh Arora
4317/3 Ansari Road
Darya Ganj, New Delhi
India
☎ +91 86994 13350
✉ toAtulArora@gmail.com
🌐 <http://knowledgepayback.blogspot.com/>

Amsterdam String Theory Group
University of Amsterdam
1012 WX Amsterdam
Netherlands

January 24, 2016

Dear Sir/Ma'am,

I am in my final year, of the five year integrated BS-MS programme from the Indian Institute of Science Education and Research, Mohali (IISER M), India and am working on my master's thesis, provisionally titled 'Contextuality in a deterministic quantum theory'. I am interested in exploring string theory and its implications through cosmology and black-hole physics, for my PhD. The relevant supporting documents have been attached herewith. It would be great to have an opportunity, to work on the aforesaid, as a member of the group.

Sincerely,

Atul Singh Arora

Attached: Statement of Purpose, Curriculum Vitæ, Marksheet

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 test¹. 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 and therefore the four year programme will be particularly efficacious. I have gleaned that string theory is a promising framework for unification of all known forces, although it's still not mature enough. Consequently, both development of string theory itself and its applications to cosmology, for example, are of broad interest to me. Recently infact, even BM was applied to cosmology as a test to distinguish it from QM. While I am unable to formulate a precise research problem now, I hope that my past work supports my application to a PhD in this exciting field.

University of Amsterdam (UvA) has a vibrant group, consisting of various erudite researchers, such as the illustrious string theorist, Prof. Erik Verlinde, who is also interested in black-holes and cosmology, and Dr. Ben Freivogel who specializes in cosmology, QFTs and string theory. With mavericks working in important and diverse fields, both within and outside QG, such as the eclectic Dr. Miranda Cheng, who is exploring the connection between string theory and mathematics, I believe, UvA will be an ideal place, for such a pursuit.

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

Atul Singh Arora

ætul siŋh ərəʊrɑː

was born on November 20, 1991
resides in 4317/3 Ansari Road Darya Ganj, New Delhi
☎ +91 86994 13350
✉ toAtulArora@gmail.com

<http://github.com/toAtulArora>
<http://KnowledgePayback.blogspot.com>

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: 9.4/10.
 - 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:** (10/10): Ethics, MS Thesis - Research Project I
 - Semester X:** (current): Cosmology and Galaxy Formation, MS Thesis - Research Project II
- 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. A, A. Asadian. *Proposal for a macroscopic test of local realism with phase-space measurements*. [Phys. Rev. A **92**, 062107](#)

Teaching

- 2015 **TA**, Teaching Assistant. Classical Mechanics for undergraduates.

2016 **TA**, Teaching Assistant. Thermodynamics for undergraduates.

Projects

- Sem VI **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 **Motion Detection - Image Processing**, This program was developed to save 2005 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 2005 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 2004 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 2004 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 2004 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 2003 ringing of school bells. The user simply needs to specify the schedule.

Recognition

- 2016 Amongst the highest scorers in the first semester of the academic session 2015-16
- 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 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

Positions of Responsibility

- 2012-13 **CR**, Class Representative. Was responsible for setting up various batch-activities, Tutorial Assistance, Summer Project Talks, Origami Meets, The MS11 digest, to name a few. Various other student responsibilities, such as infrastructure feedback, mess issues, meeting with the dean etc., were simultaneously executed.
- 2012-13 **WD**, Web Designer. Was responsible for developing and maintaining the Opportunity Cell website, a link to which was added in IISER's official web page.

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, 10; Linux: Ubuntu, Debian, 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

- 2015 Tug of War: IISER M, Boys Tug of War Champions.
- 2013 Debating: Participated in the debating event of the in-house fest, Insomnia. The home team wasn't allowed to compete beyond a stage.
- 2012 Music Performance: Played the Guitar and composed the percussion electronically, with two friends, at the Cultural Evening of IISER.
- Current Interests Playing the Guitar, Tabla; Programming, Electronics, Robotics, Physical Fitness, Krav Maga, Taekwondo (Red I)



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) : **9.4**

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				
<i>Semester IX</i>							
HSS633	Ethics	4	A				
PRJ501	Thesis Research	16	A				

Date of Issue: **December 28, 2015**

Raj H. Parangar
(Acting) 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
Total of (Credits, Points)
CPI = $\frac{\text{Total of (Credits, Points)}}{\text{Total Credits}}$
DEAN (Academics)
Indian Institute of Science Education and Research (IISER) Mohali