

# Statement of Purpose

Atul S. Arora

As a child, I wanted to discover new laws of nature. Upon growing up, my interest shifted to constructing machines that can help do everyday chores. The construction involved programming, electronics and building simple 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 remaining time.

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, 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 atleast 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 focussing 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 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 approach, as opposed to string theory. I have gleaned that the dynamics of loop quantum gravity 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.

Needless to say that Max-Planck Institute, AEI is an outstanding centre of research and learning (given their spectacular selection of courses). More specifically, I must add that, I would be grateful to have the opportunity to work under the guidance of Prof. Daniele Oriti.