

Zheyu Li

Tensor networks and many body localization

My project was (mostly) an informal directed reading program on the subject of tensor networks and many body localization, under the supervision of Thorsten Wahl, a postdoc in the theoretical physics department.

Tensor networks is a new and actively researched subject in condensed matter physics. Essentially, tensor networks are one possible 'language' in which to describe quantum states. Compared with other more venerable methods, they have many attractive features, and are particularly conducive to certain applications such as problems involving quantum entanglement. Many body localization (MBL) refers to how certain disordered (many body, as the name implies) quantum systems fail to come to thermal equilibrium and instead remain 'localized'. It is a phenomenon currently under active investigation by theoretical physicists. Recently it has been argued that tensor networks are the proper way to study MBL systems, and it was the application of tensor networks to MBL that Thorsten was working on when I contacted him about a potential summer project.

Unlike perhaps most students using the vacation projects scheme, my project was not part of a formal internship in a university department. I already had an internship to work on a machine learning and particle physics project (at an institution away from Oxford), which would occupy half of the summer. Since my strongest interest is actually in condensed matter physics, I was keen on somehow spending the other half of my summer pursuing a project in that field. I asked one of my tutors who works in the area, Richard Fern, for possible interesting people to work with, and he referred me to Thorsten.

The first few weeks of my summer 'project' were spent purely on studying the basics of tensor networks. However, it was different from typical tutorial work in that it involved much higher level material and different kinds of resources (a mix of review papers and original research literature rather than textbooks). Once or twice a week I would meet with Thorsten to ask questions. After the first few weeks Thorsten began to direct my reading towards topics he was working on, and then he introduced me to an outstanding research problem. Over the final couple of weeks of my summer project I familiarized myself with the problem and made some attempts at solutions, and we had a few discussions about it. However, in the end I don't think I made any real contribution at all. (Thorsten himself did later manage to solve the problem and the result was published.)

Although my summer project didn't lead to me actually producing anything substantial, I remained in contact with Thorsten, and just before term started, I started work with him on a related computational project, which I plan to write up as a an MMathPhys dissertation project. So, I think it's worth mentioning that often summer projects are an avenue for students to discover their interests and can influence future research interests and/or career choices, but sometimes as in my case there can be immediate benefit as well.