

## RISE Germany 2023 Internship Report

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This summer I spent three months at Technische Universität Braunschweig, working under the supervision of Marcel Martin and Prof. Nabeel Aslam in the Institute of Condensed Matter Physics' Laboratory for Emerging Nanometrology. My project was all about quantum optics and quantum sensing with nitrogen- and silicon-vacancy centres in bulk CVD-grown diamond. In layman's terms, this means I spent three months firing lasers at diamonds to see what happens. If that sounds cool, it's because it was.

Braunschweig is also very cool. I hadn't actually heard of it before applying, but it's a very beautiful city in Lower Saxony, about 45 minutes from rival city Hannover by regional train. The city is home to Germany's oldest Technical University, as well as their largest metrology institute, the Physikalisch-Technische Bundesanstalt (PTB). My project was actually split between these two institutions and this was rather exciting as I got to meet a lot of physicists from various fields while I fired my lasers at my diamond.

The specifics of the project were that the group had acquired a square-shaped diamond sample that had been strategically implanted in four quadrants with different concentrations of nitrogen and silicon atoms (diamonds with these alterations, called vacancies or point defects, can be used to measure quantum properties of materials, hence the phrase "quantum sensing"). We needed to verify that the implantation had been done as prescribed, as well as characterise which quadrant was which, and the best way to do this was... well, firing a laser at the diamond. Using a technique called confocal microscopy, you can detect the number of single photons at each point on a material over a specific, very small range in three dimensions. Then you can map out the concentration of single photons over this area to see if there are regions of much higher fluorescence than the surrounding area – if so, it could be a nitrogen or silicon vacancy! This can then be verified using fluorescence spectroscopy, which runs on liquid nitrogen, and should return the characteristic spectrum of the element in question if you have indeed found what you're looking for.

By the end of the project, the diamond was successfully characterised and mapped out using these techniques and we had also demonstrated a phenomenon called optically detected magnetic resonance to confirm beyond reasonable suspicion that there were nitrogen vacancies present (this wasn't possible for silicon vacancies as it is currently not feasible to do that at room temperature, but this is an active avenue of exploration in the field so who knows for the future). There were many technical difficulties during the project so not *quite* as much progress was made as we were hoping, but then again, this is something that happens quite a lot in laboratory settings.

Beyond the lab work, living in Germany was also a lot of fun. As one of the whopping 5 Irish interns out of the 289 total from 2023, I was not expecting as much of a culture shock as the others, and indeed the Germans and Irish have much in common (we enjoy complaining, we like beer, our trains aren't the best), but there were many aspects of living in Germany that I found pleasantly surprising. The weather was lovely (almost *too* warm), the buses were frequent and punctual, the food was better and cheaper than at home, the rent was extremely reasonable, and the people were just fantastic. I was also extremely impressed with the role of physics in German society (I mean, obviously, all societies are ultimately modelled off physics as it does sort of describe everything in the world, but I digress). Pursuing a career in physics in Ireland is a huge gamble as if you don't make it as a professor or find a rare industrial research position, you will end up in a career that doesn't really make use of what you learned in university. In Germany there are so many interesting avenues to go down that would utilise your scientific background, so much so that I kind of want to move back. Which is an option now

because thanks to the RISE programme I now have a group to potentially work with, which is fantastic.

As you will no doubt hear from most former interns, one of the best parts of the experience was also travelling on the weekends and meeting up with other interns, not to mention the brilliant RISE meeting in Heidelberg. If you partake in the programme I can't recommend enough to join the inevitable group chat or discord server that will get created and go meet up with your fellow interns in other cities, I have made some really great friends that I am still in contact with now despite living thousands of miles away from them.

I wish the interns of 2024 a very happy time in Germany and if you have a fraction of the fun I had, it will be a really great summer for you!