NDnano
Notre Dame Nanoscience and Technology

NDnano Summer Undergraduate Research
2026 Project Summary

1. Student name & home university: Balazs Floring & Budapest University of Technology and Economics

2. ND faculty name & department: Prof. Laszlo Forro & Department of Physics and Astronomy

3. Summer project title: Layer-number dependent superconductivity in doped molybdenum disulfide

4. Briefly describe new skills you acquired during your summer research:

During the program, I gained hands-on experience operating a vacuum oven, fume hood, glovebox, tipsonic, and centrifuge. I also developed in analytical techniques, including Raman spectroscopy, UV-Visible spectroscopy (UV-Vis), and atomic force microscopy (AFM). In addition, I substantially strengthened my data analysis skills.

5. Briefly share a practical application/end use of your research:

My research can be applied in the fields of semiconductor technology and low-dimensional materials.

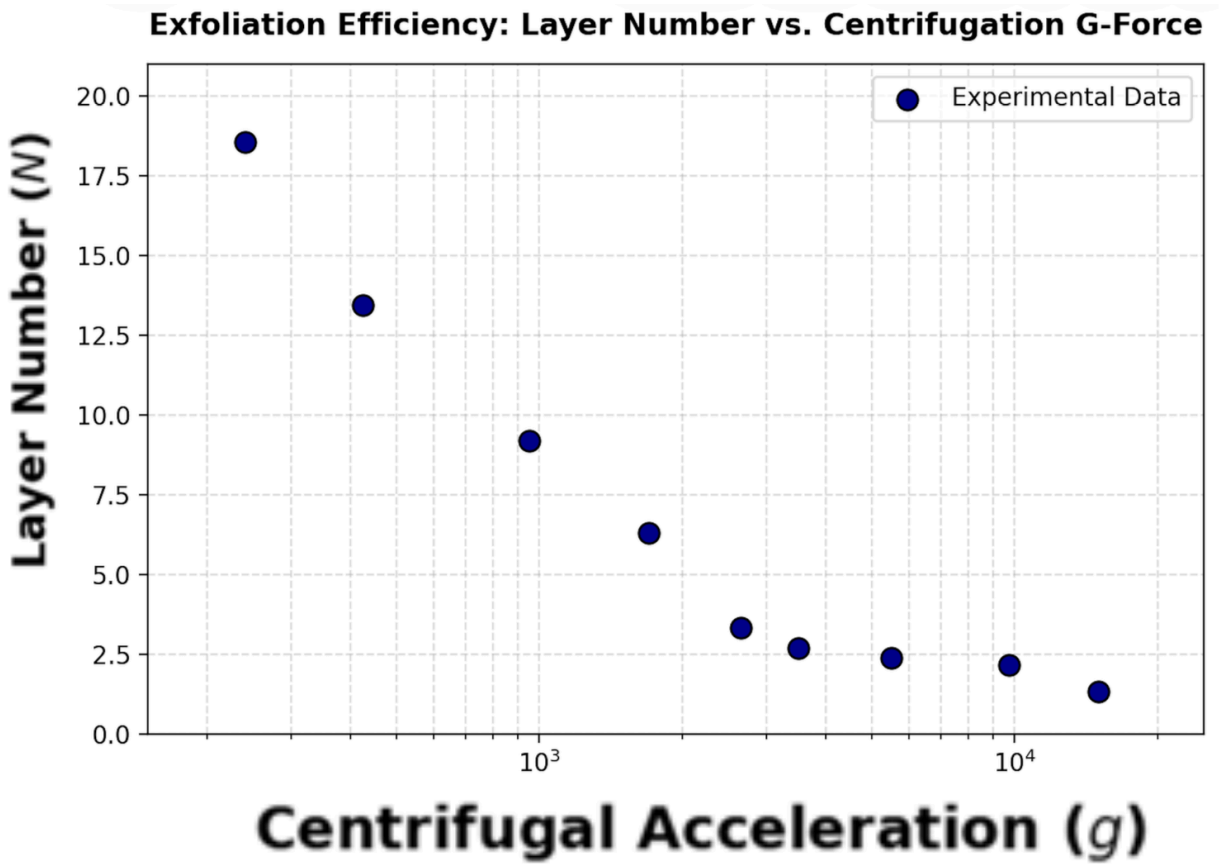
6. 50- to 75-word abstract of your project:

The goal of our research was to investigate potassium intercalated MoS_2 powders as a function of layer count by creating a catalog specifying their key superconducting properties, such as the critical temperature and critical field, beyond which superconductivity collapses. Furthermore, we aimed to develop an efficient sample preparation method capable of producing the required volume of samples, while the removal of the surfactant NaCh from the samples prior to doping also played a crucial role.

7. References for papers, posters, or presentations of your research:

One-page project summary that describes problem, project goal, and your research activities / results:

During the first weeks of the program, the focus was on acquiring the necessary independence in the lab to handle the equipment and chemicals confidently and professionally. I became familiar with the essential instruments required for my project, such as the sonicator, centrifuge, and Raman spectrometer, and started to learn from the active research of my colleagues.



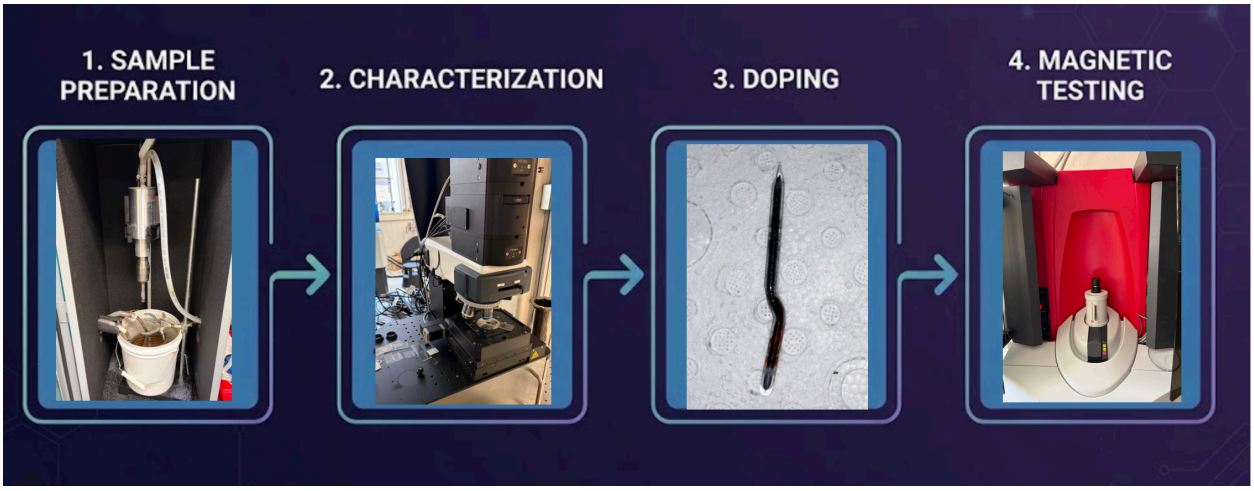
Number of layers in different samples as a function of centrifugal acceleration

The goal was clear: we needed to prepare a sufficient amount of samples for intercalation. While this sounded surprisingly simple, it proved to be quite challenging. Material loss occurs during the process, and initially, we were only able to produce around 1 mg of material for few-layers counts. However, at least 15–20 mg is ideal for successful intercalation and magnetic measurements, so the first objective was to make this process more efficient. We achieved this, on the one hand, by increasing the exfoliation time (the process in which bulk particles are broken down into mono-, and few-layers) and, on the other hand, by combining 4–5 of these

sonicated samples prior to centrifugation. This yielded a much denser liquid and allowed us to reduce relative loss.

At this phase, removing sodium cholate (NaCh) from the sample played a crucial role. This surfactant is necessary to prevent the exfoliated particles from re-aggregating, but it is an unwanted component during magnetic measurements. Several ideas emerged to address this relatively difficult task. We even attempted to demonstrate that doped NaCh does not participate in superconductivity in any way, for which we prepared specific control samples. Ultimately, however, we found a thermal annealing method in a vacuum that successfully eliminated the undesired material, making it unnecessary to further investigate its effect on the final samples.

Naturally, the sample was thoroughly characterized throughout the project using several different methods, including Raman spectroscopy, UV-Vis, and AFM. The order of these measurement techniques is not accidental: their operation required progressively more time, and access to them became increasingly limited. (The Raman spectrometer was located in our own lab, whereas the



The process of sample preparation

AFM was surprisingly slow, required a high level of expertise, and could only be operated together with my supervisor.) The various characterization methods yielded consistent results, which reassured us that our sample preparation procedure was performed correctly and that we were working with particles of the desired layer count.

Following this, we prepared quartz tubes containing the sample alongside a tube with potassium. The entire assembly was placed in a furnace at 600°C for 2–3 days, during which vapor-phase doping took place. The resulting sample was then transferred into smaller-diameter quartz tubes suitable for magnetic measurements. Unfortunately, only a few of these measurements could be completed during my stay because the equipment broke down.

The project is planned to continue: we will perform intercalation with other alkali metals and complete the magnetic measurements, after which we hope to compile our intended reference table.