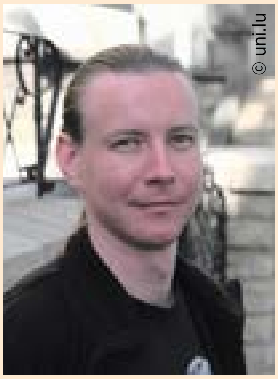
Meet the researcher

Artem Malyeyev



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Sometimes it seems like I have been around the University of Luxembourg forever: even before starting my Bachelor's studies, I've already done two internships here, one at the IT department and one at the Laboratory for Photovoltaics (LPV). In a way, this decision – to jump above my head and ask for an internship for which I had no formal qualification – set the tone for my further path at the University.

Throughout my undergraduate years, I've made sure to work for at least one semester with virtually every experimental physics group there was at the time. The University of Luxembourg is quite unique in this respect: while my Bachelor's and Master's studies took place in an area geographically smaller than a big city, effectively, I collaborated with researches from all over the world – both in the lecture halls and in the labs. A particular highlight was a research trip in the framework of my work with Prof. Dr. Andreas Michels to the Institute Laue-Langevin (ILL) in Grenoble, France, where I participated in a neutron scattering experiment aimed at resolving the magnetic-field-dependent spin structure of nanocrystalline holmium. This was my first immersion into the fascinating research at large-scale neutron facilities, and I believe that it decisively shaped my interest towards this type of research − neutron scattering, to be more specific. The interest became a passion after I got the chance to attend the annual Neutron Scattering Laboratory Course in Jülich, Germany, and it turned into a determination, after I discussed with Prof. Michels the perspective of pursuing a PhD thesis in his group, motivated by a talk on critical energy materials by Prof. Dr. Gutfleisch.

Fast-forward a few years, and I am – to my knowledge – the only person in the world who has performed neutron scattering measurement on MnBi, a rare-earth free permanent magnet with significant research and industrial potential. This deserves a bit more context, so allow me to take you on a brief detour into the world of permanent magnets.

Magnets are fascinating, because they are subtly everywhere, enabling our technology and energy without being obnoxiously celebrated on every corner as it is often the case with the nanotechnology. Magnets enable wind turbines and electric mobility – yet, for the vast majority magnets are those cute souvenirs you bring from your travels and stick on your fridge.

Having established the technological relevance, let us bring a sombre note into the discourse. The current industry standard for hard permanent magnets – those that we need approximately 2 kg of for an electric car and approximately 800 kg for a wind turbine – are made of rare-earth metals with trace quantities of very rare materials. As the name implies, there is not so much of the raw material to start with. However, the bigger issue is that about 90% of the material is either located in or owned by a single country.. And that is bound to create scarcity issues in the long run. The market has already seen the price spike of about 2000% in 2011 (yes, you read it right, two thousand percent). Additionally, considering that the recycling rate of these magnets is at about 1%, the situation does look pretty grim.

And this is where I and other researchers working on rare-earth free magnets come in. The grand aim is not to create a better magnet, no, it is to create a magnet with half of the performance – but for a tenth of the price and without requiring critical materials. To achieve that, there are, generally speaking, two strategies: what I like to call engineering and physics approach. The engineering approach lies in making a series of samples with slight changes, studying the macroscopic properties, selecting the best performer, and moving to the next series of changes. And, usually, this approach yields the best combination of the variables tried. The physics approach lies in the understanding: one aims to understand *why* and how the macroscopic properties relate to the internal structures and interactions involved. Thus, if successful in explaining the interactions, this approach might open up a completely new set of variables to change. As with all extremes, a degree of combination of both approaches works best in the long run.

In summary, my day-to-day work is about bringing a global industrial change in both energy and mobility – but in tiny steps. Yesterday, I've hand-ground the material and compressed it into samples, today, I am measuring them at the neutron facility, tomorrow, I will simulate the magnetic structure, the day after tomorrow, I'll delve into the underlying theory of the neutron scattering and, in a fortnight, I'll present my results at an international conference and meet fellow researchers from all over the world – my day-to-day job is as varied as only life can be. Optimistically, I like to compare my work to an avalanche build-up: no tiny snowflake will bring the shift to the renewable energy and away from conflict materials on its own, however, the accumulation is inevitable and the future will be a better place for all of us. ◆

Artem Malyeyev moved from Ukraine to Luxembourg after he finished high school. Due to administrative issues, he had to redo five years. After high school, he completed his Bachelor's degree in *Sciences et Ingénierie* at the University of Luxembourg and a binational Master's degree in Physics in Luxembourg and Saarbrücken. Currently, Artem is a doctoral researcher at the NanoMagnetism group working on rare-earth-free permanent magnets.