Lanthanides consist of 15 chemical elements: lanthanum, cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium and lutetium. Physical and chemical properties of these metals are similar to each other. In nature they occur in the form of minerals in which a mixture of these elements is present, from which individual lanthanides are isolated. These elements belong to the group named rare earth metals, together with scandium and yttrium. In contrary to their name some of them occur in the Earth's crust more often than other rare metals. For example, cerium is the 26th most common element in the earth's crust, and neodymium occurs more often than gold. All lanthanide ions in the +3 oxidation state, excluding lanthanum and lutetium, have some unpaired electrons. Each electron is a small magnet, and in one Ln^{3+} ion there could be up to 7 electrons. Thus, they have huge magnetic moments, for Dy^{3+} and Ho^{3+} even larger those for normal transition metals. What is more, many of the lanthanide ions (Ln^{3+}) exhibit luminescent properties after excitation, shining across the visible light range with a rich colour spectrum (while the mixture of them can emit white light).

Thanks to these properties, well-designed materials containing lanthanides ions find many applications. Approximately 85% of the worldwide production of lanthanides is used for the manufacture of glasses and as catalysts. However, using them as magnets and phosphors is more important, as in this case one cannot replace them with any other metals. Applications of lanthanides and materials/equipment based on them include: superconductors, extremely strong permanent magnets, refining catalysts, hybrid car components such as batteries and magnets. Among the applications due to their luminescent properties are the materials and optoelectronic devices such as lasers (the best known is Nd:YAG laser), optical amplifiers or television cathode ray tubes (*e.g.* europium ions glowing red). It is worth pointing out, that Gd^{3+} ions are used in medicine in magnetic resonance imaging, while La^{3+} and Ce^{3+} has been tested and used as an anti-cancer agents. It is worth noting that lanthanides (excluding the radioactive promethium) have low toxicity. In addition, strong neodymium magnets are used not only in hybrid cars, but also in power generating offshore turbines or in military applications (defence guidance systems). Such strong magnets contain not only neodymium (lanthanide) and iron (transition metal) but also boron.

Recently I have been able to prepare a series of lanthanide borohydrides and examined their fundamental magnetic properties. This project investigates the luminescent properties and advanced magnetic relaxation properties of the systems obtained. In addition, attempts will be made to obtain new systems based on $[Ln(BH_4)_4]^-$ anions and large cations, designed to increase the distance between the lanthanides ions (light emission strongly depends on that). Furthermore, I will attempt to synthesise selected lanthanides tetrafluoroborates, expecting to obtain $Ln(BF_4)_3$ compounds, to compare their properties to the above-mentioned $Ln(BH_4)_3$ compounds, and to investigate and compare the effect of these ligands on the properties of Ln^{3+} ions.

The current project is primarily aiming at screening Ln^{3+} based compounds in a borohydride environment. The possibility of their slow magnetic relaxation and their luminescence properties, including the expected emission in the visible range, will be tested. In addition, an attempt will be made to obtain BF_4^- compounds using a synthetic route developed for similar BH_4^- systems. Realisation of the project assumes obtaining a dozen of new chemical compounds, which will broaden our knowledge and contribute to the development of chemistry of boron, hydrogen or fluorine, and lanthanide compounds. Performing dynamic magnetic and optical screening tests will lead to selecting of the best and most interesting chemical compounds, and to understanding the factors influencing the properties of chemical compounds prepared.

Figure 1. Fluorescence solutions under UV light illumination (left) and neodymium magnet that holds up to 1300 times its own weight (right).
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