Squeezing double perovskites: an insight into high-pressure structures of alkali metal fluoroargentates M_2AgF_4 (M=Na-Cs)

Imagine an apple, lying on the table. If we would like to cut a hole in it, proportionally as deep, as the lowest regions of our planet that humanity was able to drill into, we would barely pierce the skin. The significant inner part of Earth is currently unreachable to us, yet we know that this hidden "dimension" under our feet can turn ordinary coal into brilliant diamonds, that it is responsible both for planetary magnetic field shielding us from deadly cosmic radiation, and dangerous earthquakes. The physical property that is one of the direct causes of all these effects is **pressure**: graphite heated under ambient pressure burns down, whereas heated without oxygen and compressed to hundred thousand atmospheres transforms into a diamond. The pressure is a parameter, which drastically changes the properties of compounds and transforms them into entirely new forms and materials.

A foul-smelling gas, H_2S, is one of the examples of a well-known substance gaining entirely different properties under high-pressure conditions. Subjected to low temperature and extremely high pressures of the order of 2 mln atm, it solidifies and becomes superconductive, letting electrons flow without any resistance. Creating material able to do so under ambient pressure and at room temperature would have an exceptional impact on technology, enabling lossless transmission of power, cheaper green transportation, and would affect our daily life. Right now most materials exhibiting superconductivity do so at temperatures below 150 K and under increased pressure. The class of compounds that superconducts at ambient pressure and at highest achieved temperatures (close to –100 ^{o}C) is called **cuprates** (name comes from copper).

In this project, I would like to study the effects of elevated pressure on a family of **silver** compounds called alkali metal fluoroargentates. I am planning to check what happens when chemical compounds with the formula M_2AgF_4 (M = Na, K, Rb, Cs) are subjected to high pressures up to 400,000 atm. These compounds have crystal structures (i.e. they are built from identical groups of atoms laid periodically in space) of so-called *double perovskites* and some of their properties are very similar to those present in superconducting cuprates (compounds of copper). As silver is in the same group in the Periodic Table of Elements as copper, it has comparable features to copper. This is one of the reasons why fluoroargentates exhibit similar structural features to those found in cuprates. Yet the two families of compounds differ in some subtle ways, and compressing them could modify their architecture in a way that would render them fully analogous to cuprates. Upon certain modifications this would enable electrons to flow through them freely, i.e. without measurable resistance.

To study the crystal structure of the title compounds under extreme pressures, first, we use a diamond anvil cell. It is composed of two small diamonds with tiny surfaces pushing against each other. When the sample is contained between them, it experiences high force on a minuscule area – hence is subject to high pressure.

The crystal structure of sample contained in diamond anvil cell can be studied using several methods. The sensitive and extremely useful ones are called x-ray diffraction spectroscopy and Raman spectroscopy. Both use the interaction of light with the sample to probe the structure of the studied material and properties dependent on the structure (for example vibrations of the crystal lattice). The project, therefore, aims to study alkali metal fluoroargentates using x-ray diffraction spectroscopy and Raman spectroscopy to find out how and why high-pressure modifies their crystal structure, changing positions of atoms in samples and their properties (especially magnetic ordering). The key target is to verify whether at high pressures **full analogy** might be achieved between fluoroargentates and cuprates.