High-pressure synthesis and characterization of novel compounds of chlorine and silver

Silver is one of the few elements that have been known to mankind since antiquity. It occurs in free state in nature, and, thanks to its malleability and chemical stability, it has been used as a currency for thousands of years. However, even though silver is not as easily oxidized as, say, iron, its chemistry is far from boring. Many interesting compounds of silver have been synthesized, and especially in the last 30-40 years many new materials containing silver have been discovered and characterized.

One of the reasons why studying chemical and physical properties of silver and its compounds is worth our while is its similarity to copper and gold. All three are located in the same group (column) of the periodic table of elements, which means that the structure of their outermost electron shell is similar. Chemists are interested in these outer electrons. In chemistry, similarities between outer shells most often results in similarities of chemical properties and between analogous compounds. Incidentally, copper – located just above silver in the periodic table – forms part of one of the most important compounds discovered in the twentieth century: copper-oxide superconductors. Superconductors are extremely interesting because of their ability to conduct electricity without losses. However, due to the fact that they exhibit these properties only at very low temperatures (below -150°C), their usefulness is limited to highly specialized scientific instruments. This also means that searching for new, higher-temperature superconductors is one of the "hottest" areas of science. Silver, due to its similarity to copper, has been pointed out as a potential precursor for new materials of this type. It is therefore reasonable to study properties of silver compounds, especially at **extreme conditions of pressure and temperature**, of which we know the least, and where most extraordinary surprises can be expected.

The intention of this project is to synthesize new **chlorides of silver** using high pressures. Only one (!) chloride of silver with chemical formula AgCl is known, which easily decomposes under exposure to light. It is an extremely important substance – it has been a basis for photography for over a hundred years! On the other hand, many different compounds of silver with fluorine and oxygen have been found and characterized. Fluorine and oxygen are the two most reactive elements – they are able to "rip" electrons from other atoms and form chemical bonds with them. Chlorine is third in this sequence, so it is probable that under proper conditions, compounds of chlorine and silver other that AgCl can also form. This conjecture is supported by theoretical calculations, which predict that other chlorides of silver can indeed be stable at high pressure and/or low temperature conditions. Possible products may include **polychlorides** – complex structures containing chains of chlorine atoms, of which very little is known, especially at high pressure.

In order to compress a mixture of silver and chlorine to high pressures and observe the effects of this process, we will use the so-called **diamond anvil cell** – an invention of Percy Williams Bridgman, for which he was awarded the Nobel Prize in Physics in 1946. This device works in a remarkably simple way. It consists of two small, opposing, brilliant-cut diamonds, between which the sample is compressed. Since diamond is the hardest known material, it is possible to subject in this way almost any kind of substance to extremely high pressure – hundreds of thousands or even millions of atmospheres. This method has been utilized in the past to study behavior of minerals at conditions resembling those in the Earth's core and to gain insight into dynamics of crystal structures with varying conditions. By mixing chlorine and silver under high pressure, we hope to find new, as yet unknown compounds and study their properties. This will deepen our understanding of chemistry of silver, chlorine, and may bring us closer to finding **new materials** with extremely interesting **properties**.