The aim of this research is to develop a method for detecting so-called "dark" electronic states that occur in tiny metallic particles, known as nanoparticles, and in chemical molecules. Electrons are the lightest components of atoms and, along with atomic nuclei, constitute the fundamental building blocks of matter—including chemical molecules and metal nanoparticles. The spatial distribution of electrons in these objects determines their energy (energy state) and many physical and chemical properties. With the aid of appropriately selected light, it is possible to influence this distribution and, therefore, these properties. There are also other ways to change the electronic state without using light. Some of these states are, in a sense, invisible to light. Such dark states are challenging to detect using traditional methods based on the interaction of these objects with light. In molecules, dark states can control how various chemical substances react and how stable they are in the presence of light. In nanoparticles, these states affect local electromagnetic fields, which in turn influence neighboring molecules. Discovering ways to detect and characterize these states could have broad applications, from creating more efficient chemical sensors to understanding and controlling chemical reactions at the molecular level.

As part of this project, the research team from the Institute of Physical Chemistry of the Polish Academy of Sciences in Warsaw proposes to test and refine a new methodology to visualize these dark states. This method relies on the use of the enhancement effect by nanoparticles of the interaction of light with molecules placed near them and the use of this effect to amplify the light signal coming from "bright", visible states for the indirect detection of dark states. Although dark states do not interact directly with light, they affect their immediate surroundings, and this influence can be detected as disturbances in bright states. This indirect approach will help in detecting the dark states themselves and understanding how metallic nanoparticles affect the states of molecules and how these dark states can be used to control chemical processes.