The primary goal of presented project is to develop a novel research technique which we called: femtosecond infrared pump – stimulated Raman probe spectroscopy. This technique will belong to the group of vibrational spectroscopies, which enable one to record vibrations of particular chemical groups of molecules. It is also an ultrafast time-resolved spectroscopy; hence it will allow us to observe time evolution of those ultrafast vibrations (e.g. evolution of energy of a vibration) upon an external stimulus (a pump). Actually, we can follow evolution of ultrafast vibrations, and ultrafast means here the order of hundreds of femto- and picoseconds (10^{-13}-10^{-12} s), thanks to the lasers able to generate pulses as short as 100-200 fs.

The unique feature of the technique that we are going to develop will be its ability to observe how, upon excitation of particular vibration of a chemical group, the energy is gradually transferred to all other vibrations “neighbouring“ the excited one. We have to stress that this new technique will be able to observe the response of all chemical groups in studied sample at once. The reason for such experimental technique to exist is certainly “basic research”, i.e. research conducted towards understanding of the fundamental aspects of world that surrounds us. In this case we will get a tool to study molecular interactions and to follow energy transfers between different molecules or different parts of the same molecule.

Due to the specific advantages of our new research technique it is a perfect tool to resolve urgent problems in the fields of physical chemistry and biochemistry. It should make possible i.e. characterization of intermolecular interactions in liquid phase, resolving secondary structures of hydrated proteins and peptides and also understanding mechanisms of enzyme-catalised reactions.

What actually made us develop this advanced research tool is our strong need to better understand supramolecular structure of liquid water and the mechanism of dissipation of thermal energy in water (strictly speaking: the mechanism of relaxation of its vibrational energy). Each water molecule is able to form up to four hydrogen bonds with neighbouring water molecules. Various possible configurations of water molecules in such a cluster lead to the transient “water structures” and specific mechanisms in which thermal energy dissipates in liquid water (excluding metal melts, water is a liquid with the highest heat conductance). Regardless of tens of years of studies and thousands of research papers devoted to liquid water, its ”secrets” and anomalies were not explained fully. We think that our novel research technique will let us understand better how thermal energy delivered to a water molecule “dissipates” over its all vibrations, is then transported to neighbouring molecules and finally influences arrangement of water molecules (water structure).