The 2018 Nobel prize in physics was awarded for the development of femtosecond (fs is 10^{-15} s) laser sources. Indeed, such lasers revolutionized the material research, allowing deeper understanding many processes responsible for function of organism, for influence of drugs or for synthesis of novel materials. Thanks to the awarded method the femtosecond (ultrafast) lasers are developed with higher and higher pulse energies, upon with the atoms and molecules react in surprising manner. Many such extreme processes lead to the change of the material structure on femtosecond time scale in irreversible way, which is very hard to monitor because the electronic devices are too slow for it. During the last years new challenges emerged mainly in medical and environmental diagnostics and material processing, which require not only ultrafast measurement, however long optical wavelengths far beyond the visible. The sensitivity of human eye is around 0.4 – 0.7 μm, however the material excitation and diagnostics is very useful in the 2 – 6 μm range, which is the so called mid-infrared.

Therefore we plan to develop a new simple diagnostics technique in the mid infrared spectral region, which will be able to monitor many extreme and ultrafast material processes. We take benefit from outstanding and complementary knowledge and technique base of two research teams to bring new solution for optical fiber based single-shot ultrafast mid-infrared spectroscopy. The Polish research team will develop a special fiber with two parallel cores made from glass, which is transparent in the mid infrared in contrast to the standard glass. The Austrian research team will develop special laser sources, which are able to enlighten the fiber simultaneously by femtosecond pulses at two distant wavelengths (1 μm and 2 μm) and prepare a special sequence of pulses, with series of mid infrared "colors". The final goal of the project is to use this novel form of optical radiation for material processes diagnostics by a relatively low cost method. It has potential in many cases to replace the expensive and bulky x-ray, magnetic resonance or particle acceleration techniques.

Important part of the project are computer based simulations, which can predict the proper structure of the dual-core fiber and its interaction with the two color femtosecond pulses. After the initial calculations the Polish team will prepare the special glasses and manufacture different type of fibers comprising two cores with dimensions and distance at the level of few μm. The Austrian research team will perform lot of experiments studying three fiber generations and the best samples will be used for the final spectroscopic investigations. To the end of the project we would like to have more optical fibers, which will be optimized for different mid infrared wavelengths. Important advantage of this method is its compactness, it will require just cm level fiber lengths. It will be usable to monitor processes under high energy pulse irradiation (millijoules), however the diagnostics itself will require just very low energies thanks to the special glass of the fiber. Therefore it should have application potential for biological or medical purposes, where even the moderate pulse energies (nanojoules) would be dangerous.