Titre Thèse **Title**	**Teraherz optical activity for biomedical applications (cotutelle)**	
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Abstract:

The main target of the thesis is to extend terahertz time-domain spectroscopy (THz-TDS) to precisely measure THz optical activity (circular birefrigence and dichroism) and apply it to biomedical sensing. First of all, the high sensitivity ellipsometric technique to measure the THz optical activity will be developed and tested. Then the method will be applied to characterize optically active chiral structures - artificial gyrotropic structures prepared by lithography and natural chiral polymers (sacharides, nucleic acids, proteins, lysozymes, RNA, etc.).

The standard spectral range for biomedical inspection of chiral molecules and their vibrational circular dichroism (VCD) has up till now always concentrated on the visible and mid-infrared part of the electromagnetic spectrum (mainly due to instrumental challenges in the low frequency range). However, low frequency molecular motions belonging to the far infrared and terahertz spectral range (such as S-S stretching important for monitoring of the peptides and protein conformation) contain unique signatures for most of these systems. This was recently demonstrated by modeling and measurement of their Raman optical activity.

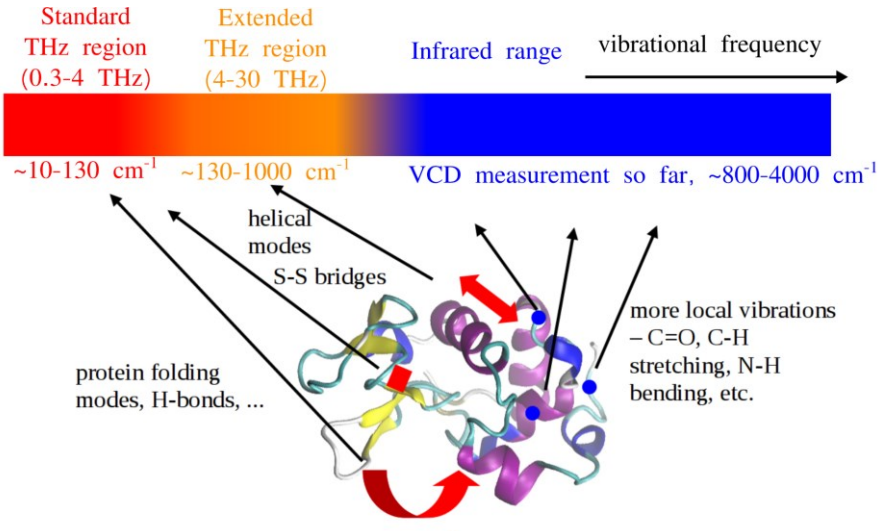

Figure. Infrared and terahertz molecular optical activity of a protein

The terahertz (THz) spectral range of electromagnetic radiation (frequency range from 0.1 to 5 THz, wavelength range from 60 micrometers to 3 mm) is currently attracting a lot of attention due to a tremendously wide application range spanning from security inspection, biomedicine, wireless high-speed communications, and detection of dangerous materials and gases. In the area of biological and medical applications, the THz radiation is applied to detect either water concentration or low frequency vibrations of heavy molecules. Typical biomedical molecules (sacharides, proteins, lysozymes, biopolymers, RNA, DNA, etc.) exhibit reduced symmetry and chirality, which enables selective sensitivity on them using circular polarization techniques. Sensing in THz spectral range is often based on the terahertz time-domain spectrometry (THz-TDS). This technique combines high sensitivity, wide spectral precision and temporal resolution on femtosecond level exploiting ultrashort laser pulses. Combining TDS with ellipsometry or polarimetry creates a unique tool to analyse for the first time the behaviour and dynamics of biomedicla chiral molecules in the terahertz range. Special consideration will also be devoted to time-domain Raman spectroscopy and THz Raman optical activity.
The use of THz radiation to get insight in a whole range of biomedical processes has over the last five years taken a huge surge by the combined developments of more powerful THz sources, more sensitive detection schemes and advanced technological processing. As such THz has become not only a unique early diagnostic tool for many viral diseases but can also detect trace markers of more severe pathogens. A time-domain temporally resolved THz spectroscopy could even take a step to get insights in protein dynamics.

This PhD research is co-funded by the Nanotechnology Center in Ostrava, Czech Republic. This funding is already in place. Part of the research will therefore be conducted in Czech Republic. The PhD stipend in both research laboratories will be guaranteed to be of similar level. The candidate is required to spend a part of the study in the Czech Republic.

Within the framework of this PhD research the candidate will be part of a multidisciplinary international research team that is currently working at the forefront of this novel topic in terahertz research. A recently obtained research project funding will come in support of this work. Both research laboratories in this project (IEMN in France and Nanotechnology Center in Ostrava, Czech Republic) have a longstanding collaboration history and have been active in the field of THz photonics for several decades. They are frequent partners in many national and international research consortia. The have at their disposal several measurement setups that are top of the line in the field. The successful candidate will therefore not only be involved in a currently societally hot topic but will get the opportunity to develop research skills in an international collaborative setting with access to top level research equipement.
Interested candidates should send their motivation letter, an up-to-date CV including curriculum scores to both PhD advisors. A solid background in electromagnetism, optics and laser physics is required. Knowledge of biochemistry is an additional plus.

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