Introduction to nonlinear THz processes and their potential applications.

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Recent advances in the development of technologies for the THz spectral range brought forward the possibility of investigating nonlinear THz processes, and their employment for creating new research tools for several unique applications.

In particular, this relates to the development of the "bright THz source" which opens the gate for exploring nonlinear THz field-matter interaction and spectroscopy. These bright THz sources that have been developed recently are high peak-power pulsed THz sources with amplitudes greater than 1 MV/cm, providing unique opportunities to study transient dynamics of non-perturbative states of matter and to investigate strong light-matter interactions.

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The special course will introduce some basic nonlinear THz processes, and explore the potential of employing them as research tools and as the basis for a number of innovative applications.

Specific Topics that will be studied within the framework of the course include:

Nonlinear THz research, where the possibilities of using the bright THz source will be described, including intense THz wave-induced Kerr effect or self-focusing effect.

THz/XUV generation where the emission efficiency for both secondary radiations (XUV and THz waves) using dual-wavelength optical excitation will be described.

Pump/probe dynamics where the transient dynamic measurements based on using a pair of highly synchronized, ultra-short laser pulses in an optical pump/probe set up will be presented, and its application in material science, chemistry, and physics will be discussed.

THz-field-oriented polar molecules where it will be shown how the unipolar THz pulses interact with polar molecules.

Time-resolved molecular level imaging where the multi-dimensional spectroscopic characterization usinf the coherent-diffractive-imaging (CDI) will be described.

Exploration of nontrivial quantum phenomena such as entanglement by employing nonlinear processes combining THz and optical photons where the THz photons are the entanled particles, and the optical photons are the reporting particles.