# Colloquium February 27th, 2019 at 2 p.m.

## Generating and shaping light in the THz frequency range

Karl Unterrainer

*Technische Universität Wien*

With the tremendous development of ultrafast lasers we are provided with a tool for efficient wavelength conversion. Down conversion allows generation of mid-infrared and THz light and provides in addition also the ability to control the phase. This additional control knob is a new feature for optical experiments which we are just beginning to use. I will show a few experiments with semiconductor nanostructures and quantum cascade lasers where the phase information allows observing physical processes directly; this includes population transfer, amplification, and short pulse formation. In addition to the phase information, down conversion provides us with very large bandwidth - spanning more than one octave. Handling these bandwidths is an interesting challenge and also extremely attractive for new optical methods like frequency comb sensing.

Quantized transitions in semiconductor nanostructures are very attractive for the realization of quantum devices from Quantum Cascade lasers to single photon emitters. Phase-resolved THz spectroscopy allows unique measurements of relaxation and dephasing times as well as of stimulated emission from Quantum Cascade lasers. The knowledge of the phase of the THz emission provides fascinating insights into the quantum optical processes. In addition, these measurements enable the study of gain band width, non-linear dispersion, gain saturation and recovery. Heterogeneous Quantum-Cascade lasers provide an octave spanning gain and allow the generation of injection seeded THz pulses.

With high intensity THz pulses we explore the non-linear regime of intersubband transitions. In meta-material coupled nanostructures we observe ultra strong coupling und study its dependence on the THz field strength. The modification of the radiative efficiency of THz meta-atoms, as the basic building blocks of a metamaterial surface will be discussed. We demonstrate a substantial influence on the radiative lifetime when the elements are arranged in densely packed super-cells. The observed change of the radiative lifetime with the density of meta-atoms is explained by superradiance.

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