Ultrafast terahertz spectroscopy:
probing and controlling fundamental motions of electrons, spins and molecules

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The terahertz (THz) frequency range is attracting increasing interest for both applied and fundamental reasons. On one hand, bit rates in current information technology may soon approach the THz range. Therefore, it is warranted to study the behavior of materials at THz frequencies. This goal is also highly interesting from a scientific viewpoint because its low photon energy (4.1 meV at 1 THz) makes THz radiation an excellent probe of many elementary excitations of solids, for instance lattice vibrations (phonons), conduction electrons, excitons and spin waves.

This talk is supposed to provide an introduction to THz spectroscopy of condensed matter. The goal is to illustrate how ultrashort THz electromagnetic pulses (duration <1 ps) can be used as ultrafast Ohmmeters and Amperemeters to gain insight into elementary motions of electrons in plasmas, excitons in semiconductors, spins in metals and rotations of molecules in solvents. Finally, it will be discussed how very strong THz electric and magnetic fields (~MV/cm and ~T) can even be used to gain control over such motions.