Strong-field physics of complex model systems in a broad spectral range

Abstract:

The interaction of strong lasers with atoms, molecules and clusters at optical frequencies has become an active field of research, triggering new developments on both, the experimental and theoretical side. Recent model calculations have shown that many electrons may be excited in large finite systems even at relatively moderate intensities above some 10^{10} Wcm^{-2}: the single active electron picture, commonly used for atoms and small molecules, cannot be used to explain details of the photophysics of complex many-body systems in strong electromagnetic fields.

In this seminar I highlight some prototypical studies on the laser-induced energetics and ultrafast dynamics of C_{60} fullerenes. With the help of femtosecond photoelectron and photoion spectroscopy in combination with pump-probe and optimal control methods deep insight into fundamental processes, such as excitation, ionisation and fragmentation can be obtained. Experiments on amino acid complexes indicate that strong-field control of photochemical reactions using femtosecond pulses tailored in a self-learning feedback loop offers an additional dimension for mass-spectrometric investigations.

On the other hand, only little is known about the effect of the photon energy in the laser matter interaction, particularly in the high energy limit. The free-electron laser (FEL) at DESY in Hamburg has recently opened the door to a new regime of strong-field matter interaction in the vacuum ultraviolet spectral range below 100 nm with photons capable to excite or ionise matter directly. The unique properties of FEL radiation promise to reveal structures of large biomolecules and to visualize ultrafast chemical processes with atomic resolution. The feasibility of these experiments largely depends on a detailed knowledge of the fundamental processes involved, if short-wavelength laser light is focussed onto large finite systems. In this context, prototypical studies on rare gas clusters will be presented.