UNIKASSEL VERSITÄT

# Physikalisches Kolloquium

**Thursday, 31.01.2019, 16:15, HS 100**
**Reception with coffee & cookies 15:45**
**(For university staff: please bring your own cup for sustainability reasons)**

**Prof. Dr. Matthias Kling**, Ludwig-Maximilians-Universität München:

## *Few-cycle laser driven reaction nanoscopy on isolated nanoparticles*

**Abstract**

The chemical composition of atmospheric aerosols is a crucial factor in their contribution to air pollution and their impact on health. Strong laser fields offer a route for single particle chemical analysis, where molecular fragments are created in the laser interaction and spectroscopically identified. Strong-field induced processes in molecules such as ionization and dissociation have been subject to theoretical and experimental investigations for many decades [1]. These processes include, e.g., above threshold ionization, high harmonic generation, and laser induced electron diffraction. Since these effects strongly rely on the exact spatial and temporal evolution of the electric fields, they are also influenced and controlled by the presence of enhanced near-fields in the proximity of a nanostructure [2]. Under irradiation with light, the associated near-fields can induce, enhance, and control molecular adsorbate reactions on the nanoscale. So far, however, there is no simple method available to spatially resolve the near-field induced reaction yield on the surface of nanoparticles. Here, we close this gap by introducing reaction nanoscopy based on three-dimensional momentum resolved photoionization.

We have developed a nanotarget reaction-microscope based on recoil-ion-momentum spectroscopy (nanoTRIMS) [3], which permits recording both ions and electrons from the interaction of light pulses with molecules on a nanoparticle surface in coincidence. Nanoparticles are injected into the interaction region using an aerosol technique and are illuminated by 5 fs laser pulses at 720 nm with a peak intensity of ~3×1013 W/cm². We have studied the dissociative ionization of water, ethanol (and silanol) molecules on SiO2 nanoparticles of various diameters, leading to the ejection of high-energy protons (see Fig. 1(a,c)). For large nanoparticles, the data show a clear propagation effect [4] and the influence of the laser-induced near-field on the yield of the dissociative ionization. The results from the nanoTRIMS experiment are modelled by semi-classical Monte-Carlo trajectory simulations [3], including Mie fields and charged particle interactions, cf. Fig. 1(b,d).

The results open the door towards strong near-field induced chemical reactions on nanoparticles and a route towards nanometer-scale spatio-selective chemical analysis of molecular adsorbates on aerosols. Reaction nanoscopy is suited for a wide range of isolated nanosystems and can provide spatially-resolved ultrafast reaction dynamics on nanoparticles, clusters, and droplets. Finally, the reaction nanoscope is suited to trace spatio-temporal variation in reaction yields in time-resolved pump-probe experiments.

References

[1] T. Brabec, Strong Field Laser Physics (Springer, New York, 2009)
[2] P. Hommelhoff and M.F. Kling, Attosecond Nanophysics: From Basic Science to Applications, (Wiley, 2015)
[3] P. Rupp et al., submitted.
[4] F. Süßmann et al., Nat. Commun. 6, 8944, (2015).

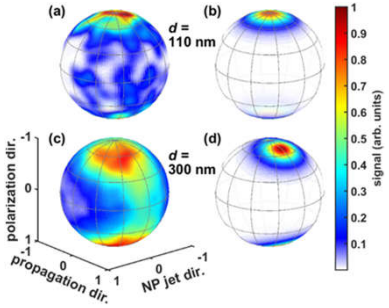


**Photo: Figure 1. Comparison of measured and simulated angular proton distributions. The 3D (φ,θ,r) momentum distributions of protons are integrated along the radial coordinate and the retrieved two dimensional (φ,θ) density map is spanned over a unit sphere. The number of protons per solid angle is encoded in the color scale: (a) and (b) show, for 110 nm particles, the measurement and Monte-Carlo trajectory simulations, respectively, and (c) and (d) the analogues for 300 nm particles.**

All of you interested in physics are cordially invited!

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