A 8: Atomic systems in external fields II

Time: Monday 14:30–16:15 Location: f303

A 8.1 Mon 14:30 f303

Strong-field photoionization of H2+ at mid-infrared wavelength — •Max Möller[1,2], Philipp Wustelt[1,2], A. Max Sayler[1,2], Stefanie Gräfe[3], and Gerhard G. Paulus[1,2] — [1]Institute of Optics and Quantum Electronics and Abbe Center of Photonics, Friedrich Schiller University, Max-Wien-Platz 1, D-07743 Jena, Germany — [2]Helmholtz Institute Jena, Fröbelstieg 3, D-07743 Jena — [3]Institute of Physical Chemistry and Abbe Center of Photonics, Friedrich-Schiller-University Jena, Helmholtzweg 4, D-07743 Jena, Germany

Increasing the driving laser wavelength into a region above 1 μm has lead to a number of interesting phenomena and applications in the field strong-field interactions of atoms. Examples are the discovery of low-energy structures or the generation or high harmonics with photon energies above 1 keV. Due to the nuclear degree of freedom, strong-field photoionization of small molecules induces more complex dynamics such as charge-resonant enhanced ionization, or laser-induced electron diffraction. Here, the fragmentation of an ion beam by a strong mid-infrared laser field is studied experimentally as a function of intensity. Three-dimensional coincidence imaging in combination with a well collimated ion beam and high pondermotive potential of the laser allows to perform a kinematically complete experiment. The experimental results are compared to solutions of the time-dependent Schrödinger equation in one and two dimensions.

A 8.2 Mon 14:45 f303

Few-cycle effect in dissociative ionization of H_2^+ — •Volker Mosert and Dieter Bauer — Institut für Physik, Universität Rostock, 18051 Rostock

We investigate the dissociative ionization of H_2^+ for few-cycle infrared laser pulses by solving the TDSE for a low dimensional model Hamiltonian including the nuclear degree of freedom. For laser intensities $I \approx 10^{14}$ W cm^{-2} the joint electron-proton spectrum exhibits intensity modulations with respect to the kinetic energy of the protons but almost independent of the electron's kinetic energy. This modulation of ionization probability is reproduced in the frozen core approximation and in other binding potentials with variable ionization potential. Furthermore the modulation of ionization yield goes hand in hand with the occupation of the first excited state of the system at the end of the pulse, and the existence of an excited bound state turns out to be a necessary condition for the effect. By employing a two state model we can reproduce the modulation of excited state occupation and ionization yield qualitatively. We provide an analytical solution for the occupation of the two states in this model, which is valid when ionization and occupation of excited states is small. This model predicts a similar modulation of the ionization yield when the wavelength is varied (ionization potentials fixed) which is confirmed by TDSE simulations. Finally we discuss the carrier envelope phase dependence of the effect.

[1] V. Mosert, D. Bauer, Phys. Rev. A 92, 043414 (2015)

A 8.3 Mon 15:00 f303

Multielectron dynamics in the tunneling ionization of a correlated quantum system — •Maximilian Hollstein and Daniela Pfannkuche — Universität Hamburg, I. Institut für Theoretische Physik, Jungiusstraße 9, 20355 Hamburg

The multielectron dynamics during the tunneling ionization of a correlated quantum system is investigated by comparison of the solution of the time-dependent Schrödinger equation (TDSE) with the time-dependent configuration interaction singles approach (TDCIS). Here, we point out the relevance of a multielectron description of the tunnel ionization process especially for weakly confined quantum systems i.e. for instance poly-atomic molecules or semiconductor quantum dots. Within this context, we observe that adiabatic driving by an intense light field can enhance the correlations between the electrons that are still trapped.

A 8.4 Mon 15:15 f303

TDRNOT applied to the laser-driven hydrogen molecular ion — •Adrian Hanusch, Julius Rapp, Martins Brics, and Dieter Bauer — Institut für Physik, Universität Rostock, 18051 Rostock, Germany

The recently introduced time-dependent renormalized-natural-orbital theory (TDRNOT) has already proven good performance in benchmarks using an exactly solvable 1D Helium model atom [1-3].

TDRNOT is now extended towards a multi-component approach in order to describe a one-dimensional H_2^+ model system beyond the Born-Oppenheimer approximation. Different kinds of natural orbitals are introduced in order to describe the electronic and nuclear degree of freedom, and exact equations of motion for them are derived.

The theory is then benchmarked by calculating ground state properties and linear response spectra and comparing them to the exact results obtained from solving the time-dependent Schrödinger equation. Furthermore, we test the ability of TDRNOT to describe the fragmentation of H_2^+ in intense laser fields and high-order harmonic generation.

[1] M. Brics, D. Bauer, Phys. Rev. A **88**, 052514 (2013).
[2] J. Rapp, M. Brics, D. Bauer Phys. Rev. A **90**, 012518 (2014).
[3] M. Brics, J. Rapp, D. Bauer, Phys. Rev. A **90**, 053418 (2014).

A 8.5 Mon 15:30 f303

An improved method for finding exceptional points and application to Rydberg systems in external fields — •Matthias Feldmaier, Jörg Main, and Günter Wunner — 1. Institut für Theoretische Physik, 70550 Stuttgart, Germany

Exceptional points are special places in the spectrum of open quantum systems, where resonances degenerate and the associated eigenvectors coalesce. An example for such a system is the hydrogen atom in parallel electric and magnetic fields, for which we solve the Schrödinger equation in a complete basis to calculate the resonances and eigenvectors. Starting from an avoided crossing within the term scheme and using a two-dimensional matrix model, we develop an iterative algorithm to calculate both the position and energy of exceptional points, and to verify their basic properties. Additionally, we are able to visualize the wavefunctions of the degenerated states. We report the existence of various exceptional points. For the hydrogen atom these points are in an experimentally inaccessible regime of field strengths. However, excitons in cuprous oxide in parallel electric and magnetic fields as the corresponding hydrogen analog in a solid state provide a suitable system where the high-field regime can be reached at much smaller external fields and for which we propose an experiment to detect exceptional points.

A 8.6 Mon 15:45 f303

A semi-analitycal description of high-harmonic generation in inhomogeneous fields — •Carlos Zagoya Montiel, Matt Bonner, Emma Slade, and Carla Figueira de Morisson Faria — University College London

In this work, we perform a semi-analytical study of the high-order harmonic generation phenomenon in inhomogeneous media. In particular, we analyse how the inhomogeinity influences the spectrum and give an explanation for the harmonics appearing beyond the usual cutoff for homogeneous media. This is managed by employing windowed Fourier transforms and ensembles of classical trajectories. Furthermore, by neglecting the atomic core and considering the inhomogeinity parameter to be small, an analytical expression for the classical returning times can found which result to be in a good agreement with the numerical results.

A 8.7 Mon 16:00 f303

From the classical to the quantum Kibble-Zurek scaling — •Pietro Silvi[1], Giovanna Morigi[2], Tommaso Calarco[1], and Simone Montangero[1] — [1]Institute for complex quantum systems, Universitaet Ulm, D-89069 Ulm — [2]Theoretische Physik, Universitaet des Saarlandes, D-66123 Saarbruecken

The Kibble-Zurek (KZ) hypothesis identifies the relevant time scales in out-of-equilibrium dynamics of critical systems employing concepts valid at equilibrium: It predicts the scaling of the defect formation immediately after quenches across classical and quantum phase transitions as a function of the quench speed. Here we study the crossover between the scaling dictated by a slow quench, which is ruled by the critical properties of the quantum phase transition, and the excitations

due to a faster quench, where the dynamics is often well described by the classical model. We estimate the value of the quench rate that separates the two regimes and support our argument using numerical simulations of the out-of-equilibrium many-body dynamics. For the specific case of a ϕ^4 model we demonstrate that the two regimes exhibit two different power-law scalings, which are in agreement with the KZ theory when applied to the quantum and to the classical case. This result contributes to extending the prediction power of the Kibble-Zurek mechanism and to provide insight into recent experimental observations in systems of cold atoms and ions.