A 16 Wechselwirkung mit starken Laserpulsen I

Zeit: Donnerstag 10:40–12:25 Raum: H6

A 16.1 Do 10:40 H6

Qualitative analysis of relativistic multiphoton processes — •Karen Z. Hatsagortsyan, Carsten Müller, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

We propose a simple, qualitative method to estimate probabilities of multiphoton processes, which also allows us to get insight into the relativistic quantum dynamics of the respective atomic system in a strong laser field. We illustrate the method by considering the known processes of above-threshold ionization, pair production in a Coulomb and a strong laser field, and pair production by a γ-quantum in a strong laser field. As an application of the method we analyze the nonperturbative multiphoton regime of the pair production process in a standing laser wave.

A 16.2 Do 10:55 H6

Ionisationsunterdrückung angeregter Atome jenseits des Stabilisierungsbereiches — •A. Staudt[1], C. H. Keitel[1] und J. S. Briggs[2] — [1]MPI für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [2]Theoretische Quantendynamik, Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg

Bei der Wechselwirkung atomarer Systeme mit hochfrequenten Laserfeldern kann es zur sogenannten Stabilisierung kommen [1], bei der die Ionisationswahrscheinlichkeit nicht zwangsläufig mit der Intensität zunehmen muß, sondern stagnieren oder sogar abnehmen kann. Mit Hilfe eines zweidimensionalen Modellatoms, welches die Integration der Schrödingergleichung unter Einbeziehung der Magnetfeldeffekte des Lasers ermöglicht [2], wird das Ionisationsverhalten des angeregten 2s-Zustandes des Heliumions in solch starken Hochfrequenzpulsen untersucht. Es zeigt sich, daß bei Intensitäten, bei denen die Stabilisierung zusammenbricht, ein zusätzlicher Effekt der Ionisationsunterdrückung auftritt, der durch einen dynamischen Populationstransfer in den Grundzustand erklärt werden kann [3]. Eine zeitunabhängige Betrachtung sowie die Analyse der Wellenpaketsdynamik geben Aufschluß über die Ursachen dieses Effekts. Weiterhin wird der Einfluß der Nichtdipoleffekte auf die Ionisationswahrscheinlichkeiten diskutiert.

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[2] A. Staudt und C.H. Keitel, J. Phys. B **36**, L203 (2003); R. Fischer, A. Staudt und C.H. Keitel, Comput. Phys. Comm. **157**, 139 (2004)
[3] A. Staudt, C.H. Keitel und J.S. Briggs, arXiv:physics/0510234 (2005)

A 16.3 Do 11:10 H6

Particle production from laser-driven positronium — •Carsten Müller, Karen Z. Hatsagortsyan, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg

We calculate muon pair creation in electron-positron collisions, where the electron and positron originate from a positronium atom that is submitted to a strong laser field. It is shown that the threshold intensity of this process is almost reached by the most powerful present laser systems. The total production rate, however, turns out to be very small due to a destructive interference effect.

A 16.4 Do 11:25 H6

Dirac-Elektronen in starken Laserfeldern: Freie und gebundene Dynamik, Erzeugung von Harmonischen und e^+e^--Paarbildung — •Guido R. Mocken, Henrik G. Hetzheim, Matthias Ruf und Christoph H. Keitel — MPI für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

Die relativistische Quantendynamik von Einelektronsystemen wird gewöhnlich durch die Dirac-Gleichung beschrieben [1]. Zu ihrer Lösung haben wir eine Implementierung des Split-Operator-Verfahrens geschaffen [2], die dank Parallelverarbeitung und adaptiver numerischer Gitter einen Einblick in Gebiete ermöglicht, der bisher nichtrelativistischen Schrödinger-Rechnungen bei entsprechend schwächeren Laserparametern und Ionenladungen vorbehalten war, wie z.B. die mehrfache lasergetriebene Streuung eines Elektrons an hochgeladenen Ionen, die gebundene Dynamik eines vorbeschleunigten Ions oder die Erzeugung von Harmonischen der Laserstrahlung mithilfe freier und gebundener Elektronen [3]. Die Elektron-Positron-Paarbildung ist schließlich eine der faszinierendsten Voraussagen der Dirac-Theorie. Wir demonstrieren diesen Effekt in einem extrem starken oszillierenden elektrischen Feld.

[1] A. Maquet, R. Grobe, J. Mod. Opt. **49**, 2001–2018 (2002); C. H. Keitel, Contemp. Phys. **42**, 353–363 (2001).
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A 16.5 Do 11:40 H6

High-harmonic generation in rare-gas atoms — •Peter Koval, Dieter Bauer, and Christoph Keitel — Max-Planck Institut for Nuclear Physics, Saupfercheckweg 1, 69117 Heidelberg

There are two alternatives to describe non-relativistic many-electron atoms within *ab initio* quantum mechanics: Scrödinger equation or density-functional theory. The wavefunctions of many-electron atoms are extremely complex objects. Their determination suffers from the exponential growth of the computational cost with the particle number (exponential wall) [1].

In contrast, density-functional theory remains computationall relatively inexpensive. It can deal with much more complex atoms, although the effective potential of electron–electron interaction has to be approximated in practice. In the framework of time-dependent density functional theory (TDDFT), effective potentials have been developed and tested for several applications such as the simulation of harmonic spectra, the computation of excitation energies and transport properties. However, the development of accurate effective potentials is far from complete [2].

In this contribution, we study the influence of electron–electron interaction on the high-order harmonic generation in rare-gas atoms. Aiming to improve the effective potentials within TDDFT, we present the spectra of the emitted harmonics. Predictions of single-active-electron approximation and TDDFT with exchange-only effective potentials will be consistently compared.

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[2] K. Burke, *etal*, *J. Chem. Phys.* **123**, 062206 (2005).

A 16.6 Do 11:55 H6

Nonlinear resonant absorption in intense laser-cluster interaction — •Mrityunjay Kundu and Dieter Bauer — Max-Planck-Institut für Kernphysik, Postfach 103980, 69029 Heidelberg, Germany

Energy absorption by clusters in intense laser fields is known to be particularly efficient. It is known from computer simulations that collisional absorption does not play a major role at laser wavelengths $\geq 800\,\text{nm}$. Although various mechanisms of collisionless absorption in clusters have been proposed it is not easy to identify, to validate (or invalidate) and to separate them by investigating the outcome of computer simulations.

It is well known that the occurrence of the linear resonance $\omega_{\text{laser}} = \omega_{\text{Mie}}$ during the cluster expansion leads to efficient absorption of laser energy and cluster ionization. In this work, instead, we focus on the ultrashort laser pulse-regime or the early cluster dynamics in the long pulse-regime where the above linear resonance condition is not fulfilled. We show that even in this case absorption is efficient and that the dominant absorption mechanism in this regime is nonlinear resonance absorption (NRA) [1,2]. We prove this assertion by clearly identifying NRA in particle-in-cell (PIC) simulations of Xe_N clusters (with N up to 14000) in intense laser fields.

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[2] P. Mulser and M. Kanapathipillai, Phys. Rev. A 71, 063201 (2005)

A 16.7 Do 12:10 H6

Controlling high-harmonic generation and above-threshold with an attosecond-pulse train — •Carla Figueira de Morisson Faria[1], Pascal Salieres[2], Pierre Villain[2], and Maciej Lewenstein[3,4] — [1]Centre for Mathematical Science, City University, London EC1V OHB, United Kingdom — [2]Groupe Attophysique, CEA-SPAM, Bât. 522, Centre d'Etudes de Saclay, F- 91191 Gif-sur -Yvette, France — [3]ICFO, Institut de Ciències Fotòniques, E-08860 Castelldefels (Barcelona), Spain — [4]Institut für theoretische Physik, Universität Hannover, Appelstr. 2, D-30167 Hannover, Germany

We perform a detailed analysis of how high-order harmonic generation

(HHG) and above-threshold ionization (ATI) can be controlled by an attosecond-pulse train superposed to a strong, near-infrared laser field, and exhibiting a time delay with respect to it. In particular we show that the high-harmonic and photoelectron intensities, the high-harmonic plateau structure and cutoff energies, and the ATI angular distributions can be manipulated by changing this delay. This is a direct consequence of the fact that the attosecond pulse train can be employed as a tool for constraining the instant an electronic wave packet is ejected in the continuum. A change in such initial conditions strongly affects its subsequent motion in the laser field, and thus HHG and ATI. In our studies, we employ the Strong-Field Approximation and explain the features observed in terms of interference effects between various electron quantum orbits. Such results are in very good agreement with results obtained from the numerical solution of the time dependent Schrödinger equation, or observed in experiments.