Dear colleagues,

2010–2011 marks a transition for Journal of Physics B between two Editors-in-Chief, both eminent atomic, molecular and optical physicists – our outgoing editor, Professor Jan Michael Rost (MPI for Physics of Complex Systems, Dresden, Germany), and Professor Paul Corkum (NRC Steacie Institute and University of Ottawa, Canada), our new editor. This time is therefore filled with mixed emotions, nostalgia and excitement about what the future will bring. J. Phys. B has already seen many changes under Jan Michael’s leadership, some fundamental such as the merger with Journal of Optics B: Quantum and Semiclassical Optics in 2006, the introduction of new article types, namely fast track communications and tutorials that have been so popular among our readers, and the implementation of subject sections, which have helped clearly set out the journal’s scope. Changes of an aesthetical nature have also been made with our new format and more recently our web platform. We are now enthusiastic to start working with Paul. Certainly the journal will benefit from his expertise and connection with the community. As Paul wrote in his recent editorial, “…it is therefore a special pleasure to be entrusted with continuing the tradition of excellence established by Jan Michael and the Editorial Board. I intend to build on this foundation by ensuring that the journal makes full use of these tools.” These tools, as Paul refers to, are the combination of topical reviews, tutorials and special issues. They give a unique flavour to the journal and are an opportunity for all to communicate the latest news and developments in their field at all levels. They reach a wide audience who shares a similar passion for science and in particular atomic, molecular and optical (AMO) physics – the community that J. Phys. B has been thriving to serve for the last 44 years.

This new edition of our Highlights brochure gives you a taste of some of the most outstanding and excellent research published in J. Phys. B in 2010. All highlights articles have been selected by our Editorial and Advisory Boards. To illustrate why particular articles have been chosen, we have invited some board members to send in their own views on the articles as we did last year. Have these articles also caught your attention? Don’t worry if you have missed them as they will be free to read for the whole of 2011 to allow you time to catch up.

Our team would like to take this opportunity to thank the Board for having once again worked incredibly hard throughout the whole of last year and for their input on this particular project. Finally we are indebted to you, the AMO community, authors and referees, who by your creativity and innovation contribute to the development of this exciting area of physics. We look forward to another fruitful year and your support in 2011.

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Published twice-monthly (24 issues per year), *Journal of Physics B: Atomic, Molecular and Optical Physics* covers the study of atoms, ions, molecules and clusters, and their structure and interactions with particles, photons or fields. The journal also publishes articles dealing with those aspects of spectroscopy, quantum optics and non-linear optics, laser physics, astrophysics, plasma physics, chemical physics, optical cooling and trapping and other investigations where the objects of study are the elementary atomic, ionic or molecular properties of processes.

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*J. Phys. B* publishes research papers and fast track communications (FTCs). FTCs are outstanding short papers reporting new and timely developments. FTCs are processed quickly, free to publish, and free to read.

The journal also publishes special issues, topical reviews and PhD tutorials details of which can be found on pages 16, 17 and 19, respectively.

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Contents

2010 Highlights

Multi-pulse scheme for enhancing electron localization through vibrational wavepacket manipulation
C R Calvert, R B King, W A Bryan, W R Newell, J F McCann, J B Greenwood and I D Williams

A two-centre convergent close-coupling approach to positron–helium collisions
R Utamuratov, A S Kadyrov, D V Fursa and I Bray

Atom chip for BEC interferometry

Photoionization of N3+ and Ar8+ in an electron beam ion trap by synchrotron radiation

Phase sensitivity of high harmonic transient grating spectroscopy
Y Mairesse, N Dudovich, D Zeidler, M Spanner, D M Villeneuve and P B Corkum

Collapse and revival in inter-band oscillations of a two-band Bose–Hubbard model
Patrick Plötz, Javier Madroñero and Sandro Wimberger

Search for interference effects in electron impact ionization of aligned hydrogen molecules
A Senftleben, T Pflüger, X Ren, O Al-Hagan, B Najjari, D Madison, A Dorn and J Ullrich

Interplay between entanglement and entropy in two-qubit systems
L Mazzola, S Maniscalco, J Piilo and K-A Suominen

Electron angular distributions in near-threshold atomic ionization
T Marchenko, H G Muller, K J Schafer and M J J Vrakking

Weakly bound cluster states of Efimov character
Javier von Stecher

Dynamics of entanglement between two free atoms with quantized motion
F Lastra and S Wallentowitz

Lyman–Birge–Hopfield emissions from electron-impact excited N2
J A Young, C P Malone, P V Johnson, J M Ajello, X Liu and I Kanik

Extending the strong-field approximation of high-order harmonic generation to polar molecules: gating mechanisms and extension of the harmonic cutoff
Adam Etches and Lars Bojer Madsen
Absolute triple-differential cross sections for intermediate energy electron impact ionization of neon and argon
L R Hargreaves, M A Stevenson and B Lohmann

Sympathetic cooling in a mixture of diamagnetic and paramagnetic atoms
S Tassy, N Nemitz, F Baumer, C Höhl, A Batár and A Görlitz

Photoionization of laser-excited caesium atoms above the 4d ionization threshold
Angelica Moise, Michele Alagia, Lorenzo Avaldi, Vitaliy Feyer, Kevin C Prince and Robert Richter

2010 Special issues

High precision atomic physics
Guest Editors: Alan Hibbert, Walter Johnson and Wolfgang Wiese

Spectroscopic diagnostics of magnetic fusion plasmas
Guest Editors: Rudolf Neu, Hugh P Summers and Yuri Ralchenko

Intense x-ray science: the first 5 years of FLASH
Guest Editors: H Chapman, J Ullrich and J M Rost

2010 Topical reviews

Multiple optical trapping and binding: new routes to self-assembly
T Čižmár, L C Dávila Romero, K Dholakia and D L Andrews

Strong-field rescattering physics—self-imaging of a molecule by its own electrons
C D Lin, Anh-Thu Le, Zhenglin Chen, Toru Morishita and Robert Lucchese

Theory and applications of atomic and ionic polarizabilities
J Mitroy, M S Safronova and Charles W Clark

The solar UV–x-ray spectrum from 1.5 to 2000 Å
G A Doschek and U Feldman
## 2010 PhD tutorials

<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>A newcomer's guide to ultrashort pulse shaping and characterization</td>
<td>19</td>
</tr>
<tr>
<td>Antoine Monmayrant, Sébastien Weber and Béatrice Chatel</td>
<td></td>
</tr>
<tr>
<td>Theoretical methods for small-molecule ro-vibrational spectroscopy</td>
<td>19</td>
</tr>
<tr>
<td>Lorenzo Lodi and Jonathan Tennyson</td>
<td></td>
</tr>
<tr>
<td>An introduction to the formulation of steady-state transport through molecular junctions</td>
<td>20</td>
</tr>
<tr>
<td>Uri Peskin</td>
<td></td>
</tr>
<tr>
<td>Discrete optics in femtosecond-laser-written photonic structures</td>
<td>20</td>
</tr>
<tr>
<td>Alexander Szameit and Stefan Nolte</td>
<td></td>
</tr>
<tr>
<td>High-order harmonic and attosecond pulse generation on plasma mirrors: basic mechanisms</td>
<td>20</td>
</tr>
<tr>
<td>C Thaury and F Quére</td>
<td></td>
</tr>
<tr>
<td><strong>The 30 most downloaded articles published in 2010</strong></td>
<td>21</td>
</tr>
</tbody>
</table>
Multi-pulse scheme for enhancing electron localization through vibrational wavepacket manipulation

C R Calvert1, R B King1, W A Bryan2, W R Newell1, J F McCann1, J B Greenwood1 and I D Williams1

1 School of Mathematics and Physics, Queen’s University Belfast, BT7 1NN, UK
2 Department of Physics, Swansea University, Swansea, SA2 8PP, UK
3 Department of Physics and Astronomy, University College London, WC1E 6BT, UK

Abstract
A novel scheme for enhancing electron localization in intense-field dissociation is outlined. Through manipulation of a bound vibrational wavepacket in the exemplar deuterium molecular ion, simulations demonstrate that the application of multiple phase-locked, few-cycle IR pulses can provide a powerful scheme for directing the molecular dissociation pathway. By tuning the time delay and carrier–envelope–phase for a sequence of pulse interactions, the probability of the electron being localized to a chosen nucleus can be enhanced to above 80%.

A two-centre convergent close-coupling approach to positron–helium collisions

R Utamuratov, A S Kadyrov, D V Fursa and I Bray

Centre for Antimatter–Matter Studies, Department of Imaging and Applied Physics, Curtin University of Technology, Perth 6152, Australia

Abstract
A two-centre convergent close-coupling method, which includes the positronium-formation channel, has been developed for positron scattering on helium. Convergent, pseudoenergy-free cross sections have been obtained. This is only possible if complete expansions are used on both the positronium and helium centres. The method is valid for all projectile energies and all transitions, including breakup, which is associated with excitation of positive-energy helium and positronium pseudostates. Generally, good agreement between calculated cross sections and available experimental data has been found across all incident energies.

Atom chip for BEC interferometry

R J Sewell1, J Dingjan1, F Baumgärtner1, I Llorente-García1, S Eriksson1,4, E A Hinds1, G Lewis1, P Srinivasan2, Z Moktadir2, C O Gollasch2 and M Kraft2

1 Centre for Cold Matter, Blackett Laboratory, Imperial College, Prince Consort Road, London SW7 2BW, UK
2 School of Electronics and Computer Science, University of Southampton, Highfield, Southampton, SO17 1BJ, UK
3 Present address: ICFO–Institut de Ciencies Fotoniques, Mediterranean Technology Park, 08860 Castelldefels (Barcelona) Spain
4 Present address: Department of Physics, Swansea University, Singleton Park, Swansea SA2 8PP, UK

Abstract
We have fabricated and tested an atom chip that operates as a matter wave interferometer. In this communication we describe the fabrication of the chip by ion-beam milling of gold evaporated onto a silicon substrate. We present data on the quality of the wires, on the current density that can be reached in the wires and on the smoothness of the magnetic traps that are formed. We demonstrate the operation of the interferometer, showing that we can coherently split and recombine a Bose–Einstein condensate with good phase stability.

Board member’s comments
‘Atomic matter waves have a high potential for practical applications if one can provide means for simple and reliable manufacturing of electromagnetic traps. Researchers from Imperial College and University of Southampton report in this paper their success on preparing an atom chip trap for ultracold Rb atoms. The magnetic fields needed to trap the atoms just above the chip surface are provided by a set of gold wires on a silicon substrate. We present data on the quality of the wires, on the current density that can be reached in the wires and on the smoothness of the magnetic traps that are formed. We demonstrate the operation of the interferometer, showing that we can coherently split and recombine a Bose–Einstein condensate with good phase stability.’

Kalle-Antti Suominen, University of Turku, Finland
Photoionization of $\text{N}^{3+}$ and $\text{Ar}^{8+}$ in an electron beam ion trap by synchrotron radiation


1 Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg, Germany
2 Max Planck Advanced Study Group, Center for Free-Electron Laser Science, Luruper Chaussee 149, D-22761 Hamburg, Germany
3 ExtreMe Matter Institute EMMI, Planckstrasse 1, D-64291 Darmstadt, Germany


Abstract

Photoionization (PI) of multiply and highly charged ions was studied using an electron beam ion trap and synchrotron radiation at the BESSY II electron storage ring. The versatile new method introduced here extends the range of ions accessible for PI investigations beyond current limitations by providing a dense target of ions in arbitrary, i.e. both low and high charge states. Data on near-threshold PI of $\text{N}^{3+}$ and $\text{Ar}^{8+}$ ions, species of astrophysical and fundamental interest, show high resolution and accuracy allowing various theoretical models to be distinguished, and highlight shortcomings of available PI calculations. We compare our experimental data with our new fully relativistic PI calculations within a multiconfiguration Dirac–Fock approach and with other advanced calculations and find generally good agreement; however, detailed examination reveals significant deviations, especially at the threshold region of $\text{Ar}^{8+}$.

Phase sensitivity of high harmonic transient grating spectroscopy

Y Mairese, N Dudovich, D Zeldier, M Spanner, D Milleneuve and P B Corkum

1 CELIA, Université Bordeaux 1, UMR5107 (CNRS, Bordeaux 1, CEA), 351, cours de la libération, 33405 Talence, France
2 National Research Council of Canada, 100 Sussex Drive, Ottawa, Ontario K1A OR6, Canada
3 Department of Physics of Complex Systems, Weizmann Institute of Science, Rehovot 76100, Israel
4 Carl Zeiss SMT AG, D-73447 Oberkochen, Germany
5 University of Ottawa, Ottawa, ON, Canada


Abstract

We study the spatial profile of high order harmonics generated by a transient grating of rotational excitation. We show that the phase modulation of the harmonic emission as a function of molecular alignment is encoded in the diffraction pattern. In molecular nitrogen, the phase difference between aligned and isotropic molecules decreases from 1.6 rad for harmonic 19 to less than 0.3 rad for harmonic 27. In CO$_2$ we observe a strong phase jump for the highest harmonics. The position of this phase jump in the harmonic spectrum depends on the laser intensity, reflecting the contribution from multiple molecular orbitals to the harmonic emission.
Collapse and revival in inter-band oscillations of a two-band Bose–Hubbard model

Patrick Plötz1, Javier Madroñero2 and Sandro Wimberger4

1 Institut für Theoretische Physik, Universität Heidelberg, Philosophenweg 19, 69120 Heidelberg, Germany
2 Physik Department, Technische Universität München, James-Franck-Str. 1, 85748 Garching, Germany


Abstract

We study the effect of a many-body interaction on inter-band oscillations in a two-band Bose–Hubbard model with an external Stark force. Weak and strong inter-band oscillations are observed, where the latter arise from a resonant coupling of the bands. These oscillations collapse and revive due to a weak two-body interaction between the atoms. Effective models for oscillations in and out of resonance are introduced that provide predictions for the system's behaviour, particularly for the time scales for the collapse and revival of the resonant inter-band oscillations.

Search for interference effects in electron impact ionization of aligned hydrogen molecules

A Senftleben1, T Pflüger2, X Ren3, O Al-Hagan2, B Najjari1, D Madison2, A Dorn1 and J Ullrich3

1 Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany
2 Department of Physics, Missouri University of Science & Technology, Rolla, MO 65409, USA


Abstract

Five-fold differential cross sections (5DCS) for electron impact ionization of a diatomic molecule have been explored experimentally as a function of molecular alignment. Using H2 as a test system, we exploited dissociative ionization by 200 eV electrons to obtain the alignment of the internuclear axis. Separation of ground-state ionization from autoionization is discussed. 5DCS are investigated for the direct channel and found to be in good agreement with M3DW calculations discarding at the same time a simple two-centre interference model discussed recently in the literature.

Board member’s comments

‘Using a simple, but fundamental model of qubits interacting with a reservoir the authors show that two phenomena caused by interaction with the environment, decoherence, i.e. a decrease of the amount of entanglement, and a loss of purity, i.e. an evolution towards a statistical, incoherent mixture, are independent processes. In particular the latter need not be accompanied by the former, which is a bit surprising (at least it was for me).’

Marek Kus, Polish Academy of Sciences, Poland

Interplay between entanglement and entropy in two-qubit systems

L Mazzola, S Maniscalco, J Pillo and K-A Suominen

Department of Physics and Astronomy, University of Turku, FI-20014 Turun yliopisto, Finland


Abstract

We study the exact entanglement and entropy dynamics of two qubits interacting with a common zero-temperature non-Markovian reservoir. It is a commonly held view that entanglement loss due to environmental decoherence is accompanied by loss of purity of the state of the system. We demonstrate that such an intuitive picture does not always apply: the deterioration of entanglement and purity does not necessarily come together; i.e. revivals of entanglement can be accompanied by deterioration of purity. To complete our investigation on entanglement–mixedness interplay we consider the case of initial mixed states and study how the entanglement dynamics and its revivals are related to both the initial purity and the initial entanglement.
Electron angular distributions in near-threshold atomic ionization

T Marchenko1,2,3, H G Muller4, K J Schafer4 and M J J Vrakking1,5
1 FOM Institute for Atomic and Molecular Physics (AMOLF), Science Park 113, 1098XG Amsterdam, The Netherlands
2 Laboratoire d’Optique Appliquée, UMR 7639 CNRS-ENSTA-Ecole Polytechnique, Chemin de la Hunière, F-91761 Palaiseau, France
3 Laboratoire de Chimie Physique-Matière et Rayonnement, UMR 7614 UPMC Univ Paris 6-CNRS, 11 rue Pierre et Marie Curie, F-75005 Paris, France
4 Department of Physics and Astronomy, Louisiana State University, Baton Rouge, LA 70803-4001, USA
5 Max-Born-Institut, Max Born Straße 2A, D-12489 Berlin, Germany

Abstract
We present angle- and energy-resolved measurements of photoelectrons produced in strong-field ionization of Xe using a tunable femtosecond laser. An occurrence of highly oscillatory patterns in the angular distribution at low photoelectron kinetic energy is observed that correlates with channel closing/opening over a wide range of laser parameters. The correlation is investigated both experimentally and by means of systematic analysis of numerical solutions of the time-dependent Schrödinger equation. Our experimental and numerical results are in quantitative agreement with the semi-classical model introduced by Arbó et al (2008 Phys. Rev. A 78 013406), which relates the oscillatory patterns to interference between photoelectrons produced during different cycles of the laser pulse in the course of non-resonant ionization of the atom. We observe that an increase of the laser intensity eventually leads to qualitative invariance of the pattern, defining a limit on the applicability of the semi-classical model.

Weakly bound cluster states of Efimov character

Javier von Stecher
JILA, University of Colorado and National Institute of Standards and Technology, Boulder, CO 80309-0440, USA

Abstract
We study the behaviour of weakly bound clusters and their relation to the well-known three-body Efimov states. We adopt a model to describe the universal behaviour of strongly interacting bosonic systems, and we test its validity by reproducing predictions of three- and four-body universal states. Then, we extend our study to larger systems and identify a series of universal cluster states that can be qualitatively interpreted as adding one particle at a time to an Efimov trimer. The properties of these cluster states and their experimental signatures are discussed.

Board member’s comments:
‘Over the past few years, it has become clear that signatures of Efimov states cannot only be found in three-body systems but also in larger systems. This paper takes a look at universal features of weakly-bound clusters with up to 13 particles. It nicely illustrates that universality extends beyond the three-body system!’

Doerte Blume, Washington State University, USA

Experimental (left column) and calculated (middle column) momentum maps for ionization of Xe at various wavelengths and intensities ranging from (a) 800 nm, 6.7 × 10^{13} W cm⁻² to (g) 600 nm, 5.7 × 10^{13} W cm⁻². The logarithmic false-colour scale covers four orders of magnitude. The right column shows experimental and calculated angular distributions at a photoelectron kinetic energy of 0.25 eV (p = 0.135 au).

Bosonic cluster energies in the negative scattering-length region for differing cluster sizes (top).
Dynamics of entanglement between two free atoms with quantized motion

F Lastra and S Wallentowitz
Facultad de Fisica, Pontificia Universidad Católica de Chile, Casilla 306, Santiago 22, Chile


Abstract
The electronic entanglement between two free atoms initially at rest is obtained including the effects of photon recoil, for the case when quantum dispersion can be neglected during the atomic excited-state lifetime. Unlike previous treatments using common or statistically independent reservoirs, a continuous transition between these limits is observed, which depends on the inter-atomic distance and degree of localization. The occurrence of entanglement sudden death and birth as predicted here deviates from the case where the inter-atomic distance is treated classically by a static value. Moreover, the creation of a dark state is predicted, which manifests itself by a stationary-entanglement that even may be created from an initially separable state.

Lyman–Birge–Hopfield emissions from electron-impact excited N₂

J A Young1, C P Malone1,2, P V Johnson1, J M Ajello1, X Liu1 and I Kanik2
1 Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109, USA
2 Department of Physics, California State University, Fullerton, CA 92834, USA


Abstract
Relative electron-impact-induced emission cross sections for the a' 1Π_v (ν = 3)→X' 3Σ_g (ν = 0) and a' 1Π_v (ν = 2)→X' 3Σ_g (ν = 0) transitions are presented. Critical comparison is made with existing cross sections showing significant discrepancy with the widely accepted excitation function of Ajello and Shemansky (1985 J. Geophys. Res. 90 9845–61) at energies below ~80 eV. A series of extensive measurements are presented that were performed to rule out any possible systematic or random errors in the present experimental apparatus and methodology. These efforts lead to the conclusion that the current measurements are robustly reproducible and, thus, should supplant the LBH cross-section shape of Ajello and Shemansky (1985 J. Geophys. Res. 90 9845–61).

Extending the strong-field approximation of high-order harmonic generation to polar molecules: gating mechanisms and extension of the harmonic cutoff

Adam Etches and Lars Bojer Madsen
Lundbeck Foundation Theoretical Center for Quantum System Research, Department of Physics and Astronomy, Aarhus University, 8000 Aarhus C, Denmark


Abstract
Polar molecules such as CO are interesting target systems for high-order harmonic generation (HHG) as they can be oriented with current laser techniques, thus allowing the study of systems without inversion symmetry. However, the asymmetry of the molecule also means that the molecular orbitals are Stark shifted in energy due to their interaction with the driving laser. We extend the strong-field approximation of HHG by incorporating the Stark shift into the Lewenstein model and discuss its impact on two different gating mechanisms in CO. In system-induced gating an oriented target molecule serves as a gate by selecting every other half-cycle due to an increased (decreased) ionization rate. In field-induced gating the waveform of the driving laser is tailored such that the harmonic emission from an aligned molecule is damped (enhanced) every other half-cycle. We show that the Stark shift weakens the strength of system-induced gating and also determines the relative contribution from opposite orientations in field-induced gating. Finally, we propose a novel scheme for extending the high-order harmonic cutoff by letting the two gating mechanisms counteract each other, thus allowing for a higher laser intensity without increased ionization of the target gas.
Absolute triple-differential cross sections for intermediate energy electron impact ionization of neon and argon

L R Hargreaves, M A Stevenson and B Lohmann
ARC Centre of Excellence for Antimatter-Matter Studies, University of Adelaide, Adelaide, SA 5005, Australia

Abstract
Absolute triple-differential cross sections for intermediate energy electron impact ionization of neon and argon are reported. The data highlight ongoing challenges for theory in the description of this ionization problem and the immense value of absolute measurements over relative data in guiding the ongoing development of theory.

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Sympathetic cooling in a mixture of diamagnetic and paramagnetic atoms

S Tassy, N Nemitz, F Baumer, C Höhl, A Batär and A Görlitz
Institut für Experimentalphysik, Heinrich-Heine-Universität Düsseldorf, Universitätsstraße 1, 40225 Düsseldorf, Germany

Abstract
We have experimentally realized a hybrid trap for ultracold paramagnetic rubidium and diamagnetic ytterbium atoms by combining a bichromatic optical dipole trap for ytterbium with a Ioffe–Pritchard-type magnetic trap for rubidium. In this hybrid trap, we have investigated sympathetic cooling for five different ytterbium isotopes through elastic collisions with rubidium. A strong dependence of the thermalization rate on the mass of the specific ytterbium isotope was observed.

Board member’s comments:
'Two electron atoms generally offer new possibilities for interesting physics beyond what is available with single electron atoms, for example using their narrow intercombination lines for clock or quantum information applications. The combination of both ultra-cold single and two electron systems as demonstrated in this experiment at Düsseldorf offers the best of both worlds, as one has both the convenience of large atom numbers achievable with Rb and the many degrees of freedoms, e.g. boson or fermion, or metastable excited states offered by Yb. We are likely to see more and more experiments on such interesting mixtures of one and two electron atoms but at the moment the Düsseldorf team are one of a few groups leading the way.'
Charles Adams, University of Durham, UK
Photoionization of laser-excited caesium atoms above the 4d ionization threshold

Angelica Moise$^1$, Michele Alagia$^{2,3}$, Lorenzo Avaldi$^1$, Vitaliy Feyer$^1$, Kevin C Prince$^{1,3}$ and Robert Richter$^1$

$^1$ Sincrotrone Trieste, Area Science Park, I-34149 Basovizza, Trieste, Italy
$^2$ CNR-ISMN, Sez. Roma 1, P.le A. Moro 5, I-00185 Roma, Italy
$^3$ CNR-IOM, Laboratorio TASC, I-34149 Basovizza, Trieste, Italy
$^4$ CNR-IMIP, Area della Ricerca di Roma 1, CP10, I-00016 Monterotondo Scalo, Italy


Abstract
The photoionization of the ground state and 6p laser-excited caesium atoms was studied above their 4d ionization thresholds. The 4d photoelectron spectrum of 6p laser-excited atoms shows a stronger excitation of satellites upon ionization than its ground state counterpart. The relative intensities of satellite and main photolines show a slow variation with the incoming photon energy for both the ground state and the 6p laser-excited states. An assignment of the excited state spectra, supported by recently published ground state photoionization spectra and calculations, is given and a preliminary analysis of the 4d Auger spectrum of laser-excited atoms is also presented.

Comparison of ground state (bottom trace, black), D$_1$ (middle trace, red) and D$_2$ (top trace, blue) excited Cs 4d photoelectron spectra recorded at 145 eV photon energy. The ground state ionization contribution has been subtracted from the excited state spectra. The figure (bottom panel) also includes an expanded view of the caesium atom ground state spectrum.
2010 Special issues

Special issues feature a concentration of papers on a subject of current topical interest.

The special issues are commissioned by the Editorial Board with the contributions invited by the guest editors of the issue or through our online call for papers. All of these special issues can be accessed via iopscience.org/jphysb.

High precision atomic physics

Guest Editors: Alan Hibbert, Walter Johnson and Wolfgang Wiese

Accurate atomic collision and structure data are an essential ingredient for a wide range of research fields as well as for major technological applications. Areas from laboratory physics to quantum processing, from plasma research applications in nuclear fusion to lighting research, as well as astrophysics and cosmology, depend critically on such data. This special issue focuses on many of the new sophisticated theoretical and experimental approaches being developed that have made high precision atomic physics a reality.

Spectroscopic diagnostics of magnetic fusion plasmas

Guest Editors: Rudolf Neu, Hugh P Summers and Yuri Ralchenko

Spectroscopy has always been an integral part of the diagnostic systems of super-hot fusion plasmas – elucidating their key physical properties and providing crucial input for development of new tokamaks, stellarators and other advanced devices. The papers collected in this special issue provide an extensive representation of the state of the art in spectroscopic diagnostics of magnetic confinement fusion plasmas.

Intense X-ray science: the first 5 years of FLASH

Guest Editors: H Chapman, J Ullrich and J M Rost

The Free electron LASer in Hamburg, FLASH at DESY, is the first user facility which has, over the last five years, delivered short (10–50 fs) and intense (up to 10^{16} W cm^{-2} peak intensity) x-ray pulses. How matter behaves and what the fundamental mechanisms and phenomena are when illuminated with such pulses, are questions that have been addressed in this time. This special issue presents a compilation of results from FLASH that provide an overview of different types of pioneering experiments, including the highlights and surprises. The articles are kept at a tutorial level in order to be accessible for the non-specialist.
2010 Topical reviews

Topical reviews present a snapshot of recent progress in a particular field. Written by leading researchers in their respective fields, these articles present the background to a particular field and the current state of the art.

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Multiple optical trapping and binding: new routes to self-assembly

T Čízmář1, L C Dávila Romero2, K Dholakia1 and D L Andrews2
1 SUPA, School of Physics and Astronomy, University of St Andrews, North Haugh, Fife, KY16 9SS, UK
2 Nanostructures and Photomolecular Systems, School of Chemical Sciences, University of East Anglia, Norwich NR4 7TJ, UK

Abstract

The impact of optical forces in the physical and biological sciences now enables the manipulation of objects ranging in size from a cell down to a single atom. The mechanical effects of optical fields have profound and far-reaching consequences, and attention is increasingly focused upon the opportunities for the non-contact assembly of particles into specific geometries. The present overview focuses on the two aspects of multi-particle trapping and optical binding. These can broadly be grouped as methods based on light-mediated inter-particle interactions, offering potential for the organization of large numbers of micro- or nano-particles using optical forces alone.

Strong-field rescattering physics—self-imaging of a molecule by its own electrons

C D Lin1, Anh-Thu Le1, Zhangjin Chen1, Toru Morishita2,3 and Robert Lucchese4
1 J. R. Macdonald Laboratory, Physics Department, Kansas State University, Manhattan, KS 66506-2604, USA
2 Department of Applied Physics and Chemistry, University of Electro-Communications, 1-5-1 Chofu-ga-oka, Chofu-shi, Tokyo, 182-8585, Japan
3 PRESTO, Japan Science and Technology Agency, Kawaguchi, Saitama 332-0012, Japan
4 Department of Chemistry, Texas A&M University, College Station, TX 77843-3255, USA

Abstract

When an atom or molecule is exposed to a short intense laser pulse, electrons that were removed at an earlier time may be driven back by the oscillating electric field of the laser to recollide with the parent ion, to incur processes like high-order harmonic generation (HHG), high-energy above-threshold ionization (HATI) and nonsequential double ionization (NSDI). Over the years, a rescattering model (the three-step model) has been used to understand these strong field phenomena qualitatively, but not quantitatively. Recently we have established such a quantitative rescattering (QRS) theory. According to QRS, the yields for HHG, HATI and NSDI can be expressed as the product of a returning electron wave packet with various field-free electron–ion scattering cross sections, namely photo-recombination, elastic electron scattering and electron-impact ionization, respectively. The validity of QRS is first demonstrated by comparing with accurate numerical results from solving the time-dependent Schrödinger equation (TDSE) for atoms. It is then applied to atoms and molecules to explain recent experimental data. According to QRS, accurate field-free electron scattering and photoionization cross sections can be obtained from the HATI and HHG spectra, respectively. These cross sections are the conventional tools for studying the structure of a molecule; thus, QRS serves to provide the required theoretical foundation for the self-imaging of a molecule in strong fields by its own electrons. Since infrared lasers of duration of a few femtoseconds are readily available today, these results imply that they are suitable for probing the dynamics of molecules with temporal resolutions of a few femtoseconds.
Theory and applications of atomic and ionic polarizabilities

J Mitroy1, M S Safronova2 and Charles W Clark3
1 School of Engineering, Charles Darwin University, Darwin NT 0909, Australia
2 Department of Physics and Astronomy, University of Delaware, Newark, DE 19716, USA
3 Joint Quantum Institute, National Institute of Standards and Technology and the University of Maryland, Gaithersburg, MD 20899-8410, USA


Abstract
Atomic polarization phenomena impinge upon a number of areas and processes in physics. The dielectric constant and refractive index of any gas are examples of macroscopic properties that are largely determined by the dipole polarizability. When it comes to microscopic phenomena, the existence of alkaline-earth anions and the recently discovered ability of positrons to bind to many atoms are predominantly due to the polarization interaction. An imperfect knowledge of atomic polarizabilities is presently looming as the largest source of uncertainty in the new generation of optical frequency standards. Accurate polarizabilities for the group I and II atoms and ions of the periodic table have recently become available by a variety of techniques. These include refined many-body perturbation theory and coupled-cluster calculations sometimes combined with precise experimental data for selected transitions, microwave spectroscopy of Rydberg atoms and ions, refractive index measurements in microwave cavities, ab initio calculations of atomic structures using explicitly correlated wavefunctions, interferometry with atom beams and velocity changes of laser cooled atoms induced by an electric field. This review examines existing theoretical methods of determining atomic and ionic polarizabilities, and discusses their relevance to various applications with particular emphasis on cold-atom physics and the metrology of atomic frequency standards.

The solar UV–x-ray spectrum from 1.5 to 2000 Å

G A Doschek1 and U Feldman2
1 Space Science Division, Naval Research Laboratory, Washington, DC 20375, USA
2 Artep, Inc., 2922 Excelsior Spring Ct, Ellicott City, MD 21042, USA


Abstract
This review illustrates the potential of UV–x-ray spectroscopy for determining the physical conditions in the solar chromosphere, transition region and corona, and how spectroscopy can be used as a tool to understand the physical mechanisms governing the atmosphere. It also illustrates the potential for understanding transient events such as solar flares. This is a vast topic, and therefore the review is necessarily not complete, but we have tried to be as general as possible in showing in particular how solar spectra are currently being used to understand the solar upper atmosphere. The review is intended for non-solar physicists with an interest in spectroscopy as well as for solar physicists who are not specialists in spectroscopy.
2010 PhD tutorials

PhD tutorials are of a pedagogical nature. Designed to guide newcomers into rapidly developing fields where textbooks are still missing, they allow interested researchers from more distant fields to gain an insight into what they see as a new subject. PhD tutorials are generally based on either an excellent PhD thesis or an outstanding lecture series at a graduate winter/summer school.

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A newcomer’s guide to ultrashort pulse shaping and characterization

Antoine Monmayrant1,2, Sébastien Weber3 and Béatrice Chatel3
1 CNRS-LAAS, 7 avenue du colonel Roche, F-31077 Toulouse, France
2 Université de Toulouse, UPS, INSA, INP, ISAE ; LAAS, F-31077 Toulouse, France
3 CNRS-Université de Toulouse; UPS, Laboratoire Collisions, Agrégats Réactivité, IRSAMC, F-31062 Toulouse, France


Abstract
This tutorial gives an overview of the most widespread techniques of both ultrashort pulse shaping and pulse characterization.

Theoretical methods for small-molecule ro-vibrational spectroscopy

Lorenzo Lodi and Jonathan Tennyson
University College London, Department of Physics and Astronomy, Gower Street, London WC1E 6BT, UK


Abstract
The solution of the first principle equations of quantum mechanics provides an increasingly accurate and predictive approach for solving problems involving atoms and small molecules. A general introduction to the methods used for the ab initio calculation of rotational–vibrational spectra of small molecules is presented, with a strong focus on triatomic systems. The use of multi-reference electronic structure methods to compute molecular potential-energy and dipole-moment surfaces is discussed. Issues related to the construction of such surfaces and the inclusion of corrections due to relativistic and non-Born–Oppenheimer effects are reviewed. The derivation of exact, internal-coordinate nuclear-motion-effective Hamiltonians and their solution using a discrete-variable representation are discussed. Sample results for the water molecules are used throughout the tutorial to illustrate the theoretical and numerical issues in such calculations.
An introduction to the formulation of steady-state transport through molecular junctions

Uri Peskin
Schulich Faculty of Chemistry and the Lise Meitner Center for Computational Quantum Chemistry, Technion—Israel Institute of Technology, Haifa 32000, Israel


Abstract
A basic theoretical introduction is given for the phenomenon of electronic transport through molecular junctions. The electrode–molecule–electrode system is represented using a model Hamiltonian framework based on separation between the molecular and the electrode single-particle subspaces, using projection operators. The Landauer formulation of the steady-state current through the junction is introduced and the transmission function is derived from basic single-particle quantum scattering theory. Detailed implementations to a generic tight-binding model demonstrate the typical characteristics of the transmission function, and resonant transport through discrete quantum molecular states is analysed in detail. An alternative formulation based on the time-dependent Liouville–von Neumann equation leads to a quantum kinetic representation of the current in terms of rate constants for electron hopping between the molecule and the electrodes. The generalization of this approach to inelastic transport is discussed.

Discrete optics in femtosecond-laser-written photonic structures

Alexander Szameit1 and Stefan Nolte2
1 Physics Department and Solid State Institute, Technion, 32000 Haifa, Israel
2 Institute of Applied Physics, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, D-07743 Jena, Germany


Abstract
Over the last few years arrays of evanescently coupled waveguides have been brought into focus as a particular representation of functionalized optical materials, in which the dispersion and diffraction of propagating light can be specifically tuned. Moreover, it turns out that the light evolution in these systems shares fundamental similarities to the quantum evolution of particle wavefunctions, so that waveguide arrays can act as a model system for emulating quantum mechanics. Recently, a novel technique was developed with which waveguides can be directly ‘written’ into various optical bulk materials using femtosecond laser pulses, which allows for the realization of a variety of innovative concepts which are not feasible using other fabrication methods. The aim of this tutorial is to give an introduction to this topic.

High-order harmonic and attosecond pulse generation on plasma mirrors: basic mechanisms

C Thaury1,2 and F Quéré3
1 Service des Photons, Atomes et Molécules, Commissariat à l’Energie Atomique, DGM/IRAMIS, CEA Saclay, 91191 Gif sur Yvette, France
2 Centre de Physique Théorique, Ecole Polytechnique, CNRS, 91128 Palaiseau, France


Abstract
When an intense femtosecond laser pulse hits an optically polished surface, it generates a dense plasma that itself acts as a mirror, known as the plasma mirror. As this mirror reflects the high-intensity laser field, its nonlinear temporal response can lead to a periodic temporal distortion of the reflected wave, associated with a train of attosecond light pulses, and, in the frequency domain, to the generation of high-order harmonics of the laser. This tutorial presents detailed theoretical and numerical analysis of the two dominant harmonic generation mechanisms identified so far, coherent wake emission and the relativistic oscillating mirror. Parametric studies of the emission efficiency are presented for these two regimes, and the phase properties of the corresponding harmonics are discussed. This theoretical study is complemented by a synthesis of recent experimental results, which establishes that these two mechanisms indeed dominate harmonic generation on plasma mirrors.
The 30 most downloaded articles published in 2010

Coherence measurements and coherent diffractive imaging at FLASH


Low-energy symmetric coplanar and symmetric non-coplanar (e,2e) studies from the 3α state of H_2 O Kate L Nixon, Andrew James Murray, Ola Al-Hagan, Don H Madison and Chuangang Ning 2010 J. Phys. B: At. Mol. Opt. Phys. 43 035201


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