

Q 62: Quantum Control (with MO)

Time: Friday 10:30–12:15

Location: F 102

Q 62.1 Fr 10:30 F 102

Field-free orientation of molecules by femtosecond two-color laser fields — ●MATTHIAS KLING^{1,2}, IRINA ZNAKOVSKAYA¹, SANKAR DE², DIPANWITA RAY², FATIMA ANIS², NORA JOHNSON², IRINA BOCHAROVA², MAIA MAGRAKVELIDZE², BRETT ESRY², CHARLES LEWIS COCKE², and IGOR LITVINYUK² — ¹MPQ, Hans-Kopfermann-Str. 1, 85748 Garching, Germany — ²JRML, K-State University, Manhattan, KS 66506, USA

We report on the first experimental observation of nonadiabatic field-free orientation of a heteronuclear diatomic molecule (CO) induced by an intense two-color (800 and 400 nm) femtosecond laser field [1]. We monitor orientation by measuring fragment ion angular distributions after Coulomb explosion with an 800 nm pulse. The orientation of the molecules is controlled by the relative phase of the two-color field. The results are compared to quantum mechanical rigid rotor calculations. The demonstrated method can be applied to study molecular frame dynamics under field-free conditions in conjunction with a variety of spectroscopy methods, such as high-harmonic generation, electron diffraction, and molecular frame photoelectron emission.

[1] De et al., Phys. Rev. Lett. 103, 153002 (2009)

Q 62.2 Fr 10:45 F 102

Die Rolle der Elektronendynamik in der Quantenkontrolle molekularer Zustände durch intensive Laserfelder — ●ROBERT SIMMERING¹, PHILIPP VON DEN HOFF¹, TIM BAYER², MATTHIAS WOLLENHAUPT², THOMAS BAUMERT² und REGINA DE VIVIE-RIEDLE¹ — ¹Ludwig-Maximilians-Universität, München, Deutschland — ²Universität Kassel, Kassel, Deutschland

Intensive phasenmodulierte Kurzpulsfelder ermöglichen neuartige Quantenkontrollszenerarien aufgrund ihrer Kohärenz und der AC Starkverschiebung. An atomarem Kalium konnte bereits ein Starkfeldkontrollschema basierend auf der selektiven Besetzung einzelner bekleideter Zustände (Selective Population of Dressed States, SPODS) erfolgreich demonstriert werden [1]. Dieses Kontrollszenerarium wurde nun auf das Molekül K₂ übertragen und theoretisch analysiert. Als Kontrollziel wurde die selektive Besetzung der elektronisch angeregten Zustände $4\Sigma_g^+$ und $5\Sigma_g^+$ des K₂ Moleküls über SPODS gewählt. Im speziellen wurde auf zwei Fragen eingegangen: I) Kann man in molekularer System eine ähnliche hohe Selektivität erreichen, also einen Zustand maximaler Kohärenz erzeugen? II) Welchen Einfluss hat dabei die Elektronendynamik? Zur Klärung dieser Fragen ist es notwendig das Wechselspiel von Kern- und Elektronendynamik zu betrachten. Hierzu haben wir unsere ab initio basierte Methode [2] eingesetzt und die Elektronendynamik auf sechs gekoppelten Zuständen verfolgt.

[1] Wollenhaupt et al., J. Opt. B 7 (2005) S270 - S276

[2] D. Geppert, J. Phys. B: At. Mol. Opt. Phys., 41 (2008)

Q 62.3 Fr 11:00 F 102

New studies on photo induced bond breaking in model peptides — ●IHAR SHCHATSININ, NICKOLAI ZHAVORONKOV, INGOLF VOLKER HERTEL, and CLAUS PETER SCHULZ — Max Born Institute, Max-Born-Str. 2A, D-12489 Berlin, Germany

Small peptides possessing a -CO-NH-CHR-CO- moiety may be regarded as "model peptides". Recently we have reported the experimental results on specific bond breaking in the one of them (Ac-Phe-NHMe) using the pulse shaping technique [1]. We have shown ability to cleave the peptide bond in this molecule preferentially with shaped femtosecond laser pulses, while keeping other more labile bonds intact [2]. These results demonstrate the potential of the pulse shaping technique and can be considered as a first move toward an analytic tool for protein sequencing. As a step further now we present detailed investigations of selective bond breaking using other model peptides. Studies on different chromophores and backbone structures provide new information about the photo induced bond breaking phenomena in model peptides. The photo physical and photo chemical mechanisms involved in the observed phenomena will be discussed in this contribution.

[1] T. Laarmann, I. Shchatsinin, P. Singh, N. Zhavoronkov, M. Gerhards, C.P. Schulz, I.V. Hertel, J. Chem. Phys. 127, 201101 (2007)

[2] T. Laarmann, I. Shchatsinin, P. Singh, N. Zhavoronkov, C.P. Schulz, I.V. Hertel, J. Phys. B 41, 074005 (2008)

Q 62.4 Fr 11:15 F 102

Control of ionization processes by tailored femtosecond pulses in dielectric materials — ●LARS ENGLERT, DIRK OTTO, JUTTA MILDNER, ALEXANDER HORN, MATTHIAS WOLLENHAUPT, and THOMAS BAUMERT — Universität Kassel, Institut für Physik und CIN-SaT, Heinrich-Plett-Str. 40, D-34132 Kassel, Germany

Femtosecond laser pulses tailored by spectral phase modulation are successfully used for coherent control of atoms and molecules [1,2]. We present experiments [3] and simulations on the ionization processes in a wide band gap material with tailored femtosecond laser pulses.

On the ultrafast timescale tailored laser pulses are used to excite electrons from the valence band to quasifree states in the conduction band by multiphoton ionization and avalanche ionization. Relaxation back to the valence band or trapping to interbandgap states leads to depopulation of the quasi free states. Reaching a critical quasifree electron density results in material ablation.

The effects of laser pulses with asymmetric intensity and frequency distributions in the time domain are studied with respect to material ablation thresholds and structure morphologies on the nanometer scale.

[1] M. Wollenhaupt *et al.*, Annu. Rev. Phys. Chem. 56, 25–56 (2005)

[2] T. Brixner *et al.*, Chap. 9, "Femtosecond Laser Spectroscopy", Editor P. Hannaford, Springer (2005)

[3] L. Englert *et al.*, Opt. Express 15, 17855 (2007)

Q 62.5 Fr 11:30 F 102

Waveform control of the dissociative ionization of D₂ with few-cycle pulses — ●IRINA ZNAKOVSKAYA¹, GILAD MARCUS¹, SERGEY ZHEREBTSOV¹, BORIS BERGUES¹, XUN GU¹, YUNPEI DENG¹, PHILIPP VON DEN HOFF², MARC J.J. VRAKKING³, REINHARD KIENBERGER¹, FERENC KRAUSZ¹, REGINA DE VIVIE-RIEDLE², and MATTHIAS KLING¹ — ¹MPQ, Hans-Kopfermann-Str. 1, 85748 Garching, Germany — ²LMU Department Chemie, Butenandt-Str. 11, 81377 München, Germany — ³FOM-Institute AMOLF, Science Park 113, 1098 XG Amsterdam, The Netherlands

A first successful example of electron localization and its control by waveform controlled few-cycle pulses (5fs, 760 nm) was demonstrated on the dissociative ionization of the prototype molecules D₂ [1] and HD [2], a high degree of light-waveform control over the directional emission of D⁺ fragments was observed. Here we report on the first experimental observation of waveform control of the dissociative ionization of D₂ with recently developed intense CEP stabile few cycle laser pulses at the central wavelength of 2.1 μm. We observed a high degree of asymmetry for D⁺ fragments in the low energy range corresponding to bond softening, whereas in the experiments at 760 nm recollision excitation was a vital element in the mechanism responsible for the observed phase control.

[1] Kling et al., Science 312, 246 (2006)

[2] Kling et al., Mol. Phys. 106, 455 (2008)

Q 62.6 Fr 11:45 F 102

Chemoselective quantum control of carbonyl bonds in Grignard reactions. — ●MARKUS KOWALEWSKI¹, CAROLINE GOLLUB², SEBASTIAN THALLMAIR¹, and REGINA DE VIVIE-RIEDLE¹ — ¹Department Chemie und Biochemie, Ludwig-Maximilians-Universität München — ²Institut für Werkstoffwissenschaft und Max-Bergmann-Zentrum für Biomaterialien, Technische Universität Dresden, Max Planck Institut für Physik Komplexer Systeme, Dresden

Under laboratory conditions Grignard reagents like methyl magnesium bromide do not react selectively with respect to different carbonyl bonds. We investigate theoretically the perspectives of selective laser excitation of CO bonds in mixed systems. As an representative example a mixture of cyclohexanone and cyclopentanone is chosen as reagent. The laser is supposed to provide the activation energy and to adopt the function of a protective group. The control aim is to elongate the CO bond of one compound until the bond length required in the transition state is reached. We optimized picosecond laser pulses in the infra red regime with optimal control theory (OCT) which excite only the desired carbonyl bond. From the theoretical results laser assisted chemo-selectivity seems possible to a large extent. To obtain control not only on the final product but also on the excitation mech-

anism the behavior of the OCT algorithm for various initial conditions and under frequency restrictions is investigated.

Q 62.7 Fr 12:00 F 102

Accurate generation of polarization-shaped fs laser pulses with application to photoelectron imaging spectroscopy —

•JENS KÖHLER, MARC KRUG, CRISTIAN SARPE-TUDORAN, TIM BAYER, MATTHIAS WOLLENHAUPT, and THOMAS BAUMERT — Universität Kassel, Institut für Physik und Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), Heinrich-Plett-Str. 40, D-34132 Kassel, Germany

Femtosecond polarization pulse shaping is a tool to generate laser pulses with a time-dependent polarization profile on an ultrashort timescale. The realization of such pulses is often affected by unde-

sired polarization-dependent amplitude modulations and phase shifts introduced by the pulse shaper itself as well as other optical elements in the beam. In order to ensure accurate generation of polarizationshaped pulses, these effects have to be taken into account and the optical setup has to be corrected accordingly. Different schemes for detection and compensation of these effects are presented and compared. Recently, realization of accurately generated polarization-shaped laser pulses in the interaction region of a vacuum chamber has been demonstrated by photoelectron imaging spectroscopy [1]. Currently, we extend the application of our polarization shaping capabilities to the generation of complex-shaped free-electron wave packets characterized by three-dimensional tomographic reconstruction methods [2]. First results are presented.

[1] M. Wollenhaupt et al., Applied Physics B, 95(2), 245-259, (2009)

[2] M. Wollenhaupt et al., Applied Physics B, 95(4), 647-651, (2009)