A 10: Posters: Atomic clusters

Zeit: Dienstag 16:30–18:30 Raum: Poster C3

A 10.1 Di 16:30 Poster C3

Laser-Driven Electron Acceleration in Metal Nanoparticles — •Christian Schaal[1], Johannes Passig[1], Thomas Fennel[1], Tilo Döppner[2], Josef Tiggesbäumker[1] und Karl-Heinz Meiwes-Broer[1] — [1]Institute of Physics, University of Rostock, Universitätsplatz 3, 18051 Rostock, Germany. — [2]Lawrence Livermore National Lab, USA.

Silver clusters Ag_N(N=500..2000) generated with a magnetron sputtering source are irradiated with intense dual fs laser pulses (I_{laser}=10^{13}...10^{14} W/cm^2). In previous experiments we have demonstrated that the charging of the clusters can be enhanced by the resonant excitation of the dipolar mode leading to the emission of delocalized electrons. A comparison of energy and angular resolved measurements of the electron emission with microscopic analysis of corresponding semiclassical simulations indicates strong temporal beating in the electron emission at resonance and identifies phase-matched electron-cluster recollisions leading to multi-plasmon deexcitation, to produce the observed directional emission of most energetic electrons along the laser polarization axis, induced by resonant plasmon excitation at optimum pulse delay [1].

[1] Th. Fennel *et al.*, Phys. Rev. Lett. **98**, 143401 (2007).

A 10.2 Di 16:30 Poster C3

Aufbau eines Mikrowellenreaktors zur CVD-Synthese von Diamantclustern — •David Wolter, Lasse Landt, Thomas Möller und Christoph Bostedt — IOAP - Technische Universität Berlin

Diamantwachstum aus thermisch zersetztem Wasserstoff- und Methanradikalen in CVD (chemical vapour deposition) Reaktoren ist seit etwa zwei Jahrzehnten ein aktives Gebiet der Forschung. Eine Möglichkeit die benötigten Radikale zu erzeugen ist die Reaktionsgase in Mikrowellen - Plasmareaktoren zu zersetzen.

Wir studieren verschiedene Mikrowellenreaktor-Designs zur CVD Synthese von Diamantclustern. Zur Ausbildung der stehenden Welle ist die Geometrie des Reaktors von zentraler Bedeutung. Die Mikrowelleneinkopplung wurde zunächst am Computer simuliert und eine optimale Geometrie für maximale Energieeinkopplung bestimmt. Der Übergang vom Rechteckhohlleiter zum zylindrischen Resonator des Reaktors wurde entsprechend der Simulationen angefertigt, um einen möglichst verlustfreien Übergang von der rechteckigen Mode zur zylindrischen Mode zu realisieren. Erste Versuche mit der resultierenden Reaktorgeometrie ein stabiles Ar-Plasma zu erzeugen verliefen erfolgreich.

A 10.3 Di 16:30 Poster C3

Erzeugung von intensiven, ultrakurzen Laserpulsen durch Weißlichtfilamentation in Argongas - Experiment und Simulation — •Robert Irsig[1], Nguyen Xuan Troung[1], Thomas Fennel[1], Tilo Döppner[2], Josef Tiggesbäumker[1] und Karl-Heinz Meiwes-Broer[1] — [1]Universität Rostock, Institut für Physik, Universitätsplatz 3, 18051 Rostock — [2]Lawrence Livermore National Laboratory, Livermore, CA 94551 USA

Durch die Fokussierung von kurzen, intensiven Laserpulsen (<50fs, 2mJ) in eine mit Argon gefüllte Gaszelle werden Weißlichtfilamente erzeugt. In diesen Filamenten kommt es durch Selbstphasenmodulation zu einer spektralen Verbreiterung der Pulse. Nichtlineare Effekte, wie z.B. Self-Steepening, führen gleichzeitig zu einer Verringerung der Pulslänge auf unter 10fs [1]. Es wird gezeigt, wie die Filamente experimentell durch Variation von Gasdruck, Pulsenergie, Pulslänge sowie Pulsform beeinflußt werden können. Die Charakterisierung der so erzeugten Pulse erfolgt durch einen Single-Shot-FROG. In einer Simulation wird die Propagation der Laserpulse im Filament durch Lösung der nichtlinearen Schrödingergleichung beschrieben. Der Einfluß von Selbstphasenmodulation, Self-Steepening und Plasmabildung wird diskutiert.

[1] G. Stibenz, N. Zhavoronkov, and G. Steinmeyer, Opt. Lett. 31, 274 (2006)

A 10.4 Di 16:30 Poster C3

Multistep ionization of Argon clusters in intense femtosecond XUV laser pulses — •Mathias Arbeiter and Thomas Fennel — Institute of Physics, University of Rostock

The ionization dynamics of Argon clusters in ultrashort and intense XUV laser pulses is investigated by molecular dynamics simulation. Corresponding experiments[1] at FLASH free electron laser at $\lambda = 32$ nm and intensities of I$\sim 10^{12-14}$W/cm^2 have demonstrated the cluster response to be completely different to the behavior observed in the infrared and the VUV regime, where plasma heating processes dominate the laser-cluster coupling. In the XUV regime, in contrast to that, the measured photoemission spectra indicate a series of direct electron emission events in the developing cluster Coulomb field, which eventually induces frustration of the photoemission at a certain level of ionization. In our MD analysis we focus on the impact of multi-electron effects, thermalization, and ionic motion within the interaction process and corresponding signature in the electron and ion emission spectra.

[1] C. Bostedt et al., submitted

A 10.5 Di 16:30 Poster C3

Optical Properties of Clusters — •Thomas Raitza, Heidi Reinholz, and Gerd Röpke — Universität Rostock

The measurements of optical properties are relevant for plasma diagnostics. The investigation of reflectivity and absorption of electromagnetic waves in inhomogeneous media will be done with special attention to laser excited clusters. Interactions of cluster systems with intense laser pulses were investigated via MD simulation.

Via MD simulation the current auto correlation function (ACF) was calculated. Optical properties derived from current ACF will be presented. The cluster size dependence of the optical properties will be discussed as well as thermodynamic relations and the influence of the laser field.

A 10.6 Di 16:30 Poster C3

3p-Absorptionsspektroskopie an neutralen Vanadiumclustern in der Gasphase — •Marlene Vogel[1], Konstantin Hirsch[1], Philipp Klar[1], Andreas Langenberg[1], Fabian Lofink[1], Jochen Rittmann[1], Vicente Zamudio-Bayer[1], Bernd von Issendorff[2], Thomas Möller[1] und Tobias Lau[1] — [1]Technische Universität Berlin, Institut für Optik und Atomare Physik, EW 3-2, Hardenbergstraße 36, D-10623 Berlin — [2]Albert-Ludwigs-Universität Freiburg, Fakultät für Physik/FMF, Stefan-Meier-Straße 21, D-79104 Freiburg

Die resonante 3*p*-Photoabsorption freier neutraler Vanadiumcluster wird vorgestellt. Die Cluster werden in einer Magnetronsputterquelle erzeugt und der neutrale Clusterstrahl mit Synchrotronstrahlung angeregt. Die im Zerfall des angeregten Zustands entstehenden Ionen werden mit einem gepulsten Wiley-McLaren-Flugzeitmassenspektrometer nachgewiesen. Erst eine genaue Analyse des Ladungszustands der erzeugten Clusterionen erlaubt eine Interpretation der Ionenausbeutespektren als Röntgenabsorptionsspektren. Als Resultat konnten Größenabhängigkeiten in der 3*p*-Photoabsorption kleiner Vanadiumcluster im Größenbereich von $n = (21-50)$ mit einer Größenauflösung von $n \pm 1$ nachgewiesen werden. Dabei zeigen besonders die Ladungszustände der Clusterionen nach der 3*p*-Anregung eine deutliche Größenabhängigkeit. Der Vergleich mit dem Spektrum des neutralen Vanadiumatoms zeigt, dass die Spektren der kleineren Cluster dem des Atoms ähnlicher sind als die der größeren Cluster.

A 10.7 Di 16:30 Poster C3

Angularly resolved photoelectron spectroscopy of Na clusters: Simple models — •Jan Huwer, Christof Bartels, Christian Hock, and Bernd v.Issendorff — Fakultät für Mathematik und Physik, Universität Freiburg, Stefan-Meier-Str. 21, 79104 Freiburg

Measurements of angularly resolved photoelectron spectra of negatively charged free sodium clusters ($n = 19 \ldots 147$) with ns-laser pulses ($\lambda = 290 \ldots 755$ nm) have been performed.

Energy-resolved photoelectron spectra of sodium clusters can be explained in the framework of the so-called Jellium model in most cases. In this model, the experimentally observed shell structure is explained by assuming that the atomic valence electrons can be treated as particles in an effective single-particle potential. The question is whether this one-particle picture also holds for excitation processes. If this was the case, the angular distributions could be calculated in analogy to one-electron atoms as shown by Bethe. The shape of the angular distributions can be reduced to one asymmetry parameter β, which only

depends on the radial transition matrix elements and the scattering phases of the outgoing partial waves.

By assuming single-particle potentials of box and Woods-Saxon type, β parameters have been calculated for the experimentally investigated states. As observed in the experiment, the angular distributions show a strong dependence on the excitation energy. Furthermore we identified some general characteristics of the angular distributions for different orbital momentum states.

A 10.8 Di 16:30 Poster C3

Ionization of Argon dimers in intense laser fields — •Birte Ulrich, Lutz Foucar, Zenghu Chang, Horst Schmidt-Böcking, and Reinhard Dörner — Institut für Kernphysik, Universität Frankfurt, Deutschland

The ionization mechanisms of dimers with synchrotron radiation via Interatomic Coulombic Decay and Two-Step-1 have been well studied in the last view years. In this experiment we investigate the double ionization of Argon dimers in ultrashort (30 fs) intense laser pulses.The COLTRIMS-technique allows us to measure all charged particles with 4 Pi angle and high accuracy. Thus we are able to reconstruct the initial momenta and deduce the angular distribution of coincident Ar+ pairs. The first results will be presented for circular and linear polarization.

A 10.9 Di 16:30 Poster C3

Heliumdimere untersucht in langsamen Stössen mit Ar^{2+} — •Jasmin Titze, Markus Schöffler, Hong-Keun Kim, Robert Grisenti, Lothar Schmidt, Nadine Neumann, Ottmar Jagutzki, Horst Schmidt-Böcking und Reinard Dörner — Johann Wolfgang Goethe-Universität, Frankfurt, Germany

Heliumdimere stellen das am weitesten gebundene atomare System dar; die Bindungslänge kann die von C60 übersteigen. In Stössen mit Ar^2+ bei Projektilenergien von 25 keV/u wurde die Zerfallsdynamik nach Elektroneneinfang (ein und zweifach) mittels der COLTRIMS-Technik (COLd Target Recoil Ion Momentum Spectroscopy) untersucht.

A 10.10 Di 16:30 Poster C3

Comparing Resonant 2p X-ray Absorption of Size-selected Cobalt Clusters on Cu(100) and in a Linear Paul Trap — •Vicente Zamudio-Bayer[1], Leif Glaser[2], Konstantin Hirsch[1], Philipp Klar[1], Andreas Langenberg[1], Fabian Lofink[1], Robert Richter[1], Jochen Rittman[1], Marlene Vogel[1], Wilfried Wurth[2], Thomas Möller[1], Bernd von Issendorff[3], and J. Tobias Lau[1] — [1]Technische Universität Berlin, Institut für Optik und Atomare Physik, EW 3-1, Hardenbergstraße 36, D-10623 Berlin — [2]Universität Hamburg, Institut für Experimentalphysik, Luruper Chaussee 149, D-22761 Hamburg — [3]Albert-Ludwigs-Universität Freiburg, Fakultät für Physik/FMF, Stefan-Meier-Straße 21, D-79104 Freiburg

Its element specificity makes resonant X-ray absorption spectroscopy an ideal tool to study deposited clusters at low coverage. At the $2p$ absorption edges of small, size-selected cobalt clusters on Cu(100), two separate sets of lines are observed which can be interpreted in terms of atomic-like multiplet splitting. For very small clusters ($n = 1, 2, 3$), these absorption lines show a strong size dependence. The size evolution of $2p$ X-ray absorption will be discussed in comparison to size-selected free cobalt clusters, recorded recently on mass selected cluster ions in a linear Paul trap at BESSY. Direct comparison of free and deposited clusters under well defined conditions allows to distinguish size-specific properties from cluster–substrate interaction effects. A shift to higher photon energies in deposited clusters indicates screening by substrate valence electrons.

A 10.11 Di 16:30 Poster C3

Ultrafast Dynamics of Neutral Sodium-Doped Water Clusters — •HongTao Liu, Jan Philippe Müller, Claus Peter Schulz, Christian Schröter, Nickolai Zhavoronkov, and Ingolf-Volker Hertel — Max-Born-Institute, Berlin, Germany

By doping pure water clusters with sodium atoms, the valence electron of sodium interacts with the dipole field of the water clusters. For $Na(H_2O)_n$ clusters with increasing size $n \geq 4$ the atomic 3s electron gets more and more detatched from the core atom, it becomes the well-known solvated electron in the bulk water [1].

One topic of our research is the lifetime of the lowest electronically excited state. Previous works in our group have shown, that the lifetimes strongly decreases for larger n [2]. For $n \geq 4$ they are on the order of 100 fs and lower. Similar results have been obtained for negatively charged pure water clusters [3, 4]. This short lifetimes are presumably provoked by fast internal conversion, which is strongly correlated to the DOS of the vibrons [2]. To resolve the lifetime for larger clusters $n \leq 20$ two colour pump-probe spectroscopy (800/ 400 nm) with 30 fs pulses has been used and will be discussed in this contribution.

[1] C.P. Schulz, C. Bobbert, T. Shimosato, K. Daigoku, N. Miura, K. Hashimoto, J. Chem. Phys. **119** (2003) 11620
[2] C.P. Schulz, A. Scholz, I.V. Hertel, Isr. J. Chem **44** (2004) 19
[3] J.R.R. Verlet, A.E. Bragg, A. Kammrath, O. Cheshnovski, D.M. Neumark, Science **307** (2005) 93
[4] A.E. Bragg, J.R.R. Verlet, A. Kammrath, O. Cheshnovski, D.M. Neumark, J. Am. Chem. Soc.**127** (2005) 15283

A 10.12 Di 16:30 Poster C3

Photoelectron spectroscopy of oxidized sodium clusters — •Kiran Majer and Bernd von Issendorff — Department of Physics, University of Freiburg, Stefan-Meier-Straße 21, 79104 Freiburg

The electronic structure of medium sized sodium dioxide clusters ($Na_nO_2^-$, n: number of sodium atoms) was investigated by photoelectron spectroscopy (PES). For cluster sizes containing up to 62 sodium atoms, the PES show comparable features (e.g. appearance of a new electronic shell) like for pure sodium clusters, but shifted in size by 4 sodium atoms towards bigger sizes. In the Jellium model picture, this can be explained by the localization of four electrons by the oxygen atoms.

This shift can not be found for bigger clusters with $n \geq 92$. In particular the electronic magic number 92 seems to be reached at the $Na_{93}O_2^-$ cluster, implying that the oxygen locates only 2 delocalized electrons.

The aim of the study was to find more information about the electronic and geometric structure of the oxidized cluster, as well as how it is influenced by the dopant.

A 10.13 Di 16:30 Poster C3

Clusters in Helium Droplets: Delaying the Coulomb Explosion in XFEL Pulses — •Christian Gnodtke, Ulf Saalmann, and Jan-Michael Rost — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Straße 38, 01187 Dresden

In the context of atomic resolution, coherent diffractive imaging of non-periodic samples as suggested by Neutze et al. [1] we have simulated the explosion dynamics of rare-gas clusters embedded in Helium droplets and exposed to an intense XFEL (X-Ray Free Electron Laser) pulse. We find that the Coulomb explosion of the sample, which is the main limiting factor for this imaging technique, is significantly delayed in comparison to the case without Helium. Using quantum-mechanical transition rates for K-shell photo-ionization and Auger-decay, which are the main damage processes, combined with a molecular dynamics simulation of free electrons and ions we calculate the laser-induced dynamics of Ar_N and Ne_N clusters, with N=55-500, and assess the decline of image quality with longer pulse lengths. We find that, embedded in a Helium droplet, the positive charge that builds up in the cluster through photo-ionization and Auger-decay is efficiently transferred to the Helium shell by ionization of the Helium atoms in the Coulomb field of the charged cluster. The Helium shell then explodes while the cluster ions are efficiently screened from each other by the electrons originating from the Helium droplet, thus enhancing the stability of the cluster and improving the overall image quality in an imaging experiment.

[1] R. Neutze et al., Nature **406**, 752 (2000)

A 10.14 Di 16:30 Poster C3

Elektronische Struktur endohedral dotierter Siliziumcluster aus resonanter Röntgenabsorptionsspektroskopie — •Philipp Klar[1], Konstantin Hirsch[1], Andreas Langenberg[1], Fabian Lofink[1], Robert Richter[1], Jochen Rittmann[1], Marlene Vogel[1], Vicente Zamudio-Bayer[1], Bernd von Issendorff[2], Thomas Möller[1] und Tobias Lau[1] — [1]Technische Universität Berlin, Institut für Optik und Atomare Physik, Hardenbergstraße 36, D-10623 Berlin — [2]Albert-Ludwigs-Universität Freiburg, Fakultät für Physik/FMF, Stefan-Meier-Straße 21, D-79104 Freiburg

Durch dotieren mit einem Übergangsmetallatom können Siliziumcluster in Käfigstrukturen stabilisiert werden. Um die Frage der Bindungsverhältnisse am Dotierungsatom zu klären, wurden VSi_n^+-Cluster elementspezifisch mit resonanter 2p-Röntgenabsorptionssektroskopie an der Synchrotronstrahlungsquelle BESSY untersucht. Dabei wurden die Cluster in einer Magnetronsputterquelle erzeugt und zur Spektroskopie in einer gekühlten Ionenfalle gespeichert. Es zeigt sich, dass das

Dotierungsatom in einem magischen VSi_{16}^+-Cluster ein strukturreiches Röntgenabsorptionsspektrum besitzt, dass deutlich von dem des freien Ions abweicht. Die Spektren magischer und nichtmagischer endohedraler Siliziumcluster werden verglichen und daraus Rückschlüsse auf die elektronische Struktur gezogen.