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**[2007-008T] SONOLISE**

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Porteur : **Philippe Delaye**

Thème 7

### **Fourier transformed picosecond synchronously pumped optical parametric oscillator without spectral filtering element**

*Article publié en 2008*

Auteurs : Ryasnyanskiy A, Dubreuil N, Philippe Delaye , Frey R, Roosen G

Réf. : JOURNAL OF THE EUROPEAN OPTICAL SOCIETY-RAPID PUBLICATIONS 3 (2008) 08037

An optical parametric oscillator for the infrared region pumped by a picosecond Ti:Sapphire laser is demonstrated. Fourier transform limited pulses of 15 and 10 ps, for signal and idler wavelengths respectively, have been obtained using a periodically poled stoichiometric lithium tantalate nonlinear crystal, without any spectral filtering. A complete experimental study of the influence of the cavity length detuning on the spectral and temporal dynamic of the output radiation is discussed.

### **Light localization induced enhancement of third order nonlinearities in a GaAs photonic crystal waveguide**

*Article publié en 2009*

Auteurs : Baron A, Ryasnyanskiy A, Dubreuil N, Delaye, Tran QV, Combrie S, de Rossi A, Frey R, Roosen G

Réf. : OPTICS EXPRESS 17 (2009)

Nonlinear propagation experiments in GaAs photonic crystal waveguides (PCW) were performed, which exhibit a large enhancement of third order nonlinearities, due to light propagation in a slow mode regime, such as two-photon absorption (TPA), optical Kerr effect and refractive index changes due to free-carriers generated by TPA. A theoretical model has been established that shows a very good quantitative agreement with experimental data and demonstrates the important role that the group velocity plays. These observations give a strong insight into the use of PCWs for optical switching devices. (C) 2008 Optical Society of America

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**[2007-010T] EMACSE**

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Porteur : **Catalin Miron**

Thème 2

### **High-resolution inner-shell coincidence spectroscopy**

*Article publié en 2009*

Auteurs : Catalin Miron , Paul Morin

Réf. : Nuclear Instruments and Methods in

Physics Research A, VOL. 601, p 66-77 (2009).

The present review article gives a historical overview of high-resolution inner-shell coincidence spectroscopies followed by selected examples showing their scientific impact in studying molecular fragmentation dynamics. The development of such spectroscopies was intimately related to the last 20 years spectacular advances of the instrumentation. They include the construction of high-performance soft X-ray beamlines at the newest synchrotron radiation facilities, but also the remarkable improvement of charged particles analyzers and detectors and the extensive use of multidimensional coincidence techniques allowing for simultaneous recording

and further correlation of several physical parameters. From the examples shown, it clearly appears the importance of using coincidence measurements in addition to pure electron spectroscopy methods in order to fully characterize the complex decay processes of inner-shell excited species leading for instance to site-selective fragmentation, vibrational motion mediated dissociation or ultrafast intramolecular recombination processes. The perspectives of the field will be briefly drawn in the end.

### Resonant Auger decay study of C1s $\rightarrow$ $\pi^*$ core-excited OCS

Article publié en 2009

**Auteurs** : Travnikova, O. Catalin Miron. Bassler, M. Feifel, R. Piancastelli, MN. Sorensen, SL.Svensson, S

Réf. : JOURNAL OF ELECTRON SPECTROSCOPY AND RELATED PHENOMENA 174 (2009) 100-106

The present work aims at characterizing short-lived C1s((-1))  $\pi^*$ ((1)) core-excited states of the OCS molecule based on the analysis of the vibrational fine structure and lineshape profiles of the high-resolution resonant Auger decay spectra recorded at the excitation energies along the C1s  $\rightarrow$   $\pi^*$  resonance in the binding energy region 15-19eV. Very different behavior in terms of lineshape and resonant enhancement is observed for the (A) over tilde, (B) over tilde and (C) over tilde final states. This is explained by (1) the variation in the C-O bond lengths for the states involved in the electronic relaxation and (2) different contributions in terms of Mulliken population to the molecular orbitals determining the electronic character of the corresponding states. Since the final-state geometries are known from a number of previous experiments and ab initio calculations, the geometry of the C1s((-1))  $\pi^*$ ((1)) intermediate states can be predicted in analogy with e.g. the N-2, CO2 and N2O molecules. (C) 2009 Elsevier B.V. All rights reserved.

### Selective vibrational excitation in the resonant Auger decay following core-to- $\pi^*$ transitions in N2O

Article publié en 2010

**Auteurs** : O. Travnikovaa,b,\*, D. Céolinc, Z. Baob, K.J. Børved, T. Tanakae, M. Hoshinoe, H. Katoe, H. Tanakae,

J.R. Harriesf, Y. Tamenorif, G. Prümperg, T. Lischkeg, X.-J. Liug, M.N. Piancastelli b, K. Uedag

Réf. : Journal of Electron Spectroscopy and Related Phenomena 181 (2010) 129–134

In N2O a detailed study of the vibrational distribution of the  $\tilde{X}$  state reached after decay of core-to- $\pi^*$  excitation of N terminal, N central and O 1s core levels is reported. We observe a change in the relative intensity of bending versus stretching modes while scanning the photon energy across all three resonances. While this effect is known to be due to the Renner–Teller splitting in the core-excited states, we could derive that the antisymmetric stretching is excited mainly in the decay of the N terminal 1s-to- $\pi^*$  excitation. An explanation for such selectivity is provided in terms of interplay of vibrational structure on potential energy surfaces of different electronic states involved in the process.

### Vibrational Scattering Anisotropy Generated by Multichannel Quantum Interference

Article publié en 2010

**Auteurs** : Catalin Miron. Kimberg, V. Morin, P. Nicolas, C. Kosugi, N. Gavriyuk, S. Gel'mukhanov, F

Réf. : PHYSICAL REVIEW LETTERS 105 (2010) 093002

Based on angularly and vibrationally resolved electron spectroscopy measurements in acetylene, we report the first observation of anomalously strong vibrational anisotropy of resonant Auger scattering through the C 1s  $\rightarrow$   $\pi^*$  excited state. We provide a theoretical model explaining the new phenomenon by three coexisting interference effects: (i) interference between resonant and direct photoionization channels, (ii) interference of the scattering channels through the core-excited bending states with orthogonal orientation of the molecular orbitals, (iii) scattering through two wells of the double-well bending mode potential. The interplay of nuclear and electronic motions offers in this case a new type of nuclear wave packet interferometry sensitive to the

anisotropy of nuclear dynamics: whether which-path information is available or not depends on the final vibrational state serving for path selection.

## Circularly Polarized X Rays: Another Probe of Ultrafast Molecular Decay Dynamics

*Article publié en 2010*

**Auteurs:** Travnikova, O; Liu, JC; Lindblad, A; Nicolas, C; Soderstrom, J; Kimberg, V; Gel'mukhanov, F; Catalin Miron

Réf. : PHYSICAL REVIEW LETTERS 105 2010 233001

Dissociative nuclear motion in core-excited molecular states leads to a splitting of the fragment Auger lines: the Auger-Doppler effect. We present here for the first time experimental evidence for an Auger-Doppler effect following F1s  $\rightarrow$  a(1g)\* inner-shell excitation by circularly polarized x rays in SF<sub>6</sub>. In spite of a uniform distribution of the dissociating S-F bonds near the polarization plane of the light, the intersection between the subpopulation of molecules selected by the core excitation with the cone of dissociation induces a strong anisotropy in the distribution of the S-F bonds that contributes to the scattering profile measured in the polarization plane.

## Angle-resolved electron spectroscopy of the resonant Auger decay in xenon with meV energy resolution

*Article publié en 2011*

**Auteurs:** Soderstrom, J; Lindblad, A; Grum-Grzhimailo, AN; Travnikova, O; Nicolas, C; Svensson, S; Catalin Miron

Réf. : NEW JOURNAL OF PHYSICS 13 10.1088/1367-2630/13/7/073014 JUL 11 2011

The angle-resolved resonant Auger spectrum of Xe is investigated with a record high meV energy resolution in the kinetic energy region of 34.45-39.20 eV at  $h\nu = 65.110$  eV, corresponding to the resonant excitation of the Auger Xe\* 4d(5/2)(-1)6p state. New lines have been observed and assigned in the spectra. The results of previous measurements concerning energies, intensities and angular distribution asymmetry parameters have been refined, complemented and, for some of the lines, corrected.

## Experimental Observation of Rotational Doppler Broadening in a Molecular System

*Article publié en 2011*

**Auteurs:** Thomas, TD; Kukk, E; Ueda, K; Ouchi, T; Sakai, K; Carroll, TX; Nicolas, C; Travnikova, O; Catalin Miron

Réf. : PHYSICAL REVIEW LETTERS 106 (19): Art. No. 193009 MAY 13 2011

The first experimental evidence of rotational Doppler broadening in photoelectron spectra, reported here, show good agreement with recently described theoretical predictions. The dependence of the broadening on temperature and photoelectron kinetic energy is quantitatively predicted by the theory. The experiments verify that the rotational contributions to the linewidth are comparable to those from translational Doppler broadening and must be considered in the analysis of high-resolution photoelectron spectra. A classical model accounting for this newly observed effect is presented.

## Imaging molecular potentials using ultrahigh resolution resonant photoemission

*Article publié en 2011*

**Auteurs:** Miron C, Nicolas C, Travnikova O, Morin P, Sun Y, Gel'mukhanov F, Kosugi N, Kimberg V

Réf. : Nature Physics (2011) doi:10.1038/nphys2159, Published online 4 December 2011

Electron-density distributions and potential-energy surfaces are important for predicting the physical properties and chemical reactivity of molecular systems. Whereas angle-resolved photoelectron spectroscopy enables the

reconstruction of molecular-orbital densities of condensed species<sup>1</sup>, absorption or traditional photoelectron spectroscopy are widely employed to study molecular potentials of isolated species. However, the information they provide is often limited because not all vibrational substates are excited near the vertical electronic transitions from the ground state. Moreover, many electronic states cannot be observed owing to selection rules or low transition probabilities. In many other cases, the extraction of the potentials is impossible owing to the high densities of overlapping electronic states. Here we use resonant photoemission spectroscopy, where the absence of strict dipole selection rules in Auger decay enables access to a larger number of final states as compared with radiative decay. Furthermore, by populating highly excited vibrational substates in the intermediate core-excited state, it is possible to 'pull out' molecular states that were hidden by overlapping spectral regions before.

### Multimode Resonant Auger Scattering from the Ethene Molecule

*Article publié en 2011*

**Auteurs :** Liu, JC; Nicolas, C; Sun, YP; Flammini, R; O'Keeffe, P; Avaldi, L; Morin, P; Kimberg, V; Kosugi, N; Gel'mukhanov, F; Catalin Miron

Réf. : JOURNAL OF PHYSICAL CHEMISTRY B 115 (18): 5103-5112 MAY 12 2011

Resonant Auger spectra of ethene molecule have been measured with vibrational resolution at several excitation energies in the region of the C1s(-1)1b(2g)(pi\*) resonance. The main features observed in the experiment have been assigned and are accurately interpreted on the basis of ab initio multimode calculations. Theory explains the extended vibrational distribution of the resonant Auger spectra and its evolution as a function of the excitation energy by multimode excitation during the scattering process. As a result, the resonant Auger spectra display two qualitatively different spectral features following the Raman and non-Raman dispersion laws, respectively. Calculations show that two observed thresholds of formation of non-Raman spectral bands are related to the "double-edge" structure of the X-ray absorption spectrum.

### High-resolution Inner-shell Photoionization, Photoelectron and Coincidence Spectroscopy

*Article publié en 2011*

**Auteurs :** Catalin Miron , Paul Morin

Réf. : Handbook of High-Resolution Spectroscopy, Vol 3, Edited by M. Quack and F. Merkt, ISBN: 978-0-470-06653-9, John Wiley & Sons, Ltd, Chichester, UK, p. 1655-1690 (2011).

This article gives an overview of high-resolution photoionization, photoelectron, and coincidence spectroscopies of inner-shell excited species of increasing complexity ranging from atoms to nanoparticles. The development and the routine use of soft X-ray techniques is intimately related to the spectacular advances in instrumentation in the last twenty years. These concern not only the construction and operation of high-performance soft X-ray beamlines at several synchrotron radiation laboratories around the world but also the remarkable improvement in charged particle analyzers and detectors (detection efficiency, resolution) and the extensive use of multidimensional coincidence techniques that allows simultaneous acquisition and further correlation of several physical parameters. From the examples we have chosen to present, it is apparent that inner-shell ionization studies are not limited anymore by the lifetime broadening effects and that a deep and unique insight into ultrafast dynamics is possible. Various examples are shown of both pure high-resolution photoionization and electron spectroscopies together with more sophisticated techniques such as the electron-ion coincidence measurements with energy and angle resolution. A prospective view of the field is given in the end. In particular, the expectations from the next-generation ultrahigh brilliance X-ray sources such as energy recovery linacs or free electron lasers are briefly tackled.



## The ESCA molecule-Historical remarks and new results

Article publié en 2012

**Auteurs:** Travnikova, Oksana; Borve, Knut J.; Patanen, Minna; Soderstrom, Johan; Miron, Catalin; Saethre, Leif J.; Martensson, Nils; Svensson, Svante

Réf. : JOURNAL OF ELECTRON SPECTROSCOPY AND RELATED PHENOMENA Volume: 185 Issue: 8-9 Special Issue: SI Pages: 191-197 DOI: 10.1016/j.elspec.2012.05.009 Published: SEP 2012

The C 1s photoelectron spectrum of ethyl trifluoroacetate (CF<sub>3</sub>-CO-O-CH<sub>2</sub>-CH<sub>3</sub>), also known as the 'ESCA molecule', is the most illustrative showcase of chemical shifts in photoelectron spectroscopy. The binding energies of the four carbon atoms of this molecule spread over more than 8 eV with energy separations ranging from 1.7 to 3.1 eV owing to different chemical environments and hence different charge states of these atoms. The paper discusses history and importance of this spectrum in the field of photoelectron spectroscopy starting from the time of invention of the ESCA technique. The main focus of the paper is a 'revisit' of this spectrum using the most modern experimental and computational tools. Large geometrical changes, different for each ionization site, and the presence of two conformers of ethyl trifluoroacetate influence the spectral lineshapes of all four C 1s lines. These effects are carefully modeled by theory and investigated in the experimental spectrum. (C) 2012 Elsevier B.V. All rights reserved.

## Nonstoichiometric Intensities in Core Photoelectron Spectroscopy

Article publié en 2012

**Auteurs:** Soderstrom J.; Martensson N.; Travnikova O.; et al.

Réf. : PHYSICAL REVIEW LETTERS Volume: 108 Issue: 19 Article Number: 193005 DOI: 10.1103/PhysRevLett.108.193005 Published: MAY 11 2012

X-ray photoemission spectroscopy is used in a great variety of research fields; one observable is the sample's stoichiometry. The stoichiometry can be deduced based on the expectation that the ionization cross sections for inner-shell orbitals are independent of the molecular composition. Here we used chlorine-substituted ethanes in the gas phase to investigate the apparent carbon stoichiometry. We observe a nonstoichiometric ratio for a wide range of photon energies, the ratio exhibits x-ray-absorption fine structure spectroscopy (EXAFS)-like oscillations and hundreds of eV above the C1s ionization approaches a value far from 1. These effects can be accounted for by considering the scattering of the outgoing photoelectron, which we model by multiple-scattering EXAFS calculations, and by considering the effects of losses due to monopole shakeup and shakeoff and to intramolecular inelastic scattering processes.

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## [2007-017T] QUANTGRA

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**Porteur :** Hélène Bouchiat

Thème 1

## Conductance Fluctuations and Field Asymmetry of Rectification in Graphene

Article publié en 2010

**Auteurs:** Ojeda-Aristizabal, C. Monteverde, M. Weil, R. Ferrier, M. Gueron, S. Hélène Bouchiat

Réf. : PHYSICAL REVIEW LETTER 104 (2010) 186802

We investigate conductance fluctuations as a function of carrier density  $n$  and magnetic field in diffusive mesoscopic samples made from monolayer and bilayer graphene. We show that the fluctuations' correlation energy and field, which are functions of the diffusion coefficient, have fundamentally different variations with  $n$ , illustrating the contrast between massive and massless carriers. The field dependent fluctuations are nearly independent of  $n$ , but the  $n$ -dependent fluctuations are not universal and are largest at the charge neutrality point.

We also measure the second-order conductance fluctuations ( mesoscopic rectification). Its field asymmetry, due to electron-electron interaction, decays with conductance, as predicted for diffusive systems.

## Transport and Elastic Scattering Times as Probes of the Nature of Impurity Scattering in Single-Layer and Bilayer Graphene

*Article publié en 2010*

Auteurs : Monteverde, M. Ojeda-Aristizabal, C. Weil, R. Bennaceur, K. Ferrier, M. Gueron, S. Glattli, C. Hélène Bouchiat. Julien FuchsN.Maslov, DL

Réf. : PHYSICAL REVIEW LETTERS 104 (2010) 126801

Transport and elastic scattering times,  $\tau(\text{tr})$  and  $\tau(\text{e})$ , are experimentally determined from the carrier density dependence of the magnetoconductance of monolayer and bilayer graphene. Both times and their dependences on carrier density are found to be very different in the monolayer and the bilayer. However, their ratio  $\tau(\text{tr})/\tau(\text{e})$  is found to be close to 1.8 in the two systems and nearly independent of the carrier density. These measurements give insight on the nature (neutral or charged) and range of the scatterers. Comparison with theoretical predictions suggests that the main scattering mechanism in our samples is due to strong (resonant) scatterers of a range shorter than the Fermi wavelength, likely candidates being vacancies, voids, adatoms or short-range ripples.

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## [2007-020T] SOLAMU

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Porteur : JM Mestdagh

Thème 2

## Unusual Quantum Interference in the S(1) State of DABCO and Observation of Intramolecular Vibrational Redistribution

*Article publié en 2010*

Auteurs : L Poisson, R Maksimenska, B Soep, JM Mestdagh, DH Parker, M Nsangou, M Hochlaf

Réf. : JOURNAL OF PHYSICAL CHEMISTRY A Volume: 114 Issue: 9 Pages: 3313-3319 DOI: 10.1021/jp909464t Published: MAR 11 2010

In this paper we report an experimental study of the time-resolved response of the molecule 1,4-diazabicyclo[2.2.2]octane (DABCO) to 266.3 nm electronic excitation of the S(1) state with a femtosecond laser. Rotational decoherence and vibrational oscillation within the S(1) state are observed. We performed state-of-the-art ab initio calculations on the ground and low electronic states of the neutral molecule and the cation, which assist in the assignment of the observed photoelectron signals. Using our theoretical and spectroscopic data, the experimental findings are interpreted in terms of an unusual quantum interference between two different vibrational modes, with only the  $v = 1$  level of each mode being populated.

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## [2007-025T] Dichromol

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Porteur : A. Zehnaker-Rentien

Thème 2

### Conformational Analysis of Quinine and Its Pseudo Enantiomer Quinidine: A Combined Jet-Cooled Spectroscopy and Vibrational Circular Dichroism Study

*Article publié en 2012*

Auteurs : Sen, Ananya; Bouchet, Aude; Lepere, Valeria; Le Barbu-Debus, Katia; Scuderi, D.; Piuze, F.; Zehnacker-Rentien, A.

Réf. : JOURNAL OF PHYSICAL CHEMISTRY A Volume: 116 Issue: 32 Pages: 8334-8344 DOI: 10.1021/jp3047888 Published: AUG 16 2012

Laser-desorbed quinine and quinidine have been studied in the gas phase by combining supersonic expansion with laser spectroscopy, namely, laser-induced fluorescence (LIF), resonance-enhanced multiphoton ionization (REMPI), and IR-UV double resonance experiments. Density functional theory (DFT) calculations have been done in conjunction with the experimental work. The first electronic transition of quinine and quinidine is of  $\pi\text{-}\pi^*$  nature, and the studied molecules weakly fluoresce in the gas phase, in contrast to what was observed in solution (Qin, W. W.; et al. J. Phys. Chem. C 2009, 113, 11790). The two pseudo enantiomers quinine and quinidine show limited differences in the gas phase; their main conformation is of open type as it is in solution. However, vibrational circular dichroism (VCD) experiments in solution show that additional conformers exist in condensed phase for quinidine, which are not observed for quinine. This difference in behavior between the two pseudo enantiomers is discussed.

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## [2007-028T] APPEAL

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Porteur : Philippe Martin

Thème 2

### Controlling the Phase-Space Volume of Injected Electrons in a Laser-Plasma Accelerator

*Article publié en 2009*

Auteurs : Rechatin, C. Faure, J. Ben-Ismaïl, A. Lim, J. Fitour, R. Specka, A. Videau, H. Tafzi, A. Burgy, F. Malka, V

Réf. : PHYSICAL REVIEW LETTERS 102 (2009) 164801

To take full advantage of a laser-plasma accelerator, stability and control of the electron beam parameters have to be achieved. The external injection scheme with two colliding laser pulses is a way to stabilize the injection of electrons into the plasma wave, and to easily tune the energy of the output beam by changing the longitudinal position of the injection. In this Letter, it is shown that by tuning the optical injection parameters, one is able to control the phase-space volume of the injected particles, and thus the charge and the energy spread of the beam. With this method, the production of a laser accelerated electron beam of 10 pC at the 200 MeV level with a 1% relative energy spread at full width half maximum (3.1% rms) is demonstrated. This unique tunability extends the capability of laser-plasma accelerators and their applications.

## Observation of Beam Loading in a Laser-Plasma Accelerator

Article publié en 2009

**Auteurs :** Rechatin C, Davoine X, Lifschitz A, Ben Ismail A, Lim J, Lefebvre E, Faure J, Malka V

Réf. : PHYSICAL REVIEW LETTERS 103 (2009) 194804

Beam loading is the phenomenon which limits the charge and the beam quality in plasma based accelerators. An experimental study conducted with a laser-plasma accelerator is presented. Beam loading manifests itself through the decrease of the beam energy, the reduction of dark current, and the increase of the energy spread for large beam charge. 3D PIC simulations are compared to the experimental results and confirm the effects of beam loading. It is found that, in our experimental conditions, the trapped electron beams generate decelerating fields on the order of 1 (GV/m)/pC and that beam loading effects are optimized for trapped charges of about 20 pC.

## Physics of colliding laser pulses in underdense plasmas

Article publié en 2009

**Auteurs :** Faure, J. Rechatin, C. Ben-Ismaïl, A. Lim, J. Davoine, X. Lefebvre, E. Malka, V

Réf. : COMPTES RENDUS PHYSIQUE 10 (2009) 148-158 H85

We report on recent experimental results on electron acceleration using two counter-propagating ultrashort and ultraintense laser pulses. At the collision, the two pulses drive a standing wave which is able to pre-accelerate plasma electrons which can then be trapped in the plasma wave. Optical diagnostics of the collision reveal signatures of this standing wave. Electron acceleration results in this regime are reviewed: the use of colliding pulses enables the generation of stable, tunable and high quality electron beams at the 100-200 MeV level. Detailed comparisons with 3D Particle in Cell (PIC) simulations give deeper insight on the role of the nonlinear propagation of the pump pulse on the performance of the accelerator. This deeper understanding has allowed us to optimize the beam charge of the accelerator at high energy. To cite this article: J. Faure et al., C R. Physique 10 (2009). (C) 2009 Academie des sciences. Published by Elsevier Masson SAS. All rights reserved.

## Characterization of the beam loading effects in a laser plasma accelerator

Article publié en 2010

**Auteurs :** Rechatin C, Faure J, Davoine X, Lundh O, Lim J, Ben-Ismaïl A, Burgy F, Tafzi A, Lifschitz A, Lefebvre E, Malka V

Réf. : NEW JOURNAL OF PHYSICS 12 (2010) 045023

In this study, electrons were injected into a laser plasma accelerator using colliding laser pulses. By varying the parameters of the injection laser pulse, the amount of charge accelerated in the plasma wave could be controlled. This external control of the injected load was used to investigate beam loading of the accelerating structure and especially its influence on the electron beam energy and energy spread. Information on the accelerating structure and bunch duration was then derived from these experimental observations.

## Influence of the Weibel instability on the expansion of a plasma slab into a vacuum

Article publié en 2010

**Auteurs :** Thauray, C. Mora, P. Heron, A. Adam, JC. Antonsen, TM

Réf. : PHYSICAL REVIEW E 82 (2010) 026408 Part 2

The development of the Weibel instability during the expansion of a thin plasma foil heated by an intense laser pulse is investigated, using both analytical models and relativistic particle-in-cell simulations. When the plasma has initially an anisotropic electron distribution, this electromagnetic instability develops from the beginning of the expansion. Then it contributes to suppress the anisotropy and eventually saturates. After the saturation, the strength of the magnetic field decreases because of the plasma expansion until it becomes too weak to maintain the distribution isotropic. For this time, the anisotropy rises as electrons give progressively their longitudinal energy to ions, so that a new instability can develop.

## Radiation generated by bunched electron beams in corrugated plasma channels

Article publié en 2010

Auteurs : Antonsen, TM

Réf. : PHYSICS OF PLASMAS 17 (2010) 073112

The excitation of radiation by bunched electron beams propagating in miniature corrugated plasma channels is considered. It is shown that the rate at which power is radiated by a beam is characterized by impedance that depends on the properties of the channel. For experimentally obtainable parameters radiation bursts of multiple millijoules can be achieved. The spectrum of the radiation can be made narrow and controlled through the properties of the channel. The effects of spatial variations in the channel parameters on the spectrum are also described. (C) 2010 American Institute of Physics. [doi:10.1063/1.3431089]

## Electron acceleration by laser wakefield and x-ray emission at moderate intensity and density in long plasmas

Article publié en 2011

Auteurs : Ferrari H. E.; Lifschitz A. F.; Maynard G.; et al.

Réf. : PHYSICS OF PLASMAS Volume: 18 Issue: 8 Article Number: 083108 DOI: 10.1063/1.3624771  
Published: AUG 2011

The dynamics of electron acceleration by laser wakefield and the associated x-rays emission in long plasmas are numerically investigated for parameters close to the threshold of laser self-focusing. The plasma length is set by the use of dielectric capillary tubes that confine the gas and the laser energy. Electrons self-injection and acceleration to the 170 MeVs are obtained for densities as low as  $5 \times 10^{18} \text{ cm}^{-3}$  and a moderate input intensity ( $0.77 \times 10^{18} \text{ W/cm}^2$ ). The associated x-ray emission at the exit of the capillary tube is shown to be an accurate diagnostic of the electrons self-injection and acceleration process. (C) 2011 American Institute of Physics. [doi: 10.1063/1.3624771]

## Laser-plasma electron acceleration in dielectric capillary tubes

Article publié en 2011

Auteurs : Genoud G.; Cassou K.; Wojda F.; et al.

Réf. : APPLIED PHYSICS B-LASERS AND OPTICS Volume: 105 Issue: 2 Pages: 309-316 DOI: 10.1007/s00340-011-4639-4  
Published: NOV 2011

Electron beams and betatron X-ray radiation generated by laser wakefield acceleration in long plasma targets are studied. The targets consist of hydrogen filled dielectric capillary tubes of diameter 150 to 200 microns and length 6 to 20 mm. Electron beams are observed for peak laser intensities as low as  $5 \times 10^{17} \text{ W/cm}^2$ . It is found that the capillary collects energy outside the main peak of the focal spot and contributes to keep the beam self-focused over a distance longer than in a gas jet of similar density. This enables the pulse to evolve enough to reach the threshold for wavebreaking, and thus trap and accelerate electrons. No electrons were observed for capillaries of large diameter (250  $\mu\text{m}$ ), confirming that the capillary influences the interaction and does not have the same behaviour as a gas cell. Finally, X-rays are used as a diagnostic of the interaction and, in particular, to estimate the position of the electrons trapping point inside the capillary.

## Modelling of laser-plasma electron acceleration in capillary tubes

Article publié en 2011

Auteurs : Ferrari HE , Lifschitz AF , Cros B

Réf. : PLASMA PHYSICS AND CONTROLLED FUSION 53 (2011) 014005

Modelling of electron acceleration driven by laser wakefield in centimetre-long capillary tubes was performed and compared with experimental results. Simulations using the WAKE code (Mora and Antonsen 1997 Phys.

Plasma 4 217) were compared with the results of the 3D particle-in-cell CALDER-CIRC code (Lifschitz et al 2009 J. Comput. Phys. 228 1803). The results give some insight into the role of guiding to achieve electron energies of the order of 250 MeV with modest input laser intensities (similar to  $0.77 \times 10^{18}$  W cm<sup>-2</sup>) and low plasma densities ( $n = 5 \times 10^{18}$  cm<sup>-3</sup>).

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## [2007-030T] LASELYSE

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**Porteur :** Jean-Louis Marignier

Axe A

### Time-Dependent Radiolytic Yield of OH(center dot) Radical Studied by Picosecond Pulse Radiolysis

Article publié en 2011

**Auteurs :** El Omar Abdel Karim; Schmidhammer Uli; Jeunesse Pierre; et al.

Réf. : JOURNAL OF PHYSICAL CHEMISTRY A Volume: 115 Issue: 44 Pages: 12212-12216 DOI: 10.1021/jp208075v Published: NOV 10 2011

Picosecond pulse radiolysis measurements using a pulse-probe method are performed to measure directly the time-dependent radiolytic yield of the OH(center dot) radical in pure water. The time-dependent absorbance of OH(center dot) radical at 263 nm is deduced from the observed signal by subtracting the contribution of the hydrated electron and that of the irradiated empty fused silica cell which presents also a transient absorption. The time-dependent radiolytic yield of OH(center dot) is obtained by assuming the yield of the hydrated electron at 20 ps equal to  $4.2 \times 10^{-7}$  mol J<sup>-1</sup> and by assuming the values of the extinction coefficients of e(aq)(-) and OH(center dot) at 782 nm ( $\epsilon(\lambda=782 \text{ nm}) = 17025 \text{ M}^{-1} \text{ cm}^{-1}$ ) and at 263 nm ( $\epsilon(\lambda=263 \text{ nm}) = 460 \text{ M}^{-1} \text{ cm}^{-1}$ ), respectively. The value of the yield of OH(center dot) radical at 10 ps is found to be  $(4.80 \pm 0.12) \times 10^{-7}$  mol J<sup>-1</sup>.

### Picosecond Pulse Radiolysis of Direct and Indirect Radiolytic Effects in Highly Concentrated Halide Aqueous Solutions

Article publié en 2011

**Auteurs :** Balcerzyk Anna; Schmidhammer Uli; El Omar Abdel Karim; et al.

Réf. : JOURNAL OF PHYSICAL CHEMISTRY A Volume: 115 Issue: 33 Pages: 9151-9159 DOI: 10.1021/jp203609e Published: AUG 25 2011

Recently we measured the amount of the single product, Br(3)(-), of steady-state radiolysis of highly concentrated Br(-) aqueous solutions, and we showed the effect of the direct ionization of Br(-) on the yield of Br(3)(-). Here, we report the first picosecond pulse-probe radiolysis measurements of ionization of highly concentrated Br(-) and Cl(-) aqueous solutions to describe the oxidation mechanism of the halide anions. The transient absorption spectra are reported from 350 to 750 nm on the picosecond range for halide solutions at different concentrations. In the highly concentrated halide solutions, the solvated electron is shifted to shorter wavelengths, but its decay, as observed that, due to the presence of Na(+), the absorption band of taking place during the spur reactions, is not affected within the first 4 ns. The kinetic measurements in the UV reveal the direct ionization of halide ions. The analysis of pulse-probe measurements show that after the electron pulse, the main reactions in solutions containing 1 M of Cl(-) and 2 M of Br(-) are the formation of ClOH(center dot) and BrOH(center dot), respectively. In contrast, in highly concentrated halide solutions, containing 5 M of Cl(-) and 6 M of Br(-), mainly Cl(2)(center dot) and Br(2)(center dot) are formed within the electron pulse without formation of ClOH(center dot) and BrOH(center dot). The results suggest that, not only Br(-) and Cl(-) are directly ionized into Br(center dot) and Cl(center dot) by the electron pulse, the halide atoms can also be rapidly generated through the reactions initiated by excitation and ionization of water, such as the prompt oxidation by the hole, H(2)O(+center dot), generated in the coordination sphere of the anion.

**[2007-033T] AVISHAI****Porteur : Gilles Montambaux****Axe B****Tuning phase transition between quantum spin Hall and ordinary insulating phases***Article publié en 2007***Auteurs :** Murakami Shuichi; Iso Satoshi; Avishai Yshai; et al.

Réf. : PHYSICAL REVIEW B Volume: 76 Issue: 20 Article Number: 205304 DOI: 10.1103/PhysRevB.76.205304 Published: NOV 2007

An effective theory is constructed for analyzing a generic phase transition between the quantum spin Hall and the insulator phases. Occurrence of degeneracies due to closing of the gap at the transition are carefully elucidated. For systems without inversion symmetry the gap closing occurs at  $\pm k(0)$  (not equal  $G/2$ ) while for systems with inversion symmetry, the gap can close only at wave numbers  $k=G/2$ , where  $G$  is a reciprocal lattice vector. In both cases, following a unitary transformation which mixes spins, the system is represented by two decoupled effective theories of massive two-component fermions having masses of opposite signs. Existence of gapless helical modes at a domain wall between the two phases directly follows from this formalism. This theory provides an elementary and comprehensive phenomenology of the quantum spin Hall system.

**Semiclassical analysis of edge state energies in the integer quantum Hall effect***Article publié en 2008***Auteurs :** Avishai Y.; Montambaux G.

Réf. : EUROPEAN PHYSICAL JOURNAL B Volume: 66 Issue: 1 Pages: 41-49 DOI: 10.1140/epjb/e2008-00404-6 Published: NOV 2008

Analysis of edge-state energies in the integer quantum Hall effect is carried out within the semiclassical approximation. When the system is wide so that each edge can be considered separately, this problem is equivalent to that of a one dimensional harmonic oscillator centered at  $x = x(c)$  and an infinite wall at  $x = 0$ , and appears in numerous physical contexts. The eigenvalues  $E(n)(x(c))$  for a given quantum number  $n$  are solutions of the equation  $S(E, x(c)) = \pi[n + \gamma(E, x(c))]$  where  $S$  is the WKB action and  $0 < \gamma < 1$  encodes all the information on the connection procedure at the turning points. A careful implication of the WKB connection formulae results in an excellent approximation to the exact energy eigenvalues. The dependence of  $\gamma[E(n)(x(c)), x(c)]$  equivalent to  $\gamma(n)(x(c))$  on  $x(c)$  is analyzed between its two extreme values  $1/2$  as  $x(c) \rightarrow -\infty$  far inside the sample and  $3/4$  as  $x(c) \rightarrow \infty$  far outside the sample. The edge-state energies  $E(n)(x(c))$  obey an almost exact scaling law of the form  $E(n)(x(c)) = 4[n + \gamma(n)(x(c))]f(x(c)/\sqrt{4n+3})$  and the scaling function  $f(y)$  is explicitly elucidated.

**Tight-binding electronic spectra on graphs with spherical topology: I. The effect of a magnetic charge***Article publié en 2008***Auteurs :** Avishai Y.; Luck J. M.

Réf. : JOURNAL OF STATISTICAL MECHANICS-THEORY AND EXPERIMENT Article Number: P06007 DOI: 10.1088/1742-5468/2008/06/P06007 Published: JUN 2008

This is the first of two papers devoted to tight-binding electronic spectra on graphs with the topology of the sphere. In this work the one-electron spectrum is investigated as a function of the radial magnetic field produced by a magnetic charge sitting at the centre of the sphere. The latter is an integer multiple of the quantized magnetic charge of the Dirac monopole, that integer defining the gauge sector. An analysis of the spectrum is

carried out for the five platonic solids ( tetrahedron, cube, octahedron, dodecahedron and icosahedron), the C(60) fullerene and two families of polyhedra, the diamonds and the prisms. Except for the fullerene, all the spectra are obtained in closed form. They exhibit a rich pattern of degeneracies. The total energy at half-filling is also evaluated in all the examples as a function of the magnetic charge.

## Tight-binding electronic spectra on graphs with spherical topology: II. The effect of spin-orbit interaction

*Article publié en 2008*

Auteurs : Avishai Y.; Luck J. M.

Réf. : JOURNAL OF STATISTICAL MECHANICS-THEORY AND EXPERIMENT Article Number: P06008  
DOI: 10.1088/1742-5468/2008/06/P06008 Published: JUN 2008

This is the second of two papers devoted to tight-binding electronic spectra on graphs with the topology of the sphere. We investigate the problem of an electron subject to a spin-orbit interaction generated by the radial electric field of a static point charge sitting at the center of the sphere. The tight-binding Hamiltonian considered is a discretization on polyhedral graphs of the familiar form  $L S$  of the spin-orbit Hamiltonian. It involves  $SU(2)$  hopping matrices of the form  $\exp(i \mu n \cdot \sigma)$  living on the oriented links of the graph. For a given structure, the dimensionless coupling constant  $\mu$  is the only parameter of the model. An analysis of the energy spectrum is carried out for the five Platonic solids ( tetrahedron, cube, octahedron, dodecahedron and icosahedron) and the C(60) fullerene. Except for the latter, the  $\mu$ - dependence of all the energy levels is obtained analytically in closed form. Rather unexpectedly, the spectra are symmetric under the exchange  $\mu \leftrightarrow T/\mu$ , where  $T$  is the common arc length of the links. For the symmetric point  $\mu = T/2$ , the problem can be exactly mapped onto a tight-binding model in the presence of the magnetic field generated by a Dirac monopole, studied recently. The dependence of the total energy at half filling on  $\mu$  is investigated in all examples.

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## [2007-036T] CIQ

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Porteur : Marc Mezard

Axe B

## Disorder-Driven Quantum Phase Transitions in Superconductors and Magnets

*Article publié en 2010*

Auteurs : Ioffe L. B.; Mezard Marc

Réf. : PHYSICAL REVIEW LETTERS Volume: 105 Issue: 3 Article Number: 037001 DOI:  
10.1103/PhysRevLett.105.037001 Published: JUL 14 2010

We develop an analytical theory, based on the quantum cavity method, describing the quantum phase transitions in low-temperature, strongly disordered ferromagnets and superconductors. At variance with the usual quantum critical points, we find a phase diagram with two critical points separating three phases. When the disorder increases, the system goes from the ordered phase to an intermediate disordered phase characterized by activated transport and then to a second disordered phase where no transport is possible. Both the ordered and disordered phases exhibit strong inhomogeneity of their basic properties typical of glassy physics.

## Fractal superconductivity near localization threshold

*Article publié en 2010*

Auteurs : Feigel'man, MV. Ioffe, LB. Kravtsov, VE. Cuevas, E

Réf. : ANNALS OF PHYSICS 325 (2010) 1390-1478

We develop a semi-quantitative theory of electron pairing and resulting superconductivity in bulk "poor conductors" in which Fermi energy  $E_F$  is located in the region of localized states not so far from the Anderson



mobility edge  $E_c$ . We assume attractive interaction between electrons near the Fermi surface. We review the existing theories and experimental data and argue that a large class of disordered films is described by this model. Our theoretical analysis is based on analytical treatment of pairing correlations, described in the basis of the exact single-particle eigenstates of the 3D Anderson Model, which we combine with numerical data on eigenfunction correlations. Fractal nature of critical Wavefunction's correlations is shown to be crucial for the physics of these systems. We identify three distinct phases: 'critical' superconductive state formed at  $E_F = E_c$ , superconducting state with a strong pseudo-gap, realized due to pairing of weakly localized electrons and insulating state realized at  $E_F$  still deeper inside a localized band. The 'critical' superconducting phase is characterized by the enhancement of the transition temperature with respect to BCS result, by the inhomogeneous spatial distribution of superconductive order parameter and local density of states. The major new feature of the pseudo-gapped state is the presence of two independent energy scales: superconducting gap  $\Delta$ , that is due to many-body correlations and a new "pseudo-gap" energy scale  $\Delta(P)$  which characterizes typical binding energy of localized electron pairs and leads to the insulating behavior of the resistivity as a function of temperature above superconductive  $T_c$ . Two gap nature of the pseudo-gapped superconductor is shown to lead to specific features seen in scanning tunneling spectroscopy and point-contact Andreev spectroscopy. We predict that pseudo-gapped superconducting state demonstrates anomalous behavior of the optical spectral weight. The insulating state is realized due to the presence of local pairing gap but without superconducting correlations; it is characterized by a hard insulating gap in the density of single electrons and by purely activated low-temperature resistivity  $\ln R(T)$  similar to  $1/T$ . Based on these results we propose a new "pseudo-spin" scenario of superconductor-insulator transition and argue that it is realized in a particular class of disordered superconducting films. We conclude by the discussion of the experimental predictions of the theory and the theoretical issues that remain unsolved. (C) 2010 Elsevier Inc. All rights reserved.

## Superconductor-insulator transition and energy localization

*Article publié en 2010*

**Auteurs :** Feigel'man M. V.; Ioffe L. B.; Mezard M.

Réf. : PHYSICAL REVIEW B Volume: 82 Issue: 18 Article Number: 184534 DOI: 10.1103/PhysRevB.82.184534 Published: NOV 29 2010

We develop an analytical theory for generic disorder-driven quantum phase transitions. We apply this formalism to the superconductor-insulator transition and we briefly discuss the applications to the order-disorder transition in quantum magnets. The effective spin-1/2 models for these transitions are solved in the cavity approximation which becomes exact on a Bethe lattice with large branching number  $K \gg 1$  and weak dimensionless coupling  $g \ll 1$ . The characteristic feature of the low-temperature phase is a large self-formed inhomogeneity of the order-parameter distribution near the critical point  $K \gg K_c(g)$ , where the critical temperature  $T_c$  of the ordering transition vanishes. We find that the local probability distribution  $P(B)$  of the order parameter  $B$  has a long power-law tail in the region where  $B$  is much larger than its typical value  $B(0)$ . Near the quantum-critical point, at  $K \rightarrow K_c(g)$ , the typical value of the order parameter vanishes exponentially,  $B(0)$  proportional to  $e^{-C/[K - K_c(g)]}$  while the spatial scale  $N_{inh}$  of the order parameter inhomogeneities diverges as  $[K - K_c(g)]^{-2}$ . In the disordered regime, realized at  $K < K_c(g)$  we find actually two distinct phases characterized by different behavior of relaxation rates. The first phase exists in an intermediate range of  $K^*(g) < K < K_c(g)$ . It has two regimes of energies: at low excitation energies,  $\omega < \omega_d(K, g)$ , the many-body spectrum of the model is discrete, with zero-level widths, while at  $\omega < \omega_d$  the level acquire a nonzero width which is self-generated by the many-body interactions. In this phase the spin model provides by itself an intrinsic thermal bath. Another phase is obtained at smaller  $K < K^*(g)$ , where all the eigenstates are discrete, corresponding to full many-body localization. These results provide an explanation for the activated behavior of the resistivity in amorphous materials on the insulating side near the superconductor-insulator transition and a semiquantitative description of the scanning tunneling data on its superconductive side.

## The cavity method for quantum disordered systems: from transverse random field ferromagnets to directed polymers in random media

Article publié en 2011

Auteurs : Dimitrova O.; Mezard M.

Réf. : JOURNAL OF STATISTICAL MECHANICS-THEORY AND EXPERIMENT Article Number: P01020  
DOI: 10.1088/1742-5468/2011/01/P01020 Published: JAN 2011

After reviewing the basics of the cavity method in classical systems, we show how its quantum version, with some appropriate approximation scheme, can be used to study a system of spins with random ferromagnetic interactions and a random transverse field. The quantum cavity equations describing the ferromagnetic-paramagnetic phase transition can be transformed into the well-known problem of a classical directed polymer in a random medium. The glass transition of this polymer problem translates into the existence of a 'Griffiths phase' close to the quantum phase transition of the quantum spin problem, where the physics is dominated by rare events. The physical behaviour of random transverse-field ferromagnets on the Bethe lattice is found to be very similar to that found in finite-dimensional systems, and the quantum cavity method gets back the known exact results of the one-dimensional problem.

## Dissipationless dynamics of randomly coupled spins at high temperatures

Article publié en 2012

Auteurs : Faoro, Lara (1,2,3); Ioffe, Lev (1,2,3); Kitaev, Alexei (4)

Réf. : Source: PHYSICAL REVIEW B Volume: 86 Issue: 13 Article Number: 134414 DOI:  
10.1103/PhysRevB.86.134414 Published: OCT 15 2012

We develop a technique to compute the high-frequency asymptotics of spin correlators in weakly interacting disordered spin systems. We show that the dynamical spin correlator decreases exponentially at high frequencies  $\ll \omega$  similar to  $\exp(-\tau^* \omega)$  and compute the characteristic time  $\tau^*$  of this dependence. In a typical random configuration, some fraction of spins form strongly coupled pairs, which behave as two-level systems. Their switching dynamics is driven by the high-frequency noise from the surrounding spins, resulting in low-frequency  $1/f$  noise in the magnetic susceptibility and other physical quantities. We discuss application of these results to the problem of susceptibility and flux noise in superconducting circuits at mK temperatures.

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## [2007-038T] DESOBEC

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Porteur : Laurent Sanchez-Palencia

Thème 1

## Dipole oscillations of a Fermi gas in a disordered trap: Damping and localization

Article publié en 2009

Auteurs : Pezze, L. Hambrecht, B. Laurent Sanchez-Palencia

Réf. : EPL 88 (2009) 54002

We theoretically study the dipole oscillations of an ideal Fermi gas in a disordered trap. We show that even weak disorder induces strong damping of the oscillations and we identify a metal-insulator crossover. For very weak disorder, we show that damping results from a dephasing effect related to weak random perturbations of the energy spectrum. For increasing disorder, we show that the Fermi gas crosses over to an insulating regime characterized by strong damping due to the proliferation of localized states. Copyright (C) EPLA, 2009

## Disordered quantum gases under control

*Article publié en 2010*

Auteurs : Sanchez-Palencia Laurent; Lewenstein Maciej

Réf. : NATURE PHYSICS Volume: 6 Issue: 2 Pages: 87-95 DOI: 10.1038/NPHYS1507 Published: FEB 2010

When attempting to understand the role of disorder in condensed-matter physics, we face considerable experimental and theoretical difficulties, and many questions are still open. Two of the most challenging ones—debated for decades—concern the effect of disorder on superconductivity and quantum magnetism. We review recent progress in the field of ultracold atomic gases, which should pave the way towards the realization of versatile quantum simulators, which help solve these questions. In addition, ultracold gases offer original practical and conceptual approaches, which open new perspectives to the field of disordered systems.

## Localization of a matter wave packet in a disordered potential

*Article publié en 2011*

Auteurs : Piraud M.; Lugan P.; Bouyer P.; et al

Réf. : PHYSICAL REVIEW A Volume: 83 Issue: 3 Article Number: 031603 DOI: 10.1103/PhysRevA.83.031603 Published: MAR 4 2011

We theoretically study the Anderson localization of a matter wave packet in a one-dimensional disordered potential. We develop an analytical model which includes the initial phase-space density of the matter wave and the spectral broadening induced by the disorder. Our approach predicts a behavior of the localized density profile significantly more complex than a simple exponential decay. These results are confirmed by large-scale and long-time numerical calculations. They shed new light on recent experiments with ultracold atoms and may impact their analysis.

## Localization of Bogoliubov quasiparticles in interacting Bose gases with correlated disorder

*Article publié en 2011*

Auteurs : Lugan P.; Sanchez-Palencia L

Réf. : PHYSICAL REVIEW A Volume: 84 Issue: 1 Article Number: 013612 DOI: 10.1103/PhysRevA.84.013612 Published: JUL 22 2011

We study the Anderson localization of Bogoliubov quasiparticles (elementary many-body excitations) in a weakly interacting Bose gas of chemical potential  $\mu$  subjected to a disordered potential  $V$ . We introduce a general mapping (valid for weak inhomogeneous potentials in any dimension) of the Bogoliubov-de Gennes equations onto a single-particle Schrodinger-like equation with an effective potential. For disordered potentials, the Schrodinger-like equation accounts for the scattering and localization properties of the Bogoliubov quasiparticles. We derive analytically the localization lengths for correlated disordered potentials in the one-dimensional geometry. Our approach relies on a perturbative expansion in  $V/\mu$ , which we develop up to third order, and we discuss the impact of the various perturbation orders. Our predictions are shown to be in very good agreement with direct numerical calculations. We identify different localization regimes: For low energy, the effective disordered potential exhibits a strong screening by the quasicondensate density background, and localization is suppressed. For high-energy excitations, the effective disordered potential reduces to the bare disordered potential, and the localization properties of quasiparticles are the same as for free particles. The maximum of localization is found at intermediate energy when the quasicondensate healing length is of the order of the disorder correlation length. Possible extensions of our work to higher dimensions are also discussed.

## Localized and Extended States in a Disordered Trap

*Article publié en 2011*

**Auteurs :** Pezze, L; Laurent Sanchez-Palencia

Réf. : PHYSICAL REVIEW LETTERS 106 (2011) 040601

We study Anderson localization in a disordered potential combined with an inhomogeneous trap. We show that the spectrum displays both localized and extended states, which coexist at intermediate energies. In the region of coexistence, we find that the extended states result from confinement by the trap and are weakly affected by the disorder. Conversely, the localized states correspond to eigenstates of the disordered potential, which are only affected by the trap via an inhomogeneous energy shift. These results are relevant to disordered quantum gases and we propose a realistic scheme to observe the coexistence of localized and extended states in these systems.

## Regimes of classical transport of cold gases in a two-dimensional anisotropic disorder

*Article publié en 2011*

**Auteurs :** Pezze L.; Robert-de-Saint-Vincent M.; Bourdel T.; et al.

Réf. : NEW JOURNAL OF PHYSICS Volume: 13 Article Number: 095015 DOI: 10.1088/1367-2630/13/9/095015 Published: SEP 26 2011

We numerically study the dynamics of cold atoms in a two-dimensional disordered potential. We consider an anisotropic speckle potential and focus on the classical dynamics, which is relevant to some recent experiments. Firstly, we study the behavior of particles with a fixed energy and identify different transport regimes. At low energy, the particles are classically localized due to the absence of a percolating cluster. At high energy, the particles undergo normal diffusion, and we show that the diffusion coefficients scale algebraically with the particle energy, with an anisotropy factor that is significantly different from that of the disordered potential. At intermediate energy, we find a transient sub-diffusive regime, which is relevant to the time scale of typical experiments. Secondly, we study the behavior of a cold atomic gas with an arbitrary energy distribution, using the above results as the groundwork. We show that the density profile of the atomic cloud in the diffusion regime is strongly peaked and, in particular, that it is not Gaussian. Its behavior at large distances allows us to extract the energy-dependent diffusion coefficients from experimental density distributions. For a thermal cloud released into the disordered potential, we show that our numerical predictions are in agreement with experimental findings. Not only does this paper give insights into recent experimental results, but it may also help in the interpretation of future experiments searching for deviation from classical diffusion and traces of Anderson localization.

## Three-dimensional localization of ultracold atoms in an optical disordered potential

*Article publié en 2012*

**Auteurs :** Jendrzejewski F.; Bernard A.; Mueller K.; et al.

Réf. : NATURE PHYSICS Volume: 8 Issue: 5 Pages: 398-403 DOI: 10.1038/NPHYS2256 Published: MAY 2012

In disordered media, quantum interference effects are expected to induce complete suppression of electron conduction. The phenomenon, known as Anderson localization, has a counterpart with classical waves that has been observed in acoustics, electromagnetism and optics, but a direct observation for particles remains elusive. Here, we report the observation of the three-dimensional localization of ultracold atoms in a disordered potential created by a speckle laser field. A phenomenological analysis of our data distinguishes a localized component of the resulting density profile from a diffusive component. The observed localization cannot be interpreted as the classical trapping of particles with energy below the classical percolation threshold in the disorder, nor can it be understood as quantum trapping in local potential minima. Instead, our data are compatible with the self-consistent theory of Anderson localization tailored to our system, involving a heuristic energy shift that offers scope for future interpretation.

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**[2007-042T] NOIBIPHOT**

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**Porteur : Anne Debarre**

**Thème 2**

### **Ligand-Induced Anisotropy of the Two-Photon Luminescence of Spherical Gold Particles in Solution Unraveled at the Single Particle Level**

*Article publié en 2010*

**Auteurs :** Loumaigne, M. Richard, A. Laverdant, J. Nutarelli, D. Anne Debarre

**Réf. :** NANO LETTERS 10 (2010) 2817-2824

Here we report on the visible luminescence properties of individual spherical gold particles in solution, obtained by two-photon excited fluorescence correlation spectroscopy and by an original dual Rayleigh-fluorescence method, correlating the Rayleigh scattering and the luminescence fluctuations of the same particle. The results demonstrate that the power needed to observe the two-photon excited visible luminescence depends on the illuminated particle and that the corresponding emission is anisotropic at low power. These observations combined with the evolution of the dynamics of the luminescence with respect to excitation power are interpreted by the presence of unique emissive surface states that are randomly switched off and on by the heat-induced movement of the molecular coating. These characteristics, which remain hidden in macroscopic experiments, have important implications with respect to the potential use of the particles as labels in two-photon imaging in aqueous samples.

### **Influence of polarization and wavelength on two-photon excited luminescence of single gold nanospheres**

*Article publié en 2011*

**Auteurs :** Loumaigne, M; Vasanthakumar, P; Richard, A; Anne Debarre

**Réf. :** PHYSICAL CHEMISTRY CHEMICAL PHYSICS 13 (24): 11597-11605 2011

The Brownian rotation of a nearly spherical gold particle capped with ligands can be observed in the correlation profile of the intensity of the two-photon excited luminescence. Here we report on a multi-parameter study of the luminescence properties, including spectral and polarization analysis of the signal at the single particle level. First, the data confirm the role of the radiative de-excitation of the surface plasmons in the luminescence process. Secondly, the results obtained at low power indicate that the capped particle in water can be approximatively described as a spherical rotor acting in the far-field as a point-like absorption and emission dipole of fixed directions. In addition, we show that the dynamics of the ligands, induced by the heat transfer from the particle to its environment, can be partly controlled by the choice of excitation wavelength.

### **Time-of-Flight Photon Spectroscopy: A Simple Scheme To Monitor Simultaneously Spectral and Temporal Fluctuations of Emission on Single Nanoparticles**

*Article publié en 2012*

**Auteurs :** Loumaigne, Matthieu; Vasanthakumar, Priya; Richard, Alain; Debarre, Anne

**Réf. :** ACS NANO Volume: 6 Issue: 12 Pages: 10512-10523 DOI: 10.1021/nn304842c Published: DEC 2012

Here we report on a novel scheme for spectral analysis that exploits the wavelength dependence of the time-of-flight of a photon in a dispersive medium. This versatile and cost-effective method, named time-of-flight photon spectroscopy (TOFPS), has the major advantage of being compatible with time-correlated single-photon counting experiments. Consequently, each photon acquired during an experiment is characterized by two parameters, its absolute time of arrival and its color, respectively. As a result, the spectral and temporal fluctuations of the emission of a single nano-object can be derived from a single measurement. As a proof of the

concept, we demonstrate in the paper that the method can be used to perform Raman spectroscopy as well as fluorescence spectroscopy. We emphasize that TOFPS proves to be very efficient for improving signal-to-noise ratio in fluorescence correlation spectroscopy measurements by subsequent spectral filtering and to record luminescence spectra from single metallic particles. We demonstrate that the opportunity of simultaneously recording spectral and temporal fluctuations could be used to sort particles of different shapes inside a sample. TOFPS furthermore allows developing a new type of time interval distribution analysis which correlates the time interval between two photons and their corresponding color shift. It is applied to the analysis of the two-photon excited luminescence of a single gold nanorod. This method has a potential for a broad range of applications, among which time-resolved SERS spectroscopy and analysis of the dynamics of emission processes can be handled with new statistical approaches based on the correlation of spectral and temporal fluctuations.

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## [2007-044T] ALICANTE

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Porteur : Karim Bouzouane

Axe A

### Anisotropic magneto-Coulomb effects and magnetic single-electron-transistor action in a single nanoparticle

*Article publié en 2009*

Auteurs : Bernard-Mantel, A. Seneor, P. Karim Bouzouane. Fusil, S. Deranlot, C. Petroff, F. Fert, A

Réf. : NATURE PHYSICS 12 (2009) 920-924

A present challenge in the field of spintronics is the study of spin-dependent transport in nanodevices where all dimensions are reduced to only a few nanometres. The archetypical device structure used to explore spin transport at such a scale consists of a nanometre-sized object such as a molecule, quantum dot or nanotube connected by ferromagnetic contacts. New magneto-Coulomb effects are expected as a consequence of the interaction between charge and spin degrees of freedom. However, the focus has been mainly theoretical up to now with a lack of results on the experimental side. More importantly, in most of the studies the influence of the ferromagnetic electrodes has been largely overlooked. Here, we demonstrate that a significant magneto-Coulomb effect can be induced by conventional magnetic electrodes and mimic spin-valve magnetoresistance. Moreover, we show that the magnetic electrode can act as a gate leading to a ferromagnetic single-electron transistor with only two terminals.

### Anisotropic magneto-Coulomb effect versus spin accumulation in a ferromagnetic single-electron device

*Article publié en 2011*

Auteurs : Bernard-Mantel A.; Seneor P.; Bouzouane K.; et al

Réf. : PHYSICAL REVIEW B Volume: 84 Issue: 18 Article Number: 180413 DOI: 10.1103/PhysRevB.84.180413 Published: NOV 28 2011

We investigate the magnetotransport characteristics of nanospintronics single-electron devices. The devices consist of single nonmagnetic nano-objects (nanometer-size nanoparticles of Al or Cu) connected to Co ferromagnetic leads. The comparison with simulations allows us attribute the observed magnetoresistance to either spin accumulation or anisotropic magneto-Coulomb effect (AMC), two effects with very different origins. The fact that the two effects are observed in similar samples demonstrates that a careful analysis of Coulomb blockade and magnetoresistance behaviors is necessary in order to discriminate them in magnetic single-electron devices. As a tool for further studies, we propose a simple way to determine if spin transport or the AMC effect dominates from the Coulomb blockade I-V curves of the spintronics device.

## Epitaxial growth and ferrimagnetic behavior of MnFe(2)O(4)(111) ultrathin layers for room-temperature spin filtering

Article publié en 2011

Auteurs : Matzen S.; Moussy J. -B.; Mattana R.; et al.

Réf. : PHYSICAL REVIEW B Volume: 83 Issue: 18 Article Number: 184402 DOI: 10.1103/PhysRevB.83.184402 Published: MAY 9 2011

We report on the epitaxial growth and physical properties of spinel MnFe(2)O(4)(111) thin films with thicknesses down to 2 nm. The thin films, grown on alpha-Al(2)O(3)(0001) single crystals or Pt(111) buffer layers by oxygen-assisted molecular beam epitaxy, exhibit high structural order with sharp interfaces and low roughness. The electrical and magnetic properties are carefully investigated and it is shown that MnFe(2)O(4)(111) ultrathin films keep an insulating and ferrimagnetic behavior at room temperature. Special attention is given to the iron/manganese valence state and the cationic ordering. X-ray absorption spectroscopy and magnetic circular dichroism measurements reveal that thin films contain mainly Fe(3+) and Mn(2+) cations, distributed predominantly in a normal spinel structure. This study proves the high potential of MnFe(2)O(4) to be used as a magnetic tunnel barrier for spin filtering applications at room temperature.

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### [2007-046T] CODERUP

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Porteur : Daniel Bonamy

Axe B

## Intermittency and roughening in the failure of brittle heterogeneous materials

Article publié en 2009

Auteurs : Bonamy, D

Réf. : JOURNAL OF PHYSICS D-APPLIED PHYSICS 42 (2010) 214014

Stress enhancement in the vicinity of brittle cracks makes the macro-scale failure properties extremely sensitive to the micro-scale material disorder. Therefore, (i) fracturing systems often display a jerky dynamics, so-called crackling noise, with seemingly random sudden energy release spanning over a broad range of scales, reminiscent of earthquakes; (ii) fracture surfaces exhibit roughness at scales much larger than that of material microstructure. Here, I provide a critical review of experiments and simulations performed in this context, highlighting the existence of universal scaling features, independent of both the material and the loading conditions, reminiscent of critical phenomena. I finally discuss recent stochastic descriptions of crack growth in brittle disordered media that seem to capture qualitatively-and sometimes quantitatively-these scaling features.

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**[2007-049T] Elecmatbt & [2009-082T] FibNanoSynth**

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Porteur : **H. Bouchiat**

**F. Fortuna**

Axe **A, C**

### **Geometry-related magnetic interference patterns in long S N S Josephson junctions**

*Article publié en 2012*

Auteurs: Chiodi, F.; Ferrier, M.; Gueron, S.; Cuevas, J. C.; Montambaux, G.; Fortuna, F.; Kasumov, A.; Bouchiat, H.

Réf. : PHYSICAL REVIEW B Volume: 86 Issue: 6 Article Number: 064510 DOI: 10.1103/PhysRevB.86.064510 Published: AUG 9 2012

We have measured the critical current dependence on the magnetic flux of two long S N S junctions differing by the normal wire geometry. The samples are made by a Au wire connected to W contacts, via focused ion beam assisted deposition. We could tune the magnetic pattern from the monotonic Gaussian-like decay of a quasi-one-dimensional (1D) normal wire to the Fraunhofer-like pattern of a square normal wire. We explain the monotonic limit with a semiclassical 1D model, and we fit both field dependencies with numerical simulations of the two-dimensional Usadel equations. Furthermore, we observe both integer and fractional Shapiro steps. The magnetic flux dependence of the integer steps reproduces as expected that of the critical current  $I_c$ , while fractional steps decay slower with the flux than  $I_c$ .

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**[2007-051T] RF-MAG**

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Porteur : **Thibault Devolder**

Thème **5**

### **Agility of vortex-based nanocontact spin torque oscillators**

*Article publié en 2009*

Auteurs: Manfrini, M. Thibault Devolder. Kim, JV. Crozat, P. Zerounian, N. Chappert, C. Van Roy, W. Lagae, L. Hrkac, G. Schrefl, T

Réf. : APPLIED PHYSICS LETTERS 97 (2010) 092118

We study the agility of current-tunable oscillators based on a magnetic vortex orbiting around a point contact in spin valves. The theory predicts that frequency tuning by currents occurs at constant orbital radius so an exceptional agility is anticipated. To test this, we have inserted an oscillator in a microwave interferometer to apply abrupt Current variations while time resolving its emission. Using frequency shift keying. we show that the oscillator can switch between two stabilized frequencies differing by 25% in less than ten periods. With a wide frequency tunability and a good agility. such oscillators possess desirable figures of merit for modulation-based rf applications. (C) 2009 American Institute of Physics. [doi: 10.1063/1.3263727]



## Direct experimental measurement of phase-amplitude coupling in spin torque oscillators

Article publié en 2010

**Auteurs** : Bianchini, L. Cornelissen, S. Kim, JV. Thibault Devolder. van Roy, W. Lagae, L. Chappert, C

Réf. : APPLIED PHYSICS LETTERS 97 (2010) 032502

We study spin-torque induced oscillations of MgO magnetic tunnel junctions in the time domain. By using the Hilbert transform on the time traces, we obtain for the first time a direct experimental measure of the coupling between the power and the phase fluctuations. We deduce the power restoration rate and we obtain low values for the coupling strength, which is consistent with the weak frequency dependence on the applied voltage. (C) 2010 American Institute of Physics. [doi: 10.1063/1.3467043]

## Vortex nucleation in spin-torque nanocontact oscillators

Article publié en 2010

**Auteurs** : Thibault Devolder. Kim, JV. Manfrini, M. van Roy, W. Lagae, L. Chappert, C

Réf. : APPLIED PHYSICS LETTERS 97 (2010) 072512

We present an experimental study of the nucleation rate associated with current-driven vortex oscillations in magnetic nanocontacts. We find that the nucleation and subsequent steady-state oscillation of a vortex can be initiated using current pulses as short as a few nanoseconds, yielding instant on oscillator capability. The nucleation rate is governed by an Arrhenius law, with an exponential dependence on the applied current magnitude. The mechanism for the vortex nucleation is discussed and compared to analytical estimates assuming the transient presence of a vortex-antivortex pair. (C) 2010 American Institute of Physics. [doi:10.1063/1.3478843]

## Configuration and temperature dependence of magnetic damping in spin valves

Article publié en 2011

**Auteurs** : Joyeux, X; Devolder, T; Kim, JV; de la Torre, YG; Eimer, S; Chappert, C

Réf. : JOURNAL OF APPLIED PHYSICS 110 (6): 10.1063/1.3638055 SEP 15 2011

Using vector-analyzer ferromagnetic resonance, we have studied the microwave susceptibility of a Py/Co/Cu/Co/MnIr spin valve over a large temperature range (5-450 K) and as a function of the magnetic configuration. An effective magnetization and Gilbert damping constant of 1.1 T and 0.021, respectively, are found for the permalloy free layer, with no discernible variation in temperature observed for either quantities. In contrast, the pinned layer magnetization is reduced by heating, and the exchange bias collapses near a temperature of 450 K. The ferromagnetic resonance linewidth of the free layer increases by 500 MHz when the layer magnetizations are aligned in antiparallel, which is attributed to a configuration-dependent contribution to the damping from spin pumping effects. (C) 2011 American Institute of Physics. [doi:10.1063/1.3638055]

## Frequency shift keying in vortex-based spin torque oscillators

Article publié en 2011

**Auteurs** : Manfrini, M; Thibault Devolder; Kim, JV; Crozat, P; Chappert, C; Van Roy, W; Lagae, L

Réf. : JOURNAL OF APPLIED PHYSICS 109 (8): Art. No. 083940 APR 15 2011

Vortex-based spin-torque oscillators can be made from extended spin valves connected to an electrical nanocontact. We study the implementation of frequency shift keying modulation in these oscillators. Upon a square modulation of the current in the 10 MHz range, the vortex frequency follows the current command, with easy identification of the two swapping frequencies in the spectral measurements. The frequency distribution of the output power can be accounted for by convolution transformations of the dc current vortex waveform, and the current modulation. Modeling indicates that the frequency transitions are phase coherent and last less than 25

ns. Complementing the multi-octave tunability and first-class agility, the capability of frequency shift keying modulation is an additional milestone for the implementation of vortex-based oscillators in radio frequency circuits. (C) 2011 American Institute of Physics.

### Vortex Nucleation Phase in Spin Torque Oscillators Based on Nanocontacts

*Article publié en 2011*

Auteurs: Thibault Devolder; Kim, JV; Petit-Watelot, S; Otxoa, R; Chappert, C; Manfrini, M; Van Roy, W; Lagae, L

Réf.: IEEE TRANSACTIONS ON MAGNETICS 47 (6): 1595-1598 Part 1 JUN 2011

We study the starting up phase of a current-controlled oscillator based on a magnetic vortex orbiting around a nanocontact in a spin-valve. From the idle state, current pulses down to a few nanoseconds can create the vortex, which is detected through the electrical signature of its steady-state gyration. Two ns are needed to reach the in-current equilibrium. The process can then be described by an Arrhenius law, with an activation energy that is consistent with the Oersted-field-induced separation of a vortex-antivortex pair. Requirements for deterministic nucleation are deduced, with prospects for instant-on oscillator capability.

### Commensurability and chaos in magnetic vortex oscillations

*Article publié en 2012*

Auteurs: Petit-Watelot, Sebastien; Kim, Joo-Von; Ruotolo, Antonio; Otxoa, Ruben M.; Bouzehouane, Karim; Grollier, Julie; Vansteenkiste, Arne; Van de Wiele, Ben; Cros, Vincent; Devolder, Thibaut

Réf.: NATURE PHYSICS Volume: 8 Issue: 9 Pages: 682-687 DOI: 10.1038/NPHYS2362 Published: SEP 2012

Magnetic vortex dynamics in thin films is characterized by gyrotropic motion, the sense of gyration depending on the vortex core polarity, which reverses when a critical velocity is reached. Although self-sustained vortex oscillations in nanoscale systems are known to be possible, the precise role of core reversal in such dynamics remains unknown. Here we report on an experimental observation of periodic core reversal during self-sustained vortex gyration in a magnetic nanocontact system. By tuning the ratio between the gyration frequency and the rate of core reversal, we show that commensurate phase-locked and incommensurate chaotic states are possible, resulting in Devil's staircases with driving currents. These systems could have the potential to serve as tunable nanoscale radiofrequency electrical oscillators for secure communications, allowing schemes such as encryption by chaos on demand.

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## [2007-052T] DYNAH

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Porteur: Marco Aprili

Thème 1

### Full counting statistics of avalanche transport: An experiment

*Article publié en 2009*

Auteurs: Gabelli, J. Reulet, B

Réf.: PHYSICAL REVIEW B 80 (2009) 161203

We report the measurement of higher order cumulants of the current fluctuations in an avalanche diode with a stationary dc current. Such a system is archetypal of devices in which transport is governed by a collective mechanism, in this case charge multiplication by avalanche. We have measured the first five cumulants of the probability distribution of the current fluctuations. We show that the charge multiplication factor is distributed according to a power law that is different from that of the usual avalanche below breakdown, when avalanches are well separated.

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**[2007-057T] CFA-Coalas**

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Porteur : Laurence Pruvost

Thème 7

**Cold atom guidance by a holographically-generated Laguerre-Gaussian laser mode**

*Article publié en 2010*

Auteurs : Mestre, M. Diry, F. de Lesegno, BV. Pruvost, L

Réf. : EUROPEAN PHYSICAL JOURNAL D 57 (2010) 87-94

We report on the quantitative study of guiding of cold rubidium atoms in a Laguerre-Gaussian laser mode LG(0) (l), which is holographically prepared using a spatial light modulator. We have measured the guiding efficiency (up to 25%) and studied the variations versus l, the order of the mode and versus the laser detuning. We interpret the observed behavior by using a two-dimensional trap model and by calculating the capture efficiency of the initial atomic cloud by the dipole guide.

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**[2007-058T] QUANTUMDYN**

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Porteur : Antoine Georges

Thème 4

**Quasiperiodic Bose-Hubbard model and localization in one-dimensional cold atomic gases**

*Article publié en 2008*

Auteurs : Roux G , Barthel T, McCulloch IP , Corinna Kollath , Schollwock U , Giamarchi T

Réf. : PHYSICAL REVIEW A 78 (2008) 023628

We compute the phase diagram of the one-dimensional Bose-Hubbard model with a quasiperiodic potential by means of the density-matrix renormalization group technique. This model describes the physics of cold atoms loaded in an optical lattice in the presence of a superlattice potential whose wavelength is incommensurate with the main lattice wavelength. After discussing the conditions under which the model can be realized experimentally, the study of the density vs the chemical potential curves for a nontrapped system unveils the existence of gapped phases at incommensurate densities interpreted as incommensurate charge-density-wave phases. Furthermore, a localization transition is known to occur above a critical value of the potential depth  $V_2$  in the case of free and hard-core bosons. We extend these results to soft-core bosons for which the phase diagrams at fixed densities display new features compared with the phase diagrams known for random box distribution disorder. In particular, a direct transition from the superfluid phase to the Mott-insulating phase is found at finite  $V_2$ . Evidence for reentrances of the superfluid phase upon increasing interactions is presented. We finally comment on different ways to probe the emergent quantum phases and most importantly, the existence of a critical value for the localization transition. The latter feature can be investigated by looking at the expansion of the cloud after releasing the trap.

## Trapping and Cooling Fermionic Atoms into Mott and Neel States

*Article publié en 2008*

**Auteurs :** De Leo L , Corinna Kollath, Antoine Georges, Ferrero M, Parcollet O

Réf. : PHYSICAL REVIEW LETTERS 101 (2008) 210403

We perform a theoretical study of a fermionic gas with two hyperfine states confined to an optical lattice. We derive a generic state diagram as a function of interaction strength, particle number, and confining potential. We discuss the central density, the double occupancy, and their derivatives as probes for the Mott state, connecting our findings to the recent experiment of Jordens et al. [Nature (London) 455, 204 (2008)]. Using entropic arguments we compare two different strategies to reach the antiferromagnetic state in the presence of a trapping potential.

## Thermodynamics of the Spin Luttinger Liquid in a Model Ladder Material

*Article publié en 2008*

**Auteurs :** Rueegg Ch.; Kiefer K.; Thielemann B.; et al.

Réf. : PHYSICAL REVIEW LETTERS Volume: 101 Issue: 24 Article Number: 247202 DOI: 10.1103/PhysRevLett.101.247202 Published: DEC 12 2008

The phase diagram in temperature and magnetic field of the metal-organic, two-leg, spin-ladder compound  $(\text{C}(5)\text{H}(12)\text{N}(2)\text{CuBr}(4))$  is studied by measurements of the specific heat and the magnetocaloric effect. We demonstrate the presence of an extended spin Luttinger-liquid phase between two field-induced quantum critical points and over a broad range of temperature. Based on an ideal spin-ladder Hamiltonian, comprehensive numerical modeling of the ladder specific heat yields excellent quantitative agreement with the experimental data across the entire phase diagram.

Accession Number: WOS:000261704100058

## Cooling fermionic atoms in optical lattices by shaping the confinement

*Article publié en 2009*

**Auteurs :** Bernier, JS. Corinna Kollath. Antoine Georges. De Leo, L. Gerbier, F. Salomon, C. Kohl, M

Réf. : PHYSICAL REVIEW A 79 (2009) 061601

We propose an experimental procedure to cool fermionic atoms loaded into an optical lattice. The central idea is to spatially divide the system into entropy-rich and -poor regions by shaping the confining potential profile. Atoms in regions of high entropy per particle are subsequently isolated from the system. We discuss how to experimentally carry out this proposal and perform a quantitative study of its efficiency. We find that the entropy per particle,  $s$ , can typically be reduced by a factor of 10 such that entropies lower than  $s/k(\text{B})$  similar to 0.2 can be reached. Cooling into highly sought-after quantum phases (such as an antiferromagnet) can thus be achieved. We show that this procedure is robust against variations of the experimental conditions.

## Field-controlled magnetic order in the quantum spin-ladder system $(\text{Hpip})(2)\text{CuBr}_4$

*Article publié en 2009*

**Auteurs :** Thielemann B, Ruegg C, Kiefer K , Ronnow HM, Normand B, Bouillot P, Corinna Kollath, Orignac E, Citro R, Giamarchi T, Lauchli AM, Biner D, Kramer KW, Zapf VS, Jaime M, Stahn J, Christensen NB, Grenier B, McMorrow DF, Mesot J

Réf. : PHYSICAL REVIEW B 79 020408 (2009)

Neutron diffraction is used to investigate the field-induced, antiferromagnetically ordered state in the two-leg spin-ladder material  $(\text{Hpip})(2)\text{CuBr}_4$ . This "classical" phase, a consequence of weak interladder coupling, is nevertheless highly unconventional: its properties are influenced strongly by the spin Luttinger-liquid state of the ladder subunits. We determine directly the order parameter (transverse magnetization), the ordering temperature,

the spin structure, and the critical exponents around the transition. We introduce a minimal microscopic model for the interladder coupling and calculate the quantum fluctuation corrections to the mean-field interaction.

### All-optical pump-and-probe detection of two-time correlations in a Fermi gas

*Article publié en 2010*

Auteurs : Dao, TL. Corinna Kollath. Carusotto, I. Kohl, M

Réf. : PHYSICAL REVIEW A 81 (2010) 043626

We propose an all-optical scheme to probe the dynamical correlations of a strongly interacting gas of ultracold atoms in an optical lattice potential. The proposed technique is based on a pump-and-probe scheme: a coherent light pulse is initially converted into an atomic coherence and later retrieved after a variable storage time. The efficiency of the proposed method to measure the two-time one-particle Green function of the gas is validated by numerical and analytical calculations of the expected signal for the two cases of a normal Fermi gas and a BCS superfluid state. Protocols to extract the superfluid gap and the full quasiparticle dispersions are discussed.

### Effect of Rare Fluctuations on the Thermalization of Isolated Quantum Systems

*Article publié en 2010*

Auteurs : Biroli G, Corinna Kollath, Lauchli AM

Réf. : PHYSICAL REVIEW LETTERS 105 (2010) 250401

We consider the question of thermalization for isolated quantum systems after a sudden parameter change, a so-called quantum quench. In particular, we investigate the prerequisites for thermalization, focusing on the statistical properties of the time-averaged density matrix and of the expectation values of observables in the final eigenstates. We find that eigenstates, which are rare compared to the typical ones sampled by the microcanonical distribution, are responsible for the absence of thermalization of some infinite integrable models and play an important role for some nonintegrable systems of finite size, such as the Bose-Hubbard model. We stress the importance of finite size effects for the thermalization of isolated quantum systems and discuss two scenarios for thermalization.

### Thermometry and signatures of strong correlations from Raman spectroscopy of fermionic atoms in optical lattices

*Article publié en 2010*

Auteurs : Bernier, JS. Dao, TL. Corinna Kollath. Antoine Georges. Cornaglia, PS

Réf. : PHYSICAL REVIEW A 81 (2010) 063618

A method is proposed to directly measure the temperature of a gas of weakly interacting fermionic atoms loaded into an optical lattice. This technique relies on Raman spectroscopy and is applicable to experimentally relevant temperature regimes. Additionally, a similar spectroscopy scheme can be used to obtain information on the quasiparticle properties and Hubbard bands of the metallic and Mott-insulating states of interacting fermionic spin mixtures. These two methods provide experimentalists with probes to accurately characterize fermionic quantum gases confined to optical lattices.

### Quantitative Determination of Temperature in the Approach to Magnetic Order of Ultracold Fermions in an Optical Lattice

*Article publié en 2010*

Auteurs : Jordens, R. Tarruell, L. Greif, D. Uehlinger, T. Strohmaier, N. Moritz, H. Esslinger, T. De Leo, L. Corinna Kollath. Antoine Georges. Scarola, V. Pollet, L. Burovski, E. Kozik, E. Troyer, M

Réf. : PHYSICAL REVIEW LETTERS 104 (2010) 180401

We perform a quantitative simulation of the repulsive Fermi-Hubbard model using an ultracold gas trapped in an optical lattice. The entropy of the system is determined by comparing accurate measurements of the equilibrium

double occupancy with theoretical calculations over a wide range of parameters. We demonstrate the applicability of both high-temperature series and dynamical mean-field theory to obtain quantitative agreement with the experimental data. The reliability of the entropy determination is confirmed by a comprehensive analysis of all systematic errors. In the center of the Mott insulating cloud we obtain an entropy per atom as low as 0.77k(B) which is about twice as large as the entropy at the Neel transition. The corresponding temperature depends on the atom number and for small fillings reaches values on the order of the tunneling energy.

### **Quantitative Determination of Temperature in the Approach to Magnetic Order of Ultracold Fermions in an Optical Lattice**

*Article publié en 2010*

**Auteurs :** Joerdens R.; Tarruell L.; Greif D.; et al.

Réf. : PHYSICAL REVIEW LETTERS Volume: 104 Issue: 18 Article Number: 180401 DOI: 10.1103/PhysRevLett.104.180401 Published: MAY 7 2010

We perform a quantitative simulation of the repulsive Fermi-Hubbard model using an ultracold gas trapped in an optical lattice. The entropy of the system is determined by comparing accurate measurements of the equilibrium double occupancy with theoretical calculations over a wide range of parameters. We demonstrate the applicability of both high-temperature series and dynamical mean-field theory to obtain quantitative agreement with the experimental data. The reliability of the entropy determination is confirmed by a comprehensive analysis of all systematic errors. In the center of the Mott insulating cloud we obtain an entropy per atom as low as 0.77k(B) which is about twice as large as the entropy at the Neel transition. The corresponding temperature depends on the atom number and for small fillings reaches values on the order of the tunneling energy.

### **Slow Quench Dynamics of a One-Dimensional Bose Gas Confined to an Optical Lattice**

*Article publié en 2011*

**Auteurs :** Bernier, JS; Roux, G; Corinna Kollath

Réf. : PHYSICAL REVIEW LETTERS 106 (20): Art. No. 200601 MAY 18 2011

We analyze the effect of a linear time variation of the interaction strength on a trapped one-dimensional Bose gas confined to an optical lattice. The evolution of different observables such as the experimentally accessible on site particle distribution are studied as a function of the ramp time by using time-dependent numerical techniques. We find that the dynamics of a trapped system typically displays two regimes: For long ramp times, the dynamics is governed by density redistribution, while at short ramp times, local dynamics dominates as the evolution is identical to that of an homogeneous system. In the homogeneous limit, we also discuss the nontrivial scaling of the energy absorbed with the ramp time.

### **Slow quench dynamics of periodically driven quantum gases**

*Article publié en 2011*

**Auteurs :** Dario Poletti, Corinna Kollath

Réf. : PHYSICAL REVIEW A 84 (1): 10.1103/PhysRevA.84.013615 JUL 22 2011

We study the evolution of bosons in a periodically driven optical lattice during a slow change of the driving amplitude. Both the regime of high-frequency and low-frequency driving are investigated. In the low-frequency regime, resonant absorption of energy is observed. In the high-frequency regime, the dynamics is compared to a system with an effective Hamiltonian in which the atoms are "dressed" by the driving field. This "dressing" can dramatically change the amplitude and sign of the effective tunneling. A particular focus of this study is the investigation of the time scales necessary for the evolving quantum state to follow almost adiabatically to the ground state of the effective many-body system.

## Thermodynamics of the three-dimensional Hubbard model: Implications for cooling cold atomic gases in optical lattices

Article publié en 2011

Auteurs : De Leo, L; Bernier, JS; Corinna Kollath; Antoine Georges; Scarola, VW

Réf. : PHYSICAL REVIEW A 83 (2011) 023606

We present a comprehensive study of the thermodynamic properties of the three-dimensional fermionic Hubbard model, with application to cold fermionic atoms subject to an optical lattice and a trapping potential. Our study is focused on the temperature range of current experimental interest. We employ two theoretical methods—dynamical mean-field theory and high-temperature series—and perform comparative benchmarks to delimit their respective range of validity. Special attention is devoted to understand the implications that thermodynamic properties of this system have on cooling. Considering the distribution function of local occupancies in the inhomogeneous lattice, we show that, under adiabatic evolution, the variation of any observable (e. g., temperature) can be conveniently disentangled into two distinct contributions. The first contribution is due to the redistribution of atoms in the trap during the evolution, while the second one comes from the intrinsic change of the observable. Finally, we provide a simplified picture of a recently proposed cooling procedure, based on spatial entropy separation, by applying this method to an idealized model.

## Controllable manipulation and detection of local densities and bipartite entanglement in a quantum gas by a dissipative defect

Article publié en 2011

Auteurs : Barmettler Peter; Kollath Corinna

Réf. : PHYSICAL REVIEW A Volume: 84 Issue: 4 Article Number: 041606 DOI: 10.1103/PhysRevA.84.041606 Published: OCT 19 2011

We study the complex dynamics of a one-dimensional Bose gas subjected to a dissipative local defect which induces one-body atom losses. In experiments these atom losses occur, for example, when a focused electron or light beam or a single trapped ion is brought into contact with a quantum gas. We discuss how within such setups one can measure or manipulate densities locally and specify the excitations that are induced by the defect. In certain situations the defect can be used to generate entanglement in a controlled way despite its dissipative nature. The careful examination of the interplay between hole excitations and the collapse of the wave function due to nondetection of loss is crucial for the understanding of the dynamics we observe.

## Light-cone-like spreading of correlations in a quantum many-body system

Article publié en 2012

Auteurs : Cheneau, Marc; Barmettler, Peter; Poletti, Dario; Endres, Manuel; Schauss, Peter; Fukuhara, Takeshi; Gross, Christian; Bloch, Immanuel; Kollath, Corinna; Kuhr, Stefan

Réf. : NATURE, 481 (7382):484-487; 10.1038/nature10748 JAN 26 2012

In relativistic quantum field theory, information propagation is bounded by the speed of light. No such limit exists in the non-relativistic case, although in real physical systems, short-range interactions may be expected to restrict the propagation of information to finite velocities. The question of how fast correlations can spread in quantum many-body systems has been long studied(1). The existence of a maximal velocity, known as the Lieb-Robinson bound, has been shown theoretically to exist in several interacting many-body systems (for example, spins on a lattice(2-5))—such systems can be regarded as exhibiting an effective light cone that bounds the propagation speed of correlations. The existence of such a 'speed of light' has profound implications for condensed matter physics and quantum information, but has not been observed experimentally. Here we report the time-resolved detection of propagating correlations in an interacting quantum many-body system. By quenching a one-dimensional quantum gas in an optical lattice, we reveal how quasiparticle pairs transport correlations with a finite velocity across the system, resulting in an effective light cone for the quantum dynamics. Our results open perspectives for understanding the relaxation of closed quantum systems far from equilibrium(6), and for engineering the efficient quantum channels necessary for fast quantum computations(7).

## Slow quench dynamics of Mott-insulating regions in a trapped Bose gas

Article publié en 2012

**Auteurs :** Bernier Jean-Sebastien; Poletti Dario; Barmettler Peter; et al.

Réf. : PHYSICAL REVIEW A Volume: 85 Issue: 3 Article Number: 033641 DOI: 10.1103/PhysRevA.85.033641 Published: MAR 29 2012

We investigate the dynamics of Mott-insulating regions of a trapped bosonic gas as the interaction strength is changed linearly with time. The bosonic gas considered is loaded into an optical lattice and confined to a parabolic trapping potential. Two situations are addressed: the formation of Mott domains in a superfluid gas as the interaction is increased and their melting as the interaction strength is lowered. In the first case, depending on the local filling, Mott-insulating barriers can develop and hinder the density and energy transport throughout the system. In the second case, the density and local energy adjust rapidly, whereas long-range correlations require a longer time to settle. For both cases, we consider the time evolution of various observables: the local density and energy and their respective currents, the local compressibility, the local excess energy, the heat, and single-particle correlators. The evolution of these observables is obtained using the time-dependent density-matrix renormalization-group technique and comparisons with time evolutions done within the Gutzwiller approximation are provided.

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### [2007-060T] COQSYS

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**Porteur :** Fabien Bretenaker

Thème 7

## Measurement of the coupling constant in a two-frequency VECSEL

Article publié en 2010

**Auteurs :** Pal, V. Trofimoff, P. Miranda, B. X. Baili, G. Alouini, M. Morvan, L. Dolfi, D. Goldfarb, F. Sagnes, I. Ghosh, R. Fabien Bretenaker

Réf. : OPTICS EXPRESS 18 (2010) 5008-5014

We measure the coupling constant between the two perpendicularly polarized eigenstates of a two-frequency Vertical External Cavity Surface Emitting Laser (VECSEL). This measurement is performed for different values of the transverse spatial separation between the two perpendicularly polarized modes. The consequences of these measurements on the two-frequency operation of such class-A semiconductor lasers are discussed. (C) 2010 Optical Society of America

## Observation of Slow Light in the Noise Spectrum of a Vertical External Cavity Surface-Emitting Laser

Article publié en 2010

**Auteurs :** El Amili, A.; Miranda, B. -X.; Goldfarb, F.; Baili, G.; Beaudoin, G.; Sagnes, I.; Bretenaker, F.; Alouini, M.

Réf. : PHYSICAL REVIEW LETTERS 105 (22): 10.1103/PhysRevLett.105.223902 NOV 24 2010

The role of coherent population oscillations is evidenced in the noise spectrum of an ultralow noise laser. This effect is isolated in the intensity noise spectrum of an optimized single-frequency vertical external cavity surface-emitting laser. The coherent population oscillations induced by the lasing mode manifest themselves through their associated dispersion that leads to slow light effects probed by the spontaneous emission present in the nonlasing side modes.



## Lock-exchange experiments with an autocatalytic reaction front

Article publié en 2010

**Auteurs :** Malham, IB; Jarrige, N; Martin, J; Rakotomalala, N; Talon, L; Salin, D

Réf. : JOURNAL OF CHEMICAL PHYSICS 133 (2010) 244505

A viscous lock-exchange gravity current corresponds to the reciprocal exchange of two fluids of different densities in a horizontal channel. The resulting front between the two fluids spreads as the square root of time, with a diffusion coefficient reflecting the buoyancy, viscosity, and geometrical configuration of the current. On the other hand, an autocatalytic reaction front between a reactant and a product may propagate as a solitary wave, namely, at a constant velocity and with a stationary concentration profile, resulting from the balance between molecular diffusion and chemical reaction. In most systems, the fluid left behind the front has a different density leading to a lock-exchange configuration. We revisit, with a chemical reaction, the classical situation of lock-exchange. We present an experimental analysis of buoyancy effects on the shape and the velocity of the iodate arsenous acid autocatalytic reaction fronts, propagating in horizontal rectangular channels and for a wide range of aspect ratios (1/3 to 20) and cylindrical tubes. We do observe stationary-shaped fronts, spanning the height of the cell and propagating along the cell axis. Our data support the contention that the front velocity and its extension are linked to each other and that their variations scale with a single variable involving the diffusion coefficient of the lock-exchange in the absence of chemical reaction. This analysis is supported by results obtained with lattice Bathnagar-Gross-Krook (BGK) simulations Jarrige et al. [Phys. Rev. E 81, 06631 (2010)], in other geometries (like in 2D simulations by Rongy et al. [J. Chem. Phys. 127, 114710 (2007)]) and experiments in cylindrical tubes by Pojman et al. [J. Phys. Chem. 95, 1299 (1991)], and for another chemical reaction Schuszter et al. [Phys. Rev. E 79, 016216 (2009)]. (C) 2010 American Institute of Physics.

## Interacting double dark resonances in a hot atomic vapor of helium

Article publié en 2011

**Auteurs :** Kumar, S.; Laupretre, T.; Ghosh, R.; Fabien Bretenaker.; Goldfarb, F

Réf. : PHYSICAL REVIEW A 84 (2): 10.1103/PhysRevA.84.023811 AUG 9 2011

We experimentally and theoretically study two different tripod configurations using metastable helium ( $(4)He^*$ ), with the probe field polarization perpendicular and parallel to the quantization axis, defined by an applied weak magnetic field. In the first case, the two dark resonances interact incoherently and merge together into a single electromagnetically induced transparency peak with increasing coupling power. In the second case, we observe destructive interference between the two dark resonances inducing an extra absorption peak at the line center.

## Observation of noise phase locking in a single-frequency VECSEL

Article publié en 2011

**Auteurs :** El Amili A.; Pal V.; Goldfarb F.; et al.

Réf. : OPTICS EXPRESS Volume: 19 Issue: 18 Pages: 17250-17259 Published: AUG 29 2011

We present an experimental observation of phase locking effects in the intensity noise spectrum of a semiconductor laser. These noise correlations are created in the medium by coherent carrier-population oscillations induced by the beatnote between the lasing and non-lasing modes of the laser. This phase locking leads to a modification of the intensity noise profile at around the cavity free-spectral-range value. The noise correlations are evidenced by varying the relative phase shift between the laser mode and the non-lasing adjacent side modes. (C) 2011 Optical Society of America.

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**[2007-068T] SLAMP**

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Porteur : Qingli Kou

Axe A

### A multicolor microfluidic droplet dye laser with single mode emission

*Article publié en 2011*

Auteurs : Aubry, G; Qingli Kou; Soto-Velasco, J; Wang, C; Meance, S; He, JJ; Haghiri-Gosnet, AM

Réf. : APPLIED PHYSICS LETTERS 98 (2011)

A digital microfluidic dye laser that integrates a Fabry-Perot cavity with two fiber-based mirrors is shown to exhibit a single mode emission. In addition, fast switching is achieved via the alternation of droplet streams that contain two different dyes. Single-longitudinal-mode emission is observed for each dye wavelength (at 565 and 586 nm) with a linewidth narrower than 0.12 nm. This system appears thus well suited for on-chip spectroscopy and flow cytometry. (C) 2011 American Institute of Physics.

### On-chip production of liquid optical microcavities

*Article publié en 2011*

Auteurs : Aubry, G.; Wang, C.; Soto-Velasco, J.; Meance, S.; Haghiri-Gosnet, A. -M.; Kou, Q.

Réf. : MICROELECTRONIC ENGINEERING 88 (8): 2618-2621 10.1016/j.mee.2010.12.084 AUG 2011

Microfluidic production of droplets acting as optical resonators has been investigated for different liquid materials and cross-junction geometries. Liquid couples are selected to meet the requirements to refractive indexes. The generation of unconfined droplets is studied by monitoring the liquid flow rates and by changing the channel geometry. Such optical resonators used passively or actively can be of great interest as on-chip laser sources or biosensors. (C) 2011 Elsevier B.V. All rights reserved.

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**[2007-070T] SAX 2**

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Porteur : Philippe Zeitoun

Thème 6

### Seed level requirement for improving the temporal coherence of a Free-Electron Laser

*Article publié en 2009*

Auteurs : Lambert G.; Hara T.; Labat M.; et al.

Réf. : EPL Volume: 88 Issue: 5 Article Number: 54002 DOI: 10.1209/0295-5075/88/54002  
Published: DEC 2009

The temporal coherence of Free-Electron Laser (FEL) sources, which exhibit, in the self-amplified spontaneous-emission mode, spiking spectral and temporal distributions, can be drastically improved by seeding with an external laser or high-order harmonics. Here, experiments at 160 nm put in evidence that the improvement of spectral properties (and thus temporal coherence) of the FEL radiation takes place for a larger seed intensity than the one required to overcome the shot noise. Copyright (C) EPLA, 2009

## Nonlinear harmonic generation in a free-electron laser seeded with high harmonic radiation

Article publié en 2011

**Auteurs :** Tanikawa, T; Lambert, G; Hara, T; Labat, M; Tanaka, Y; Yabashi, M; Chubar, O; Marie-Emmanuelle Couprie

Réf. : EPL 94 (3): Art. No. 34001 MAY 2011

Seeding a Free-Electron Laser (FEL) drastically improves the temporal coherence of the self-amplified spontaneous emission and reduces the saturation length, even with very low-intensity seed. We report here on the achievement of single-shot nonlinear harmonics from the 2nd to the 7th order at 23 nm, on the FEL of the SCSS Test Accelerator operated at 150MeV and seeded at 160nm with harmonics generated in gas. In particular, a clear intensity enhancement leading to saturation effect observations and temporal coherence improvement for both odd and even harmonics are highlighted due to the seeding. Single-shot measurements both in spatial (vertical) and spectral domains are compared to analytical theory and numerical simulations.

## Single-Shot Diffractive Imaging with a Table-Top Femtosecond Soft X-Ray Laser-Harmonics Source

Article publié en 2009

**Auteurs :** Ravasio, A. Gauthier, D. Maia, FRNC. Billon, M. Caumes, JP. Garzella, D. Geleoc, M. Gobert, O. Hergott, JF. Pena, AM. Perez, H. Carre, B. Bourhis, E. Gierak, J. Madouri, A. Mailly, D. Schiedt, B. Fajardo, M. Gautier, J. Philippe Zeitoun. Bucksbaum, PH. Ha

Réf. : PHYSICAL REVIEW LETTERS 103 (2009) 028104

Coherent x-ray diffractive imaging is a powerful method for studies on nonperiodic structures on the nanoscale. Access to femtosecond dynamics in major physical, chemical, and biological processes requires single-shot diffraction data. Up to now, this has been limited to intense coherent pulses from a free electron laser. Here we show that laser-driven ultrashort x-ray sources offer a comparatively inexpensive alternative. We present measurements of single-shot diffraction patterns from isolated nano-objects with a single 20 fs pulse from a table-top high-harmonic x-ray laser. Images were reconstructed with a resolution of 119 nm from the single shot and 62 nm from multiple shots.

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## [2007-071T] THEX-EELS

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**Porteur :** Francesco Sottile

Axe B

## Ab initio calculations of electronic excitations: Collapsing spectral sums

Article publié en 2010

**Auteurs :** Berger, JA. Reining, L. Francesco Sottile

Réf. : PHYSICAL REVIEW B 82 (2010) 041103

We present a method for the evaluation of electronic excitations of advanced materials by reformulating spectral sum-over-states expressions such that only occupied states appear. All empty states are accounted for by one effective energy. Thus we keep the simplicity and precision of the sum-over-states approach while speeding up calculations by more than an order of magnitude. We demonstrate its power by applying it to the GW method, where a huge summation over empty states appears twice (screening and self-energy). The precision is shown for bulk Si and solid and atomic Ar. We then use it to determine the band gap of the technologically important oxide SnO<sub>2</sub>.

## Efficient calculation of the polarizability: a simplified effective-energy technique

Article publié en 2012

**Auteurs** : Berger, J. A.; Reining, L.; Sottile, F.

Réf. : EUROPEAN PHYSICAL JOURNAL B Volume: 85 Issue: 9 Article Number: 326 DOI: 10.1140/epjb/e2012-30237-5 Published: SEP 2012

In a recent publication [J.A. Berger, L. Reining, F. Sottile, Phys. Rev. B 82, 041103(R) (2010)] we introduced the effective-energy technique to calculate in an accurate and numerically efficient manner the GW self-energy as well as the polarizability, which is required to evaluate the screened Coulomb interaction  $W$ . In this work we show that the effective-energy technique can be used to further simplify the expression for the polarizability without a significant loss of accuracy. In contrast to standard sum-over-state methods where huge summations over empty states are required, our approach only requires summations over occupied states. The three simplest approximations we obtain for the polarizability are explicit functionals of an independent- or quasi-particle one-body reduced density matrix. We provide evidence of the numerical accuracy of this simplified effective-energy technique as well as an analysis of our method.

## Efficient GW calculations for SnO<sub>2</sub>, ZnO, and rubrene: The effective-energy technique

Article publié en 2012

**Auteurs** : Berger J. A.; Reining Lucia; Sottile Francesco

Réf. : PHYSICAL REVIEW B, 85 (8):10.1103/PhysRevB.85.085126 FEB 27 2012

In a recent Rapid Communication [J. A. Berger, L. Reining, and F. Sottile, Phys. Rev. B 82, 041103(R) (2010)], we presented the effective-energy technique to evaluate, in an accurate and numerically efficient manner, electronic excitations by reformulating spectral sum-over-states expressions such that only occupied states appear. In our approach all the empty states are accounted for by a single effective energy that can be obtained from first principles. In this work we provide further details of the effective-energy technique, in particular, when combined with the GW method, in which a huge summation over empty states appears in the calculation of both the screened Coulomb interaction and the self-energy. We also give further evidence of the numerical accuracy of the effective-energy technique by applying it to the technological important materials SnO<sub>2</sub> and ZnO. Finally, we use this technique to predict the band gap of bulk rubrene, an organic molecular crystal with a 140-atom unit cell.

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## [2007-074T] GULFSTREAM & [2009-035T] GULFSTREAM II

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**Porteur** : Pierre Pillet

Axe A

## Triplet-singlet conversion by broadband optical pumping

Article publié en 2012

**Auteurs** : Horchani R.; Lignier H.; Bouloufa-Maafa N.; et al.

Réf. : PHYSICAL REVIEW A Volume: 85 Issue: 3 Article Number: 030502 DOI: 10.1103/PhysRevA.85.030502 Published: MAR 6 2012

We demonstrate the conversion of cold Cs-2 molecules initially distributed over several vibrational levels of the lowest triplet state  $a(3) \Sigma^+(u)$  into the singlet ground state  $X-1 \Sigma^+(g)$ . This conversion is realized by a broadband laser exciting the molecules to a well-chosen state from which they may decay to the singlet state through two sequential single-photon emission steps: The first photon populates levels with mixed triplet-singlet

character, making possible a second spontaneous emission down to several vibrational levels of the X-1 Sigma+(g) states. By adding an optical scheme for vibrational cooling, a substantial fraction of molecules are transferred to the ground vibrational level of the singlet state. The efficiency of the conversion process, with and without vibrational cooling, is discussed at the end of the article. The presented conversion is general in scope and could be extended to other molecules.

### Vibrational cooling of cesium molecules using noncoherent broadband light

*Article publié en 2009*

**Auteurs :** Sofikitis, D. Horchani, R. Li, XL. Pichler, M. Allegrini, M. Fioretti, A. Comparat, D. Pierre Pillet

Réf. : PHYSICAL REVIEW A 80 ((2009) 051401

We demonstrate selective vibrational population transfer in cold cesium dimers using a simple approach based on the use of a shaped incoherent broadband diode laser near threshold. Optical pumping into a single vibrational level is accomplished with an incoherent light source by eliminating transitions from the targeted vibrational level. The broadband spectrum of the laser is wide enough to electronically excite several vibrational states of the molecule simultaneously. This method is relatively inexpensive, simple, and flexible to allow for development of new applications, in particular, the preparation of optically closed molecular system, opening the way to direct laser cooling of molecules.

### Deeply bound cold caesium molecules formed after 0(g)(-) resonant coupling

*Article publié en 2011*

**Auteurs :** Lignier H.; Fioretti A.; Horchani R.; et al.

Réf. : PHYSICAL CHEMISTRY CHEMICAL PHYSICS Volume: 13 Issue: 42 Pages: 18910-18920 DOI: 10.1039/c1cp21488h Published: 2011

Translationally cold caesium molecules are created by photoassociation below the  $6s + 6p(1/2)$  excited state and selectively detected by resonance enhanced two photon ionization (RE2PI). A series of excited vibrational levels belonging to the 0(g)(-) symmetry is identified. The regular progression of the vibrational spacings and of the rotational constants of the 0(g)(-) ( $6s + 6p(1/2)$ ) levels is strongly altered in two energy domains. These deviations are interpreted in terms of resonant coupling with deeply bound energy levels of two upper 0(g)(-) states dissociating into the  $6s + 6p(3/2)$  and  $6s + 5d(3/2)$  asymptotes. A theoretical model is proposed to explain the coupling and a quantum defect analysis of the perturbed level position is performed. Moreover, the resonant coupling changes dramatically the spontaneous decay products of the photoexcited molecules, strongly enhancing the decay into deeply bound levels of the a (3)Sigma+(u) triplet state and of the X(1)Sigma+(g) ground state. These results may be relevant when conceiving population transferring schemes in cold molecule systems.

### Photoionization spectroscopy of excited states of cold caesium dimers

*Article publié en 2010*

**Auteurs :** Bouloufa, N. Favilla, E. Viteau, M. Chotia, A.Fioretti, A. Gabbanini, C. Allegrini, M. Aymar, M. Comparat, D.Olivier Dulieu. Pierre Pillet

Réf. : MOLECULAR PHYSICS 108 (2010) 2355-2368

Photoionization spectroscopy of cold caesium dimers obtained by photoassociation of cold atoms in a magneto-optical trap is reported here. In particular, we report on the observation and on the spectroscopic analysis of all the excited states that have actually been used for efficient detection of cold molecules stabilized in the triplet [image omitted] ground state. They are: the [image omitted] state connected to the  $6s + 6p$  asymptote, the [image omitted] and (2)3g states connected to the  $6s + 5d$  asymptote and finally the [image omitted] state connected to the  $6s + 7s$  asymptote. The detection through these states spans a wide range of laser energies, from 8000 to 16,500  $\text{cm}^{-1}$ , obtained with different laser dyes and techniques. Information on the initial distribution of cold molecules among the different vibrational levels of the [image omitted] ground state is also provided. This spectroscopic knowledge is important when conceiving schemes for quantum manipulation, population transfer and optical detection of cold caesium molecules.

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**[2007-077T] FEASO**

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Porteur : **Pascale Mercere**

Axe **A**

**Quadriwave lateral shearing interferometry in an achromatic and continuously self-imaging regime for future x-ray phase imaging**

*Article publié en 2011*

Auteurs : Rizzi Julien; Weitkamp Timm; Guerineau Nicolas; et al.

Réf. : OPTICS LETTERS Volume: 36 Issue: 8 Pages: 1398-1400 Published: APR 15 2011

We present in this Letter a type of quadriwave lateral shearing interferometer for x-ray phase imaging. This device is based on a phase chessboard, and we take advantage of the large spectrum of the source to produce interferograms with a propagation-invariant contrast. Such a grating has been created for hard x-ray interferometry and experimentally tested on a synchrotron beamline at Soleil. (C) 2011 Optical Society of America

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**[2007-084T] OMC**

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Porteur : **Georges Gauthier**

Thème **3**

**Particle Pressure in a Sheared Suspension: A Bridge from Osmosis to Granular Dilatancy**

*Article publié en 2009*

Auteurs : Deboeuf A, Gauthier G, Martin J, Yurkovetsky Y, Morris JF

Réf. : PHYSICAL REVIEW LETTERS 102 (2009) 108301

The normal stress exerted by particles in a sheared suspension is measured by analogy with a method used to measure osmotic pressure in solutions. Particles in a liquid are confined by a fine screen to a gap between two vertical concentric cylinders, the inner of which rotates. Pressure in the liquid is sensed either by a manometer or by a pressure transducer across the screen. The particles are large enough so that Brownian motion and equilibrium osmotic pressure are vanishingly small. The measured pressure yields the shear-induced particle pressure  $P_i$ , the nonequilibrium continuation of equilibrium osmotic pressure. For volume fractions  $0.3 \leq \phi \leq 0.5$ ,  $P_i$  is strongly dependent on  $\phi$ , and linear in shear rate. Comparisons of the measured particle pressure with modeling and simulation show good agreement.

**Segregation and periodic mixing in a fluidized bidisperse suspension**

*Article publié en 2011*

Auteurs : Deboeuf, A; Gauthier, G; Martin, J; Salin, D

Réf. : NEW JOURNAL OF PHYSICS 13 10.1088/1367-2630/13/7/075005 JUL 15 2011

We address the issue of segregation in bidisperse suspensions of glass beads, by using a liquid fluidized bed in the inertialess regime and an acoustic technique for acquiring the axial composition along the column. Fluidization balances the buoyancy of the particles by a constant uniform upward flow, and therefore enables long-time experiments. From the analysis of the transient segregation fronts, we have collected precise measurements on the sedimentation velocities of small and large beads,  $U(s)$  and  $U(1)$ , in homogeneous suspensions at the same volume fraction,  $\bar{\phi}$ , for both the bead species, and for different size ratios,

$1.13 \leq \gamma \leq 1.64$ , and solid concentrations,  $25\% \leq \bar{\Phi} \leq 50\%$ . Our measurements provide evidence for a difference in the sedimentation velocities,  $U(s)$  and  $U(1)$ , over all the ranges of  $\lambda$  and  $\bar{\Phi}$  covered. These results make one expect that a long-term fluidization should then result in a stationary segregated!

state, which was indeed always obtained for large enough particle size ratios,  $\lambda \geq 1.43$ . However, at high concentration and for particles of close sizes,  $\lambda \leq 1.41$ , we observed a surprising pseudo-periodic intermittency of slow segregation and quick mixing phases. The intermittency time is much longer than the batch sedimentation time and becomes noisy at very high concentration, for which metastable states have been observed. The origin of the mixing destabilization remains an open issue, but we note however that the domain of occurrence,  $\lambda \leq 1.41$ , also corresponds, in our experiments, to a continuous size distribution of the particles.

## Normal stress measurements in sheared non-Brownian suspensions

*Article publié en 2013*

Auteurs : Garland, S.; Gauthier, G.; Martin, J.; Morris, J. F.

Réf. : JOURNAL OF RHEOLOGY Volume: 57 Issue: 1 Pages: 71-88 DOI: 10.1122/1.4758001  
Published: JAN 2013

Measurements in a cylindrical Taylor-Couette device of the shear-induced radial normal stress in a suspension of neutrally buoyant non-Brownian (noncolloidal) spheres immersed in a Newtonian viscous liquid are reported. The radial normal stress of the fluid phase was obtained by measurement of the grid pressure  $P_g$ , i.e., the liquid pressure measured behind a grid which restrained the particles from crossing. The radial component of the total stress of the suspension was obtained by measurement of the pressure,  $P_m$ , behind a membrane exposed to both phases. Pressure measurements, varying linearly with the shear rate, were obtained for shear rates low enough to insure a grid pressure below a particle size dependent capillary stress. Under these experimental conditions, the membrane pressure is shown to equal the second normal stress difference,  $N_2$ , of the suspension stress whereas the difference between the grid pressure and the total pressure,  $P_g - P_m$ , equals the radial normal stress of the particle phase,  $\Sigma(p)(rr)$ . The collected data show that  $\Sigma(p)(rr)$  is about 1 order of magnitude higher than the second normal stress difference of the suspension. The  $\Sigma(p)(rr)$  values obtained in this manner are independent of the particle size, and their ratio to the suspension shear stress increases quadratically with  $\phi$ , in the range  $0 < \phi < 0.4$ . This finding, in agreement with the theoretical particle pressure prediction of Brady and Morris [J. Fluid Mech. 348, 103-139 (1997)] for small  $\phi$ , supports the contention that the particle phase normal stress  $\Sigma(p)(rr)$  is due to asymmetric pair interactions under dilute conditions, and may not require many-body effects. Moreover we show that the values of  $\Sigma(p)(rr)$ , normalized by the fluid shear stress,  $\eta(f)|\dot{\gamma}|$  with  $\eta(f)$  the suspending fluid viscosity and  $|\dot{\gamma}|$  the magnitude of the shear rate, are well-described by a simple analytic expression recently proposed for the particle pressure. (C) 2013 The Society of Rheology. [<http://dx.doi.org/10.1122/1.4758001>]