Les publications des projets 2009

[2009-002T] DETAMI ................................................................. 6
  Acoustic Analog to the Dynamical Casimir Effect in a Bose-Einstein Condensate ............................ 6
  Violation of the Cauchy-Schwarz Inequality with Matter Waves ........................................................ 6

[2009-006T] LEEPAR ........................................................................ 6
  Direct and Indirect Radiolytic Effects in Highly Concentrated Aqueous Solutions of Bromide ....... 7
  Energy Dependence of Gold Nanoparticle Radiosensitization in Plasmid DNA ................................. 7
  Picosecond Pulse Radiolysis Study of Highly Concentrated Nitric Acid Solutions: Formation Mechanism of NO3 center dot Radical ........................................................... 8

[2009-007T] RADICAUX .................................................................. 8
  Comprehensive vacuum ultraviolet photoionization study of the CF3 center dot trifluoromethyl radical using synchrotron radiation ................................................................. 8
  Photoionization of Propargyl and Bromopropargyl Radicals: A Threshold Photoelectron Spectroscopic Study ................................................................. 9
  The photoionisation of propargylene and diazopropyne ...................................................................... 10
  Threshold Photoelectron Spectroscopy of Cyclopropenylidene, Chlorocyclopropenylidene, and Their Deuterated Isotopomers ................................................................. 10

[2009-009T] RHEO2D ........................................................................ 11
  Active membranes with bound F-actin: sliding vs. sticking conditions ................................................. 11
  Amorphous freezing in two dimensions: From soft coils to rigid particles ........................................ 11
  Langmuir polymer films: recent results and new perspectives ................................................................. 12
  Reptation in langmuir polymer monolayers ............................................................................................ 12
  Shear rheology of lipid monolayers and insights on membrane fluidity ............................................... 13
  Solid Character of Membrane Ceramides: A Surface Rheology Study of Their Mixtures with Sphingomyelin ................................................................. 13

[2009-014T] MELYSCO ...................................................................... 13
  Long-Range Architecture of Single Lipid-Based Complex Nanoparticles with Local Hexagonal Packing .............................................................................................................. 14

[2009-014T & 2009-073T] MELYSCO & DYNNANOCAPS ................................................................. 14
  Supramolecular Assemblies of Lipid-Coated Polyelectrolytes ................................................................. 14

[2009-016T] SURFOAM ................................................................. 15
  Adsorption, Organization, and Rheology of Catanionic Layers at the Air/Water Interface .............. 15
  On the origin of the stability of foams made from catanionic surfactant mixtures ............................. 16

[2009-017T] FRACHET ................................................................. 16
  A simple device for dielectric spectroscopy of polymers with temperature regulation close to 300 K based on a Peltier junction ................................................................. 16
  Bulk Elastic Fingering Instability in Hele-Shaw Cells ........................................................................ 17
Permeability of self-affine aperture fields

[2009-019T] TSI2D

Effect of annealing on the superconducting properties of a-NbxSi1-x thin films

Tunable Superconducting Properties of a-NbSi Thin Films and Application to Detection in Astrophysics

[2009-020T] MONOSUPER

Different effects of Ni and Co substitution on the transport properties of BaFe2As2

Incommensurate spin density wave versus local magnetic inhomogeneities in Ba(Fe1-xNix)(2)As-2: a Fe-57 Mossbauer spectral study

[2009-023T] IMMAGE

Polarization control of high order harmonics in the EUV photon energy range

[2009-023T & 2009-084T] IMMAGE & POL-IMMAGE

Laser-induced ultrafast demagnetization in the presence of a nanoscale magnetic domain network

Table-top resonant magnetic scattering with extreme ultraviolet light from high-order harmonic generation

[2009-024T] SEMICMAG

Joule heating and current-induced domain wall motion

Spin Drift Velocity, Polarization, and Current-Driven Domain-Wall Motion in (Ga,Mn)(As,P)

Track heating study for current-induced domain wall motion experiments

[2009-024T & 2010-033T] SEMICMAG & SEMIMAG II

Current induced domain wall motion in GaMnAs close to the Curie temperature

[2009-026T] FEMTOCOMBO

Coherent beam combination of narrow-linewidth 1.5 μm fiber amplifiers in a long-pulse regime

Coherent beam combining of two femtosecond fiber chirped-pulse amplifiers

Impact of spectral phase mismatch on femtosecond coherent beam combining systems

Passive coherent beam combining of two femtosecond fiber chirped-pulse amplifiers

[2009-028T] JECAL

Highly radiative shock experiments driven by GEKKO XII

Laser-driven plasma jets propagating in an ambient gas studied with optical and proton diagnostics

[2009-029T] AGRAWAL

Raman amplification of optical pulses in silicon nanowaveguides: Impact of spectral broadening of pump pulses

[2009-031T] PICORRE

Polariton Condensation in Photonic Molecules

[2009-033T] HACOR

In vivo structural imaging of the cornea by polarization-resolved second harmonic microscopy
Polarization-resolved Second Harmonic microscopy in anisotropic thick tissues

[2009-034T] COX

ANKAphase: software for single-distance phase retrieval from inline X-ray phase-contrast radiographs

Assessment of grating-based X-ray phase-contrast CT for differentiation of invasive ductal carcinoma and ductal carcinoma in situ in an experimental ex vivo set-up

At-wavelength characterization of refractive x-ray lenses using a two-dimensional grating interferometer

Fabrication of two-dimensional hard X-ray diffraction gratings

Global and local hard X-ray tomography of a centimeter-size tumor vessel tree

Heat bump on a monochromator crystal measured with X-ray grating interferometry

High-order-harmonic generation in gas with a flat-top laser beam

Impact of wave front and coherence optimization in coherent diffractive imaging

Interlaced phase stepping in phase-contrast x-ray tomography

Multimodal imaging of human cerebellum - merging X-ray phase microtomography, magnetic resonance microscopy and histology

Numerical comparison of X-ray differential phase contrast and attenuation contrast

Protocol to study wavefront preservation capabilities of reflective X-ray optics with coherent synchrotron light

Protocol to study wavefront preservation capabilities of reflective X-ray optics with coherent synchrotron light

Quantitative X-ray phase-contrast computed tomography at 82 keV

Single-shot Femtosecond X-Ray Holography Using Extended References

Three-dimensional quantification of capillary networks in healthy and cancerous tissues of two mice

Trimodal low-dose X-ray tomography

X-Ray Phase-Contrast CT of a Pancreatic Ductal Adenocarcinoma Mouse Model

X-ray vector radiography for bone micro-architecture diagnostics

[2009-038T] DYNQG

Implementing quantum algorithms in hyperfine levels of ultracold polar molecules by optimal control

Quantum gates driven by microwave pulses in hyperfine levels of ultracold heteronuclear dimers

Toward scalable information processing with ultracold polar molecules in an electric field: A numerical investigation

[2009-039T] CIRMOQ

Controlled full adder-subtractor by vibrational computing

[2009-042T] ASSENSOR

Functionalized nanoporous track-etched beta-PVDF membrane electrodes for lead(II) determination by square wave anodic stripping voltammetry
Nanopore size tuning of polymeric membranes using the RAFT-mediated radical polymerization [2009-059T] ARPNIC ................................................................................................................................................. 42
Opening of the superconducting gap in the hole pockets of Ba(Fe1-xCox)(2)As-2 as seen via angle-resolved photoelectron spectroscopy ............................................................................................................ 43
Enhanced H-2 catalytic formation on specific topological defects in interstellar graphenic dust grain models ................................................................. 43
Enhancement of x-rays generated by a guided laser wakefield accelerator inside capillary tubes 44
Nanometer Scale Spectral Imaging of Quantum Emitters in Nanowires and Its Correlation to Their Atomically Resolved Structure ............................................................................................................ 45
Visualizing highly localized luminescence in GaN/AlN heterostructures in nanowires 45
Anisotropy of graphite optical conductivity ................................................................................................................................................. 46
Higher-order photon correlations in pulsed photonic crystal nanolasers .......................................................................................................................... 46
Identification of the stimulated-emission threshold in high-beta nanoscale lasers through phase-space reconstruction ............................................................................................................ 47
All-silicon photonic crystal photoconductor on silicon-on-insulator at telecom wavelength........... 47
Schottky MSM junctions for carrier depletion in silicon photonic crystal microcavities ................. 48
Norovirus Capsid Proteins Self-Assemble through Biphasic Kinetics via Long-Lived Stave-like Intermediates ................................................................. 48
Unusual self-assembly properties of Norovirus Newbury2 virus-like particles ............................ 49
A proposal for multi-tens of GW fully coherent femtosecond soft X-ray lasers ......................... 49
Comparison of natural and forced amplification regimes in plasma-based soft-x-ray lasers seeded by high-order harmonics .......................................................................................................................... 50
Optical and electrical properties of laser doped Si:B in the alloy range ........................................ 50
Soft x-ray plasma-based seeded multistage amplification chain ..................................................... 51
Bismuth-Catalyzed and Doped Silicon Nanowires for One-Pump-Down Fabrication of Radial Junction Solar Cells ................................................................................................................................................. 52
Geometry-related magnetic interference patterns in long S N S Josephson junctions ................. 52
Magnetic imaging by Fourier transform holography using linearly polarized x-rays ................... 53
Co-59 NMR evidence for charge and orbital order in the kagome-like structure of Na2/3CoO2 .... 53
[2009-086T] ATTOS .................................................................................................................................................. 54
  Dual Antiferromagnetic Coupling at La0.67Sr0.33MnO3/SrRuO3 Interfaces ...................................................... 54
  Low frequency noise in La0.7Sr0.3MnO3 based magnetic tunnel junctions .................................................. 54

[2009-087T] XUV-PHLAG ......................................................................................................................................... 55
  Two-colour generation in a chirped seeded free-electron laser: a close look .............................................. 55

[2009-088T] SUPRASPIN ......................................................................................................................................... 55
  Controllable manipulation of superconductivity using magnetic vortices .................................................. 56
  Equal-spin Andreev reflection and long-range coherent transport in high-temperature superconductor/half-metallic ferromagnet junctions ................................................................. 56
  Hysteretic magnetic pinning and reversible resistance switching in high-temperature superconductor/ferromagnet multilayers .................................................................................. 57
  Imprinting nanoporous alumina patterns into the magneto-transport of oxide superconductors 57
  Ultrathin oxide films and interfaces for electronics and spintronics .......................................................... 57
  Vortex lattice dynamics in Nb films with competing intrinsic random and artificial periodic pinning
  ........................................................................................................................................................................... 58
Acoustic Analog to the Dynamical Casimir Effect in a Bose-Einstein Condensate

_Article publié en 2012_


Réf.: PHYS REV LETT 109 (2012), -

_Thématiques_: Physics, Multidisciplinary

We have modulated the density of a trapped Bose-Einstein condensate by changing the trap stiffness, thereby modulating the speed of sound. We observe the creation of correlated excitations with equal and opposite momenta, and show that for a well-defined modulation frequency, the frequency of the excitations is half that of the trap modulation frequency.

Violation of the Cauchy-Schwarz Inequality with Matter Waves

_Article publié en 2012_

_Auteurs_: Kheruntsyan, K. V.; Jaskula, J-C.; Deuar, P.; Bonneau, M.; Partridge, G. B.; Ruaudel, J.; Lopes, R.; Boiron, D.; Westbrook, C. I.

Réf.: PHYS REV LETT 108 (2012), -

_Thématiques_: Physics, Multidisciplinary

The Cauchy-Schwarz (CS) inequality—one of the most widely used and important inequalities in mathematics—can be formulated as an upper bound to the strength of correlations between classically fluctuating quantities. Quantum-mechanical correlations can, however, exceed classical bounds. Here we realize four-wave mixing of atomic matter waves using colliding Bose-Einstein condensates, and demonstrate the violation of a multimode CS inequality for atom number correlations in opposite zones of the collision halo. The correlated atoms have large spatial separations and therefore open new opportunities for extending fundamental quantum-nonlocality tests to ensembles of massive particles.
Direct and Indirect Radiolytic Effects in Highly Concentrated Aqueous Solutions of Bromide

*Article publié en 2011*

*Auteurs:* Balcerzyk, Anna; LaVerne, Jay; Mostafavi, Mehran

*Réf.:* J PHYS CHEM A **115** (2011), 4326-4333

**Thématiques:** Chemistry, Physical; Physics, Atomic, Molecular & Chemical

Highly concentrated aqueous solutions of bromide were used to examine the total radical yield in the direct decomposition of water by gamma-rays. Bromide concentrations were varied up to 6 M at which almost all OH center dot radicals, H-center dot atoms, and hydrated electrons produced in the picosecond range oxidize bromide to ultimately form Br-3(-), a stable species that can easily be measured with a spectrometer. Considering only the decomposition of water in the presence of air and in acidic conditions, the apparent yield of oxidizing species is found to be around \((10 \pm 0.05) \times 10^{-7}\) mol J\(^{-1}\). The absorption of irradiation dose by the solute at high concentration is discussed and quantitatively evaluated. At 6 M Br- solutions, 38% of the dose is absorbed by solutes and Br- is directly ionized. The optimal value for the initial yield of the radicals produced by direct radiolytic Br- ionization is found to be \((9.6 \pm 0.5) \times 10^{-7}\) mol J\(^{-1}\).

Energy Dependence of Gold Nanoparticle Radiosensitization in Plasmid DNA

*Article publié en 2011*

*Auteurs:* McMahon, Stephen J.; Hyland, Wendy B.; Brun, Emilie; Butterworth, Karl T.; Coulter, Jonathan A.; Douki, Thierry; Hirst, David G.; Jain, Suneil; Kavanagh, Anthony P.; Krpetic, Zeljka; Mendenhall, Marcus H.; Muir, Mark F.; Prise, Kevin M.; Requardt, Herwig; Sanche, Leon; Schettino, Giuseppe; Currell, Fred J.; Sicard-Roselli, Cecile

*Réf.:* J PHYS CHEM C **115** (2011), 20160-20167

**Thématiques:** Chemistry, Physical; Nanoscience & Nanotechnology; Materials Science, Multidisciplinary

Gold nanoparticles (GNPs) are of considerable interest for use as a radiosensitizer, because of their biocompatibility and their ability to increase dose deposited because of their high mass energy absorption coefficient. Their sensitizing properties have been verified experimentally, but a discrepancy between the experimental results and theoretical predictions suggests that the sensitizing effect does not depend solely on gold’s superior absorption of energetic photons. This work presents the results of three sets of experiments that independently mapped out the energy dependence of the radiosensitizing effects of GNPs on plasmid DNA suspended in water. Incident photon energy was varied from 11.8 to 80 keV through the use of monochromatic synchrotron and broadband X-rays. These results depart significantly from the theoretical predictions in two ways: First, the sensitization is significantly larger than would be predicted; second, it does not vary with energy as would be predicted from energy absorption coefficients. These results clearly
demonstrate that the effects of GNP-enhanced therapies cannot be predicted by considering additional dose alone and that a greater understanding of the processes involved is necessary for the development of future therapeutics.

**Picosecond Pulse Radiolysis Study of Highly Concentrated Nitric Acid Solutions: Formation Mechanism of NO3 center dot Radical**

*Article publié en 2012*

**Auteurs**: Balcerzyk, Anna; El Omar, Abdel Karim; Schmidhammer, Uli; Pernot, Pascal; Mostafavi, Mehran

**Réf.**: J PHYS CHEM A **116** (2012), 7302-7307

**Thématiques**: Chemistry, Physical; Physics, Atomic, Molecular & Chemical

The formation of nitrate radical, NO3 center dot, is observed for the first time directly by picosecond pulse radiolysis of highly concentrated nitric acid solutions. The experimental yield of NO3- ionization is deduced from the pulse-probe transient absorption measurements in the visible region where this radical absorbs. On the basis of the value of the extinction coefficient of nitrate radical at 640 nm equal to 1300 M cm(-1), the experimental yield of NO3 center dot at 20 ps is found to be around 0.36 x 10(-7), 1.33 x 10(-7), and 2.85 x 10(-7) mol J(-1) for 1, 3.5, and 7 M nitric acid solutions, respectively. Relative to the dose absorbed by nitric acid by the direct effect, we find an unexpected high formation yield of the nitrate radical within the electron pulse. Therefore, we suggest that the trapping of the positive hole, H2O center dot+, by NO3- also contributes to the formation of NO3 center dot within the electron pulse. Moreover, after the pulse and within 4 ns, the beginning of the reaction of OH center dot radical with undissociated nitric acid is observed for the most concentrated nitric acid solution.

**[2009-007T] RADICAUX**

**Porteur**: Christian Alcaraz

**Thème 2**

**Comprehensive vacuum ultraviolet photoionization study of the CF3 center dot trifluoromethyl radical using synchrotron radiation**

*Article publié en 2012*

**Auteurs**: Dossmann (Soldi-Lose), Heloise; Garcia, Gustavo A.; Nahon, Laurent; de Miranda, Barbara K. C.; Alcaraz, Christian

**Réf.**: J CHEM PHYS **136** (2012), -
The trifluoromethyl radical, CF3 center dot, is studied for the first time by means of threshold photoelectron spectroscopy (TPES). The radical is produced in the gas phase using the flash-pyrolysis technique from hexafluoroethane as a precursor. CF3+ total ion yield and mass-selected TPES of the radical are recorded using a spectrometer based upon velocity map imaging and Wiley-McLaren time-of-flight coupled to the synchrotron radiation. The high resolution of the instrument and of the photons allows the observation of rich vibrational progressions in the TPES of CF3 center dot. By using Franck-Condon factors computed by Bowman and coworkers, we have been able to simulate the TPES. The initial vibrational temperature of the radical beam has been evaluated at 350 +/- 70 K. The structures have been identified as transitions between (n(1), n(2)) and (n(1)(+), n(2)(+)) vibrational levels of CF3 and CF3+ with small excitation of the breathing mode, nu(+)(1), and large excitation (n(2)(+) = 10-26) of the umbrella mode, nu(+)(2), in the cation. From the energy separation between the two resolved peaks of each band, a value of 994 +/- 16 cm(-1) has been derived for the nu(+)(1) breathing frequency of CF3+. For the high-lying n(2)(+) levels, the apparent nu(+)(2) umbrella spacing, 820 +/- 14 cm(-1), is fairly constant. Taking into account the nu(+)(2) anharmonicity calculated by Bowman and coworkers, we have deduced nu(+)(2) = 809 +/- 14 cm(-1), and semi-empirical estimations of the adiabatic ionization energy IEad.(CF3 center dot) are proposed in good agreement with most of previous works. A value of the vertical ionization potential, IEvert.(CF3 center dot) = 11.02 eV, has been derived from the observation of a photoelectron spectrum recorded at a fixed photon energy of 12 eV.

(C) 2012 American Institute of Physics. [http://dx.doi.org/10.1063/1.4719529]

Photoionization of Propargyl and Bromopropargyl Radicals: A Threshold Photoelectron Spectroscopic Study

Article publié en 2011

Auteurs : Hemberger, Patrick; Lang, Melanie; Noller, Bastian; Fischer, Ingo; Alcaraz, Christian; Cunha de Miranda, Barbara K.; Garcia, Gustavo A.; Soldi-Lose, Heloise

Réf. : J PHYS CHEM A 115 (2011), 2225-2230

In this Article, we present mass-selected threshold photoelectron spectra of propargyl as well as the 1- and 3-bromopropargyl radicals. The reactive intermediates were produced by flash pyrolysis of suitable precursors and ionized by VUV synchrotron radiation. The TPES of the propargyl radical was simulated using data from a recent high-level computational study. An ionization energy (IE) of 8.71 +/- 0.02 eV was obtained, in excellent agreement with computations, but slightly above previous experimental IEs. The pyrolysis of 1,3-dibromopropyne delivers both 1- and 3-bromopropargyl radicals that can be distinguished by their different ionization energies (8.34 and 8.16 eV). To explain the vibrational structure, a Franck-Condon simulation was performed, based on DFT calculations, which can account for all major spectral features. Bromopropargyl photoionizes dissociatively beginning at around 10.1 eV. Cationic excited states of 1- and 3-bromopropargyl were tentatively identified. The dissociative photoionization of the precursor (1,3-dibromopropyne) was also examined, delivering an AE(0K) (C(3)H(2)Br(+)/C(3)H(2)Br(2)) of 10.6 eV.
The photoionisation of propargylene and diazopropyne

*Article publié en 2011*

**Auteurs** : Steinbauer, Michael; Lang, Melanie; Fischer, Ingo; Cunha de Miranda, Barbara K.; Romanzin, Claire; Alcaraz, Christian

**Réf.** : PHYS CHEM CHEM PHYS 13 (2011), 17956-17959

**Thématiques** : Chemistry, Physical; Physics, Atomic, Molecular & Chemical

The photoionisation of the C(3)H(2) isomer propargylene was studied using synchrotron radiation and coincidence techniques. An adiabatic ionisation energy (IE(ad)) of 8.99 ± 0.02 eV was determined. The precursor diazopropyne was investigated as well. Ionisation and appearance energies were measured.

Threshold Photoelectron Spectroscopy of Cyclopropenylidene, Chlorocyclopropenylidene, and Their Deuterated Isotopomers

*Article publié en 2010*

**Auteurs** : Hemberger, Patrick; Noller, Bastian; Steinbauer, Michael; Fischer, Ingo; Alcaraz, Christian; Cunha de Miranda, Barbara K.; Garcia, Gustavo A.; Soldi-Lose, Heloise

**Réf.** : J PHYS CHEM A 114 (2010), 11269-11276

**Thématiques** : Chemistry, Physical; Physics, Atomic, Molecular & Chemical

Cyclopropenylidene (c-C(3)H(2)), chlorocyclopropenylidene (c-C(3)HCl), and their deuterated isotopomers were studied by the threshold photoelectron-photoion coincidence (TPEPICO) technique using VUV synchrotron radiation. The carbenes were generated via flash pyrolysis. In all species a change in geometry is visible upon ionization, with significant activity in the C=C, C-C-stretching mode and, in the case of c-C(3)H(2)/D(2), the C-H-bending mode. The electron is removed from an sp(2) like hybrid orbital centered on the carbene C atom. The mass selected threshold photoelectron (TPE) spectra were fitted by a Franck-Condon simulation, yielding the equilibrium geometry of the cation ground state ((1)A(1)). The adiabatic ionization energy IE(ad) of c-C(3)H, was determined to be 9.17 eV, in good agreement with calculations and literature values. Two vibrational wavenumbers of the cation were determined experimentally (nu(+) = 1150 cm(-1)) and nu(+) = 1530 cm(-1)). Chlorocyclopropenylidene was also studied by TPE spectroscopy and has a similar IE(ad) of 9.17 eV. The spectrum also shows a vibrational progression that corresponds to the C=C- and C-C-stretching modes of the cation. The equilibrium geometry was also determined by a Franck-Condon fit. The IE(ad) of the deuterated isotopomers, c-C(3)D(2) and c-C(3)DCl, were also determined to be 9.17 eV. The spectra confirm the assignments for the nondeuterated species.
Active membranes with bound F-actin: sliding vs. sticking conditions

*Article publié en 2011*

*Auteurs*: Isanta, Silvia; Espinosa, Gabriel; Rodriguez-Garcia, Ruddy; Natale, Paolo; Lopez-Montero, Ivan; Langevin, Dominique; Monroy, Francisco

*Réf.*: *SOFT MATTER* 7 (2011), 3100-3107

**Thématiques**: Chemistry, Physical; Materials Science, Multidisciplinary; Physics, Multidisciplinary; Polymer Science

Actin is a multifunctional protein able to polymerise under ATP consumption as dynamic filaments involved in a number of membrane processes. Its ability to perform treadmilling motion is efficiently exploited to exert directed forces on the membrane structures where filaments are attached. In addition to the structural impact of fastening rigid actin filaments to a flexible membrane, out-of-equilibrium actin motions must impinge special membrane activity features. In this paper, we report an experimental study on the compression and shear rheology of lipid monolayers where filamentous actin is attached. Two different binding scenarios are proposed to simulate respectively sliding and sticking conditions. Covalent actin binding causes a significant enhancement of membrane fluidity, observed as a systematic decrease of compression and shear surface viscosities upon filament sticking. This fluidification can be only understood as a dynamical consequence of actin activity. These results constitute a first piece of rheological evidence on the active viscoelasticity of actin-based membranes.

Amorphous freezing in two dimensions: From soft coils to rigid particles

*Article publié en 2010*

*Auteurs*: Maestro, A.; Langevin, D.; Monroy, F.

*Réf.*: *EUR PHYS J E* 31 (2010), 89-94

**Thématiques**: Chemistry, Physical; Materials Science, Multidisciplinary; Physics, Applied; Polymer Science

The topic of the gel transition in two dimensions is revisited by considering data on the shear elasticity of Langmuir monolayers of different spherical objects. Amorphous freezing can be associated to structural percolation in a lattice able to resist shear stresses. The shear modulus and its dependence on the packing fraction are found to strongly depend on the details of the interaction potential and largely differ from expectations for entropic networks. This behaviour can
be interpreted in terms of more elaborated percolation theories including central forces and bond-bending forces.

Langmuir polymer films: recent results and new perspectives

*Article publié en 2012*

*Auteurs*: Monroy, F.; Arriaga, L. R.; Langevin, D.

*Réf.*: PHYS CHEM CHEM PHYS 14 (2012), 14450-14459

*Thématiques*: Chemistry, Physical; Physics, Atomic, Molecular & Chemical

Langmuir polymer films (LPFs) are very interesting systems to probe quasi-two dimensional dynamics. Although adsorbed on water, the substrate is fluid enough to avoid irreversible pinning at adsorption sites, as with solid substrates. LPFs in dense states can exhibit a high degree of metastability, however reproducible measurements can be performed on films which have not been previously compressed. The shear rheology is one of the most active fields of research, especially because it allows investigation of flow behaviour in LPFs, thus of possible reptation motion in semidilute films under good solvent conditions. It also allows probing glassy behaviour in dense films under poor solvent conditions. In this perspective article, we review the recent literature and discuss unpublished results on the dynamics of the glass transition, recently observed in these quasi-2D systems at low temperatures. We conclude by listing new problems and open questions emerging from this research area.

Reptation in langmuir polymer monolayers

*Article publié en 2010*

*Auteurs*: Maestro, Armando; Hilles, Hani M.; Ortega, Francisco; Rubio, Ramon G.; Langevin, Dominique; Monroy, Francisco

*Réf.*: SOFT MATTER 6 (2010), 4407-4412

*Thématiques*: Chemistry, Physical; Materials Science, Multidisciplinary; Physics, Multidisciplinary; Polymer Science

We report the existence of reptation motion typical of entangled polymer chains in dense polymer monolayers spread at the air-water interface. Ellipsometry determinations of the layer thickness reveal a thickening of the layers in the semi-dilute region, enabling the existence of entanglements. Relaxation measurements were performed using compression and shear surface deformations. The resulting dependence on the chain concentration and size are compatible with the existence of diffusion reptation motions controlling molecular transport inside the monolayer. As in the bulk, these features are observed above a critical number of monomers, N(e), for which chain entanglements become possible.
Shear rheology of lipid monolayers and insights on membrane fluidity

Article publié en 2011

Auteurs: Espinosa, Gabriel; Lopez-Montero, Ivan; Monroy, Francisco; Langevin, Dominique

Réf.: P NATL ACAD SCI USA 108 (2011), 6008-6013

Thématiques: Multidisciplinary Sciences

The concept of membrane fluidity usually refers to a high molecular mobility inside the lipid bilayer which enables lateral diffusion of embedded proteins. Fluids have the ability to flow under an applied shear stress whereas solids resist shear deformations. Biological membranes require both properties for their function: high lateral fluidity and structural rigidity. Consequently, an adequate account must include, in addition to viscosity, the possibility for a nonzero shear modulus. This knowledge is still lacking as measurements of membrane shear properties have remained incomplete so far. In the present contribution we report a surface shear rheology study of different lipid monolayers that model distinct biologically relevant situations. The results evidence a large variety of mechanical behavior under lateral shear flow.

Solid Character of Membrane Ceramides: A Surface Rheology Study of Their Mixtures with Sphingomyelin

Article publié en 2011

Auteurs: Catapano, Elisa R.; Arriaga, Laura R.; Espinosa, Gabriel; Monroy, Francisco; Langevin, Dominique; Lopez-Montero, Ivan

Réf.: BIOPHYS J 101 (2011), 2721-2730

Thématiques: Biophysics

The compression and shear viscoelasticities of egg-ceramide and its mixtures with sphingomyelin were investigated using oscillatory surface rheology performed on Langmuir monolayers. We found high values for the compression and shear moduli for ceramide, compatible with a solid-state membrane, and extremely high surface viscosities when compared to typical fluid lipids. A fluidlike rheological behavior was found for sphingomyelin. Lateral mobilities, measured from particle tracking experiments, were correlated with the monolayer viscosities through the usual hydrodynamic relationships. In conclusion, ceramide increases the solid character of sphingomyelin-based membranes and decreases their fluidity, thus drastically decreasing the lateral mobilities of embedded objects. This mechanical behavior may involve important physiological consequences in biological membranes containing ceramides.

[2009-014T] MELYSICO

Porteur: Medhi Zeghal
Long-Range Architecture of Single Lipid-Based Complex Nanoparticles with Local Hexagonal Packing

Article publié en 2011

Auteurs : Tresset, Guillaume; Lansac, Yves

Réf. : J PHYS CHEM LETT 2 (2011), 41-46

Thématiques : Chemistry, Physical; Nanoscience & Nanotechnology; Materials Science, Multidisciplinary; Physics, Atomic, Molecular & Chemical

The three-dimensional architecture of single nanoparticles made of inverse micellar lipids templated on polyelectrolytes and exhibiting a local hexagonal packing is elucidated by high-resolution cryoelectron microscopy and coarse-grained Monte Carlo simulations. Cryoelectron microscopy demonstrates that the internal structure of the complexes is less ordered than commonly recognized from X-ray diffraction. We have devised a coarse-grained model of self-avoiding flexible tubes mimicking the lipid-coated polyelectrolytes and interacting via a short-range attractive potential. Consistently with cryoelectron microscopy, the resulting clusters obtained through a Monte Carlo scheme exhibit a varying degree of order ranging from weakly organized aggregates to partially organized spooled and straight bundles, depending on the length and on the persistence length of the tubes. These findings may help in the design of self-assembled lipid-based complexes for biomechanical and nanotechnological applications.

[2009-014T & 2009-073T] MELYSCO & DYNNANOCAPS

Porteur : Medhi Zeghal & Guillaume Tresset

Supramolecular Assemblies of Lipid-Coated Polyelectrolytes

Article publié en 2012

Auteurs : Tresset, Guillaume; Lansac, Yves; Romet-Lemonne, Guillaume

Réf. : LANGMUIR 28 (2012), 5743-5752

Thématiques : Chemistry, Multidisciplinary; Chemistry, Physical; Materials Science, Multidisciplinary

We reveal the existence of a general class of supramolecular assemblies made up of lipid-coated polyelectrolytes including the celebrated lipid nucleic acid complexes. With the aid of high-resolution cryo-electron microscopy, we unveil the nanoscale internal organization of assemblies generated with a wide range of synthetic and biological polyelectrolytes, several of them being investigated in this context for the first time, namely, poly(styrene sulfonic acid),
carboxymethylcellulose, and filamentous actin. Using an original coarse-grained model representing lipid-coated polyelectrolytes as semiflexible tubes, we thoroughly explored the morphologies resulting from the self-assembly process as a function of tube lengths and rigidities; the computed structures are fully consistent with the experimental observations. In particular, we found a strong extension of the correlation range of the order parameter as the rigidity of the lipid-coated polyelectrolytes increases. Electrostatic interactions provide a stabilizing mechanism leading to finite-size equilibrium assemblies. These assemblies may constitute a generic route for interfacing polyelectrolytes to living cells to perform gene delivery, for instance.

[2009-016T] SURFOAM

Porteur : Wiebke Drenckhan

Thème 3

Adsorption, Organization, and Rheology of Catanionic Layers at the Air/Water Interface

Article publié en 2013

Auteurs : Arriaga, Laura R.; Varade, Dharmesh; Carriere, David; Drenckhan, Wiebke; Langevin, Dominique

Réf. : LANGMUIR 29 (2013), 3214-3222

Thématiques : Chemistry, Multidisciplinary; Chemistry, Physical; Materials Science, Multidisciplinary

We have investigated the adsorption and organization at the air/water interface of catanionic molecules released from a dispersion of solid-like catanionic vesicles composed of myristic acid and cetyl trimethylammonium chloride at the 2:1 ratio. These vesicles were shown recently to be promising foam stabilizers. Using Brewster angle microscopy, we observed the formation of a catanionic monolayer at the air/water interface composed of liquid-condensed domains in a liquid-expanded matrix. Further adsorption of catanionic molecules forced them to pack, thereby forming a very dense monolayer that prevented further vesicle rupture by avoiding contact of the vesicles with air. Moreover, confocal fluorescence microscopy revealed the presence of layers of intact vesicles that were progressively creaming toward this catanionic monolayer; the surface tension of the vesicle dispersion remained constant upon creaming. The catanionic monolayer behaved as a soft glassy material, an amorphous solid with time- and temperature-dependent properties. Using interfacial oscillatory rheology, we found that the monolayer relaxed mechanical stresses in seconds and melted at a temperature very close to the melting transition temperature of the vesicle bilayers. These results have potential application in the design of smart foams that have temperature-tunable stability.
On the origin of the stability of foams made from catanionic surfactant mixtures

*Article publié en 2011*


*Réf.*: SOFT MATTER 7 (2011), 6557-6570

**Thématiques**: Chemistry, Physical; Materials Science, Multidisciplinary; Physics, Multidisciplinary; Polymer Science

Using mixtures of the anionic myristic acid (C13COOH) and the cationic cetyl trimethylammonium chloride (C(16)TA(+))Cl(-)) in aqueous solutions at a 2 : 1 ratio, we show that the outstanding stability of foams generated from sufficiently concentrated "catanionic" surfactant mixtures can be explained by a synergy effect between two fundamentally different mechanisms. Applying a multiscale approach, in which we link static and dynamic properties of the bulk solutions, isolated gas/liquid interfaces, thin liquid films and foams, we identify these two mechanisms to be as follows: firstly, cationic mixtures create tightly packed surfactant layers at gas/liquid interfaces, which are strongly viscoelastic and also confer high disjoining pressures when two interfaces are approaching each other to form a thin liquid film. Foams created with such kind of interfaces tend to be extremely stable against coalescence (film rupture) and coarsening (gas exchange). However, typical time scales to cover the interfaces are much longer than typical foaming times. This is why a second mechanism plays a key role, which is due to the presence of micron-sized catanionic vesicles in the foaming solution. The bilayers of these vesicles are in a gel-like state, therefore leading to nearly indestructible objects which act like elastic micro-spheres. At sufficiently high concentrations, these vesicles jam in the presence of the confinement between bubbles, slowing down the drainage of liquid during the initial foaming process and therefore providing time for the interfaces to be covered. Furthermore, the tightly packed vesicles strongly reduce bubble coalescence and gas transfer between bubbles.

**[2009-017T] FRACHET**

*Porteur*: Elisabeth Bouchaud

**Thème 3**

A simple device for dielectric spectroscopy of polymers with temperature regulation close to 300 K based on a Peltier junction

*Article publié en 2012*

*Auteurs*: Raihane, A.; Tourbot, R.; Ladieu, F.; L’Hôte, D.

*Réf.*: REV SCI INSTRUM 83 (2012), -

**Thématiques**: Instruments & Instrumentation; Physics, Applied
We present a simple thermostat device for performing dielectric spectroscopy measurements on polymers close to their glass transition temperature. By using a vacuum chamber containing a Peltier junction with its regulator, we show that a very simple setup yields a temperature accuracy which is good enough for accurate studies of polymer dielectric properties. This technique is also more cost effective than standard setups using cryogenic fluids. (© 2012 American Institute of Physics. [http://dx.doi.org/10.1063/1.3700217]

**Bulk Elastic Fingering Instability in Hele-Shaw Cells**

*Article publié en 2013*

**Auteurs:** Saintyves, B; Dauchot, O; Bouchaud, E

**Réf.:** PHYS REV LETT 111 (2013), -

**Thématiques:** Physics, Multidisciplinary

We demonstrate experimentally the existence of a purely elastic, nonviscous fingering instability which arises when air penetrates into an elastomer confined in a Hele-Shaw cell. Fingers appear sequentially and propagate within the bulk of the material as soon as a critical strain, independent of the elastic modulus, is exceeded. Key elements in the driving force of the instability are the confinement of the gel and its adhesion to the plates of the cell, which result in a considerable expense of elastic energy during the growth of the air bubble.

**Permeability of self-affine aperture fields**

*Article publié en 2010*

**Auteurs:** Talon, Laurent; Auradou, Harold; Hansen, Alex

**Réf.:** PHYS REV E 82 (2010), -

**Thématiques:** Physics, Fluids & Plasmas; Physics, Mathematical

We introduce a model that allows for the prediction of the permeability of self-affine rough channels (one-dimensional fracture) and two-dimensional fractures over a wide range of apertures. In the lubrication approximation, the permeability shows three different scaling regimes. For fractures with a large mean aperture or an aperture small enough to the permeability being close to disappearing, the permeability scales as the cube of the aperture when the zero level of the aperture is set to coincide with the disappearance of the permeability. Between these two regimes, there is a third regime where the scaling is due to the self-affine roughness. For rough channels, the exponent is found to be 3-1/H, where H is the Hurst exponent. For two-dimensional fractures, it is necessary to introduce an equivalent aperture b(c) to make the scaling regime apparent. b(c) is defined as the hydraulic aperture of the most restrictive barrier crossing the fracture normal to the flow direction. This regime is characterized by an exponent higher than that for the one-dimensional case: it is 2.25 for H=0.8 and 2.16 for H=0.3.
Effect of annealing on the superconducting properties of a-NbSi1-x thin films

Article publié en 2013


Réf. : PHYS REV B 87 (2013), -

Thématiques : Physics, Condensed Matter

Tunable Superconducting Properties of a-NbSi Thin Films and Application to Detection in Astrophysics

Article publié en 2011

Auteurs : Crauste, Olivier; Marrache-Kikuchi, Claire A.; Berge, Laurent; Collin, Sophie; Dolgorouky, Youri; Marnieros, Stefanos; Nones, Claudia; Dumoulin, Louis

Réf. : J LOW TEMP PHYS 163 (2011), 60-66

Thématiques : Physics, Applied; Physics, Condensed Matter

a-NbSi1-x thin films with thicknesses down to 25 angstrom have been structurally characterized by transmission electron microscopy measurements. As-deposited or annealed films are shown to be continuous and homogeneous in composition and thickness, up to an annealing temperature of 500 degrees C. We have carried out low-temperature transport measurements on these films close to the superconductor-to-insulator transition (SIT) and shown a qualitative difference between the effect of annealing or composition and a reduction of the film thickness on the superconducting properties of a-NbSi. These results question the pertinence of the sheet resistance R-square as the relevant parameter to describe the SIT. DOI: 10.1103/PhysRevB.87.144514

We report on the superconducting properties of amorphous Nb (x) Si1-x thin films. The normal-state resistance and critical temperatures can be separately adjusted to suit the desired application. Notably, the relatively low electron-phonon coupling of these films makes them good candidates for an "all electron bolometer" for Cosmological Microwave Background radiation detection. Moreover, this device can be made to suit both high and low impedance readouts.
Different effects of Ni and Co substitution on the transport properties of BaFe2As2

_Article publié en 2011_

**Auteurs:** Olariu, A.; Rullier-Albenque, F.; Colson, D.; Forget, A.

**Réf.:** PHYS REV B **83** (2011), -

**Thématiques:** Physics, Condensed Matter

We report resistivity and Hall effect results on Ba(Fe1-xNix)(2)As-2 and compare them with those in Ba(Fe1-xCox)(2)As-2. The Hall constant R-H is negative for all x values from 0.01 to 0.14, which indicates that electron carriers dominate the transport in both the magnetic and the paramagnetic regimes. We analyze the data in the framework of a two-band model. Without any assumption on the number of carriers, we show that the electron resistivity can be estimated with good accuracy in the low-temperature paramagnetic range. Although the phase diagrams of the two families are very similar with respect to the extra electrons added in the system, we find that the transport properties differ in several aspects. First, we evidence that the contribution of holes to the transport is more important for Ni doping than for Co doping. Second, Ni behaves as a stronger scatterer for the electrons, as the increase of residual electron resistivity Delta rho(e)/x is about four times larger for Ni than for Co in the most doped samples.

Incommensurate spin density wave versus local magnetic inhomogeneities in Ba(Fe1-xNix)(2)As-2: a Fe-57 Mossbauer spectral study

_Article publié en 2012_

**Auteurs:** Olariu, A.; Bonville, P.; Rullier-Albenque, F.; Colson, D.; Forget, A.

**Réf.:** NEW J PHYS **14** (2012), -

**Thématiques:** Physics, Multidisciplinary

We report Fe-57 Mossbauer spectral results in pure and doped Ba(Fe1-xNix)(2)As-2 with x = 0.01 and 0.03. We show that all these materials present a first-order magnetic transition towards a magnetically ordered state. In the doped compounds, a broad distribution of Fe hyperfine fields is present in the magnetic phase. We successfully fit the Mossbauer data in Ba(Fe1-xNix)(2)As-2 in the framework of two different models: (i) an incommensurate spin density wave (IC-SDW); (ii) a dopant-induced perturbation of the Fe polarization, recently proposed to interpret As-75 NMR data in Ba(Fe1-xNix)(2)As-2, which is valid only in the very dilute limit x = 0.01. Moreover, we show here that these NMR data can also be successfully analysed in terms of the 'incommensurate model' for all
doping contents by using the parameters obtained from the Mossbauer spectral analysis. Therefore it is not possible to rule out the presence of an IC-SDW on the basis of the As-75 NMR data.

**[2009-023T] IMMAGE**

*Porteur*: Julien Gautier

**Thème 5**

**Polarization control of high order harmonics in the EUV photon energy range**

*Article publié en 2011*

*Auteurs*: Vodungbo, Boris; Sardinha, Anna Barszczak; Gautier, Julien; Lambert, Guillaume; Valentín, Constance; Lozano, Magali; Iaquaniello, Gregory; Delmotte, Franck; Sebban, Stephane; Luening, Jan; Zeitoun, Philippe

*Réf.*: OPT EXPRESS 19 (2011), 4346-4356

**Thématiques**: Optics

We report the generation of circularly polarized high order harmonics in the extreme ultraviolet range (18-27 nm) from a linearly polarized infrared laser (40 fs, 0.25 TW) focused into a neon filled gas cell. To circularly polarize the initially linearly polarized harmonics we have implemented a four-reflector phase-shifter. Fully circularly polarized radiation has been obtained with an efficiency of a few percents, thus being significantly more efficient than currently demonstrated direct generation of elliptically polarized harmonics. This demonstration opens up new experimental capabilities based on high order harmonics, for example, in biology and materials science. The inherent femtosecond time resolution of high order harmonic generating table top laser sources renders these an ideal tool for the investigation of ultrafast magnetization dynamics now that the magnetic circular dichroism at the absorption M-edges of transition metals can be exploited. (C) 2011 Optical Society of America

**[2009-023T & 2009-084T] IMMAGE & POL-IMMAGE**

*Porteur*: Julien Gautier

**Thème 5**

**Laser-induced ultrafast demagnetization in the presence of a nanoscale magnetic domain network**

*Article publié en 2012*
Femtosecond magnetization phenomena have been challenging our understanding for over a decade. Most experiments have relied on infrared femtosecond lasers, limiting the spatial resolution to a few micrometres. With the advent of femtosecond X-ray sources, nanometric resolution can now be reached, which matches key length scales in femtomagnetism such as the travelling length of excited 'hot' electrons on a femtosecond timescale. Here we study laser-induced ultrafast demagnetization in [Co/Pd](30) multilayer films, which, for the first time, achieves a spatial resolution better than 100 nm by using femtosecond soft X-ray pulses. This allows us to follow the femtosecond demagnetization process in a magnetic system consisting of alternating nanometric domains of opposite magnetization. No modification of the magnetic structure is observed, but, in comparison with uniformly magnetized systems of similar composition, we find a significantly faster demagnetization time. We argue that this may be caused by direct transfer of spin angular momentum between neighbouring domains.

Table-top resonant magnetic scattering with extreme ultraviolet light from high-order harmonic generation

We demonstrate for the first time the applicability of high-order harmonic generation for probing magnetization properties with nanometer spatial resolution. High harmonics were generated by focusing an infrared femtosecond laser into a neon-filled gas cell. Using a high throughput monochromator, EUV pulses with a photon energy resonant to the magnetically dichroic Co M(2,3) absorption resonance were obtained. These were focused onto a CoPd alloy film and the magnetic scattering pattern was recorded in a transmission geometry. The scattering pattern induced by the magnetic domain structure consists of two well-defined bright spots revealing the presence of stripe domains of about 63nm in width. With the inherent femtosecond time resolution given by high harmonics, this demonstration paves the way to investigate ultrafast magnetization dynamics with femtosecond time and nanometer spatial resolutions, in jitter-free experiment based on table-top EUV light sources. Copyright (C) EPLA, 2011
Porteur : Aristide Lemaître

Thème 5

**Joule heating and current-induced domain wall motion**

*Article publié en 2012*

**Auteurs** : Curiale, J.; Lemaître, A.; Niazi, T.; Faini, G.; Jeudy, V.

**Réf.** : J APPL PHYS 112 (2012), -

**Thématiques** : Physics, Applied

We investigate numerically and experimentally the Joule heating produced by current pulses and its contribution to current-induced domain wall (DW) motion in a (Ga,Mn)As ferromagnetic semiconductor. Different thermal coupling between tracks and substrates are explored. A direct contact leads to a logarithmic transient temperature rise and a stationary state determined by the substrate thickness. The introduction of a low thermal conducting (Ga, In) As interlayer produces an additional temperature rise whose time variation and magnitude are analyzed. Experimentally, the measured temperature rises present a good agreement with predictions over more than four orders of magnitude in time for values of the heat conductivity and of the heat capacity close to those reported in the literature. The Joule heating is shown to produce non-linearities in the domain wall velocity versus current density characteristics. A correction of Joule heating is proposed and permits the identification of the flow regimes from a comparison of domain-wall dynamics in tracks presenting different pinning characteristics.

(C) 2012 American Institute of Physics. [http://dx.doi.org/10.1063/1.4765032]

**Spin Drift Velocity, Polarization, and Current-Driven Domain-Wall Motion in (Ga,Mn)(As,P)**

*Article publié en 2012*

**Auteurs** : Curiale, J.; Lemaître, A.; Ulysse, C.; Faini, G.; Jeudy, V.

**Réf.** : PHYS REV LETT 108 (2012), -

**Thématiques** : Physics, Multidisciplinary

Current-driven domain-wall motion is studied in (Ga,Mn)(As,P) ferromagnetic semiconducting tracks with perpendicular anisotropy. A linear steady state flow regime is observed over a large temperature range of the ferromagnetic phase (0.1T(θ) < T < T-c). Close to 0 K, the domain-wall velocity is found to coincide with the spin drift velocity. This result is obtained below the intrinsic threshold for domain-wall motion which implies a nonadiabatic contribution to the spin transfer torque. The current spin polarization is deduced close to 0 K and to T-c. It suggests that the temperature dependence of the spin polarization can be inferred from the domain-wall dynamics.
Track heating study for current-induced domain wall motion experiments

*Article publié en 2010*

**Auteurs**: Curiale, J.; Lemaitre, A.; Faini, G.; Jeudy, V.

**Réf.**: APPL PHYS LETT *97* (2010), -

**Thématiques**: Physics, Applied

We investigate the Joule heating produced by current pulses in (Ga,Mn)(As,P) ferromagnetic semiconducting nanotrackx. The transient and the stationary heating regimes are determined experimentally. A good quantitative agreement is obtained with simulations and analytical calculations. The temperature of the tracks is shown to be essentially determined by the heat diffusion through the substrate. Implications for current-induced domain wall motion experiments are discussed. (C) 2010 American Institute of Physics. [doi: 10.1063/1.3526755]

[2009-024T & 2010-033T] SEMICMAG & SEMIMAG II

**Porteur**: Aristide Lemaître

**Thème 5**

Current induced domain wall motion in GaMnAs close to the Curie temperature

*Article publié en 2011*

**Auteurs**: Jeudy, V.; Curiale, J.; Adam, J-P; Thiaville, A.; Lemaitre, A.; Faini, G.

**Réf.**: J PHYS-CONDENS MAT *23* (2011), -

**Thématiques**: Physics, Condensed Matter

Domain wall dynamics produced by spin transfer torques is investigated in (Ga, Mn) As ferromagnetic semiconducting tracks with perpendicular anisotropy, close to the Curie temperature. The domain wall velocities are found to follow a linear flow regime which only slightly varies with temperature. Using the Doring inequality, boundaries of the spin polarization of the current are deduced. A comparison with the predictions of the mean field *k . p* theory leads to an estimation of the carrier density whose value is compatible with results published in the literature. The spin polarization of the current and the magnetization of the magnetic atoms present similar temperature variations. This leads to a weak temperature dependence of the spin drift velocity and thus of the domain wall velocity. A combined study of field-and current-driven motion and deformation of magnetic domains reveals a motion of domain walls in the steady state regime without transition to the precessional regime. The ratio between the non-adiabatic torque beta and the Gilbert damping factor alpha is shown to remain close to unity.
Coherent beam combination of narrow-linewidth 1.5 \( \mu \)m fiber amplifiers in a long-pulse regime

*Article publié en 2011*

**Auteurs:** Lombard, L.; Azarian, A.; Cadoret, K.; Bourdon, P.; Goular, D.; Canat, G.; Jolivet, Y.; Jaouen, Y.; Vasseur, O.

**Réf.** : OPT LETT 36 (2011), 523-525

**Thématiques** : Optics

We report what we believe to be the first experimental demonstration of coherent beam combining of two fiber amplifiers in a 100 ns pulse regime using a signal leak between the pulses. Pulses of similar to 100 W stimulated-Brillouin-scattering limited peak power are combined with 95% efficiency, a residual phase error of \( \lambda/27 \), and no significant beam quality degradation. (C) 2011 Optical Society of America

Coherent beam combining of two femtosecond fiber chirped-pulse amplifiers

*Article publié en 2011*

**Auteurs:** Daniault, L.; Hanna, M.; Lombard, L.; Zaouter, Y.; Mottay, E.; Goular, D.; Bourdon, P.; Druon, F.; Georges, P.

**Réf.** : OPT LETT 36 (2011), 621-623

**Thématiques** : Optics

We demonstrate coherent beam combining of two femtosecond fiber chirped-pulse amplifiers seeded by a common oscillator. Using a feedback loop based on an electro-optic phase modulator, an average power of 7.2W before compression is obtained with a combining efficiency of 90%. The spatial and temporal qualities of the oscillator are retained, with a recombined pulse width of 325 fs. This experiment opens up a way to scale the peak/average power of ultrafast fiber sources. (C) 2011 Optical Society of America

Impact of spectral phase mismatch on femtosecond coherent beam combining systems

*Article publié en 2012*

Réf. : OPT LETT 37 (2012), 650-652

Thématiques : Optics

We experimentally investigate the impact of spectral phase mismatch on the coherent beam combining of two femtosecond fiber chirped-pulse amplifiers. By measuring the differential spectral phase, both linear and nonlinear contributions are identified. An accumulated nonlinear phase as high as 6 rad has been measured, for which a combination efficiency of 91% can be obtained by symmetrizing the pump and injection powers. This also allows us to quantitatively separate the spatial and temporal contributions of the nonperfect combining efficiency. (C) 2012 Optical Society of America

Passive coherent beam combining of two femtosecond fiber chirped-pulse amplifiers

Article publié en 2011

Auteurs : Daniault, Louis; Hanna, Marc; Papadopoulos, Dimitris N.; Zaouter, Yoann; Mottay, Eric; Druon, Frederic; Georges, Patrick

Réf. : OPT LETT 36 (2011), 4023-4025

Thématiques : Optics

We propose and demonstrate an architecture that achieves passive coherent combination of two femtosecond fiber chirped-pulse amplifiers. The setup consists in the use of a well-balanced amplifying Sagnac interferometer. The experiment shows that the temporal, spectral, and spatial qualities of each beam are retained, with the generation of 250 fs pulses at 35 MHz repetition rate, an uncompressed average power of 10W, and a combining efficiency of 96%. The behavior of this architecture in the presence of high accumulated nonlinear phase is investigated. (C) 2011 Optical Society of America

[2009-028T] JECAL

Porteur : Michel Koenig

Thème 6

Highly radiative shock experiments driven by GEKKO XII

Article publié en 2011
In this paper, recent results obtained on highly radiative shocks generated in a xenon filled gas cell using the GEKKO XII laser facility are presented. Data show extremely high shock velocity (a parts per thousand yen150 km/s) never achieved before in gas. Preliminary analyses based on theoretical dimensionless numbers and numerical simulations suggest that these radiative shocks reach a new radiative regime where the radiative pressure plays a role in the dynamics and structure of the shock. A major effect observed is a strong anisotropic emission in the downstream gas. This unexpected feature is discussed and compared to available 2D radiation hydrodynamic simulations.

Laser-driven plasma jets propagating in an ambient gas studied with optical and proton diagnostics

Article publié en 2010

The results of an experiment to propagate laser-generated plasma jets into an ambient medium are presented. The jets are generated via laser irradiation of a foam-filled cone target, the results and characterization of which have been reported previously [Loupias, Phys. Rev. Lett. 99, 265001 (2007)] for propagation in vacuum. The introduction of an ambient medium of argon at varying density is seen to result in the formation of a shock wave, and the shock front displays perturbations that appear to grow with time. The system is diagnosed with the aid of proton radiography, imaging the perturbed structure in the dense parts of the shock with high resolution. (C) 2010 American Institute of Physics. [doi: 10.1063/1.3431094]
Raman amplification of optical pulses in silicon nanowaveguides: Impact of spectral broadening of pump pulses

*Article publié en 2011*

*Auteurs*: Baron, Alexandre; Dubreuil, Nicolas; Delaye, Philippe; Frey, Robert; Agrawal, Govind P.

*Réf.:* J EUR OPT SOC-RAPID *6* (2011), -

**Thématiques**: Optics

We consider the Raman amplification problem for silicon waveguides in the regime in which both the pump and signal pulses are relatively short but wide enough that their duration exceeds the phonon lifetime (about 3 ps in silicon). We use the coupled pump-signal equations for numerical simulations that include all competing nonlinear effects such as self- and cross-phase modulations, two-photon and free-carrier absorptions, and changes in the refractive index induced by the free carriers. However, numerical simulations do not provide much physical insight. For this reason, we also develop an approximate analytic approach for solving the Raman amplification problem. We introduce the concept of an effective Raman gain and show analytically how it depends on the pump bandwidth. As the pump spectrum broadens inside the silicon waveguide, the effective Raman gain is reduced considerably. We obtain an analytical form of the nonlinear phase accumulated during propagation inside a silicon waveguide and use it to calculate the total spectral broadening experienced by a pump pulse. Using this result, we can predict changes in the effective Raman gain as a function of pump pulse energy. A comparison of our predictions with the recent experimental data shows that our model is reasonable and captures the essential physics.

[DOI: 10.2971/jeos.2011.11030]

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**[2009-031T] PICORRE**

*Porteur*: Pascale Senellart

**Thème 7**

Polariton Condensation in Photonic Molecules

*Article publié en 2012*

*Auteurs*: Galbiati, Marta; Ferrier, Lydie; Solnyshkov, Dmitry D.; Tanese, Dimitrii; Wertz, Esther; Amo, Alberto; Abbarchi, Marco; Senellart, Pascale; Sagnes, Isabelle; Lemaître, Aristide; Galopin, Elisabeth; Malpuech, Guillaume; Bloch, Jacqueline

*Réf.:* PHYS REV LETT *108* (2012), -

**Thématiques**: Physics, Multidisciplinary

We report on polariton condensation in photonic molecules formed by two coupled micropillars. We show that the condensation process is strongly affected by the interaction with the cloud of
uncondensed excitons and thus strongly depends on the exact localization of these excitons within the molecule. Under symmetric excitation conditions, condensation is triggered on both binding and antibinding polariton states of the molecule. On the opposite, when the excitonic cloud is injected in one of the two pillars, condensation on a metastable state is observed and a total transfer of the condensate into one of the micropillars can be achieved. Our results highlight the crucial role played by relaxation kinetics in the condensation process.

[2009-033T] HACOR

Porteur : Marie-Claire Schanne-Klein/Karsten Plamann

Thème 7

In vivo structural imaging of the cornea by polarization-resolved second harmonic microscopy

Article publié en 2012

Auteurs : Latour, Gael; Gusachenko, Ivan; Kowalczuk, Laura; Lamarre, Isabelle; Schanne-Klein, Marie-Claire

Réf. : BIOMED OPT EXPRESS 3 (2012), 1-15

Thématiques : Biochemical Research Methods; Optics; Radiology, Nuclear Medicine & Medical Imaging

The transparency and mechanical strength of the cornea are related to the highly organized three-dimensional distribution of collagen fibrils. It is of great interest to develop specific and contrasted in vivo imaging tools to probe these collagenous structures, which is not available yet. Second Harmonic Generation (SHG) microscopy is a unique tool to reveal fibrillar collagen within unstained tissues, but backward SHG images of cornea fail to reveal any spatial features due to the nanometric diameter of stromal collagen fibrils. To overcome this limitation, we performed polarization-resolved SHG imaging, which is highly sensitive to the submicrometer distribution of anisotropic structures. Using advanced data processing, we successfully retrieved the orientation of the collagenous fibrils at each depth of human corneas, even in backward SHG homogenous images. Quantitative information was also obtained about the submicrometer heterogeneities of the fibrillar collagen distribution by measuring the SHG anisotropy. All these results were consistent with numerical simulation of the polarization-resolved SHG response of cornea. Finally, we performed in vivo SHG imaging of rat corneas and achieved structural imaging of corneal stroma without any labeling. Epi-detected polarization-resolved SHG imaging should extend to other organs and become a new diagnosis tool for collagen remodeling.

(C) 2011 Optical Society of America
Polarization-resolved Second Harmonic microscopy in anisotropic thick tissues

*Article publié en 2010*

**Auteurs**: Gusachenko, Ivan; Latour, Gael; Schanne-Klein, Marie-Claire

**Réf.**: OPT EXPRESS 18 (2010), 19339-19352

**Thématiques**: Optics

We thoroughly analyze the linear propagation effects that affect polarization-resolved Second Harmonic Generation imaging of thick anisotropic tissues such as collagenous tissues. We develop a theoretical model that fully accounts for birefringence and diattenuation along the excitation propagation, and polarization scrambling upon scattering of the harmonic signal. We obtain an excellent agreement with polarization-resolved SHG images at increasing depth within a rat-tail tendon for both polarizations of the forward SHG signal. Most notably, we observe interference fringes due to birefringence in the SHG depth profile when excited at $\pi/4$ angle from the tendon axis. We also measure artifactual decrease of $\rho = \chi(xxx)/\chi(xyy)$ with depth due to diattenuation of the excitation. We therefore derive a method that proves reliable to determine both $\rho$ and the tendon birefringence and diattenuation. (C) 2010 Optical Society of America

**ANKAphase: software for single-distance phase retrieval from inline X-ray phase-contrast radiographs

*Article publié en 2011*


**Réf.**: J SYNCHROTRON RADIAT 18 (2011), 617-629

**Thématiques**: Instruments & Instrumentation; Optics; Physics, Applied

A computer program named ANKAphase is presented that processes X-ray inline phase-contrast radiographs by reconstructing the projected thickness of the object(s) imaged. The program uses a single-distance non-iterative phase-retrieval algorithm described by David Paganin et al. [(2002), J. Microsc. 206, 33-40]. Allowing for non-negligible absorption in the sample, this method is strictly valid only for monochromatic illumination and single-material objects but tolerates deviations from these conditions, especially polychromaticity. ANKAphase is designed to be applied to tomography data (although it does not perform tomographic reconstruction itself). It can process series of images and perform flat-field and dark-field correction. Written in Java, ANKAphase has an intuitive graphical user interface and can be run either as a stand-alone application or as a plugin to ImageJ, a
widely used scientific image-processing program. A description of ANKApHase is given and example applications are shown.

Assessment of grating-based X-ray phase-contrast CT for differentiation of invasive ductal carcinoma and ductal carcinoma in situ in an experimental ex vivo set-up

*Article publié en 2013*

**Auteurs:** Sztrokay, Aniko; Herzen, Julia; Auweter, Sigrid D.; Liebhardt, Susanne; Mayr, Doris; Willner, Marian; Hahn, Dieter; Zanette, Irene; Weitkamp, Timm; Hellerhoff, Karin; Pfefifer, Franz; Reiser, Maximilian F.; Bamberg, Fabian

**Réf.:** EUR RADIOL **23** (2013), 381-387

**Thématiques:** Radiology, Nuclear Medicine & Medical Imaging

Limited contrast between healthy and tumour tissue is a limiting factor in mammography and CT of the breast. Phase-contrast computed tomography (PC-CT) provides improved soft-tissue contrast compared with absorption-based techniques. In this study, we assessed the technical feasibility of grating-based PC-CT imaging of the breast for characterisation of ductal carcinoma in situ (DCIS). Grating-based PC-CT was performed on one breast specimen containing an invasive ductal carcinoma and DCIS using monochromatic radiation of 23 keV. Phase-contrast and absorption-based images were compared qualitatively and quantitatively with histopathology in a blinded fashion. Grating-based PC-CT showed improved differentiation of soft-tissue components. Circular structures of high phase-shift contrast corresponding to the walls of the dilated ductuli of the DCIS were visualised with a contrast-to-noise ratio (CNR) of 9.6 using PC-CT but were not detectable on absorption-based images (CNR = 0.27). The high phase-shift structures of the dilated ductuli were identifiable in the PC-CT volume data set allowing for 3D characterisation of DCIS. Our results indicate that unlike conventional CT, grating-based PC-CT may allow the differentiation between invasive carcinoma and intraductal carcinoma and healthy breast tissue and provide 3D visualisation of DCIS. aEuro cent Phase-contrast computed tomography (CT) yields improved soft-tissue contrast. aEuro cent The method can resolve the fine structure of a breast tumour. aEuro cent Invasive and intraductal carcinoma can be differentiated. aEuro cent Differentiation is possible by visual inspection and quantification. aEuro cent The method could improve early breast cancer diagnosis.

At-wavelength characterization of refractive x-ray lenses using a two-dimensional grating interferometer

*Article publié en 2011*

**Auteurs:** Rutishauser, Simon; Zanette, Irene; Weitkamp, Timm; Donath, Tilman; David, Christian

**Réf.:** APPL PHYS LETT **99** (2011), -

**Thématiques:** Physics, Applied
We report on the application of a two-dimensional hard x-ray grating interferometer to x-ray optics metrology. The interferometer is sensitive to refraction angles in two perpendicular directions with a precision of 10 nrad. It is used to observe the wavefront changes induced by a single parabolic beryllium focusing lens of large radius of curvature. The lens shape is reconstructed and its residual aberrations are analyzed. Its profile differs from an ideal parabolic shape by less than 2 μm or λ/50 at λ = 0.54 angstrom wavelength. (C) 2011 American Institute of Physics. [doi:10.1063/1.3665063]

Fabrication of two-dimensional hard X-ray diffraction gratings

Article publié en 2013

Auteurs : Rutishauser, S.; Bednarzik, M.; Zanette, I.; Weitkamp, T.; Boerner, M.; Mohr, J.; David, C.

Réf. : MICROELECTRON ENG 101 (2013), 12-16

Thématiques : Engineering, Electrical & Electronic; Nanoscience & Nanotechnology; Optics; Physics, Applied

Hard X-ray grating interferometry has shown promising results in phase and scattering imaging, as well as in metrology applications. Recently, the technique has been extended to two dimensions, recording the full phase gradient vector and a directional scattering signal. Here, we present a process for fabricating the key optical elements required for this technique: phase and absorption gratings with periods of few micrometers and high aspect ratios, with a particular focus on two-dimensional grating structures. The fabrication process is based on deep reactive ion etching in silicon and electroplating of gold. (C) 2012 Elsevier B.V. All rights reserved.

Global and local hard X-ray tomography of a centimeter-size tumor vessel tree

Article publié en 2012

Auteurs : Lang, Sabrina; Dominietto, Marco; Cattin, Philippe; Ulmann-Schuler, Alexandra; Weitkamp, Timm; Mueller, Bert

Réf. : J SYNCHROTRON RADIAT 19 (2012), 114-125

Thématiques : Instruments & Instrumentation; Optics; Physics, Applied

The visualization of the vascular network in tumors down to the smallest vessels requires high spatial resolution and reasonable contrast. Stained corrosion casts of the microvasculature network guarantee superior X-ray absorption contrast and highest reproduction fidelity. Tomography of a centimeter-size tumor, however, is unfeasible at the spatial resolution needed to reveal the smallest vessels. Therefore, local tomography has been performed to visualize the smallest capillaries within the region of interest. These three-dimensional data show the detailed morphology, but the reconstructed absorption coefficients obtained in local tomography differ substantially from the absorption coefficients retrieved from the less detailed global tomography data. This paper deals with the adaptation of local tomography data using the global data and considers two-parameter histogram matching of the radiographs, sinogram extension, and multi-
parameter cupping correction. It is demonstrated that two-parameter histogram matching of the radiographs already provides reasonable agreement. The change of the lens in front of the detector's camera, however, significantly affects the obtained local X-ray absorption coefficients in the tomograms predominantly owing to the dissimilar point-spread functions of the two configurations used, and much less to the fact that one of the data sets was acquired in a local geometry.

Heat bump on a monochromator crystal measured with X-ray grating interferometry

*Article publié en 2013*

*Auteurs*: Rutishauser, Simon; Rack, Alexander; Weitkamp, Timm; Kayser, Yves; David, Christian; Macrander, Albert T.

*Réf.:* J SYNCHROTRON RADIAT 20 (2013), 300-305

*Thématiques*: Instruments & Instrumentation; Optics; Physics, Applied

Deformation of the first crystal of an X-ray monochromator under the heat load of a high-power beam, commonly referred to as 'heat bump', is a challenge frequently faced at synchrotron beamlines. Here, quantitative measurements of the deformations of an externally water-cooled silicon (111) double-crystal monochromator tuned to a photon energy of 17.6 keV are reported. These measurements were made using two-dimensional hard X-ray grating interferometry, a technique that enables in situ at-wavelength wavefront investigations with high angular sensitivity. The observed crystal deformations were of the order of 100 nm in the meridional and 5 nm in the sagittal direction, which lead to wavefront slope errors of up to 4 μrad in the meridional and a few hundred nanoradians in the sagittal direction.

High-order-harmonic generation in gas with a flat-top laser beam

*Article publié en 2011*

*Auteurs*: Boutu, W.; Auguste, T.; Boyko, O.; Sola, I.; Balcou, Ph.; Binazon, L.; Gobert, O.; Merdji, H.; Valentin, C.; Constant, E.; Mevel, E.; Carre, B.

*Réf.:* PHYS REV A 84 (2011), -

*Thématiques*: Optics; Physics, Atomic, Molecular & Chemical

We present experimental and numerical results on high-order-harmonic generation with a flat-top laser beam. We show that a simple binary tunable phase plate, made of two concentric glass plates, can produce a flat-top profile at the focus of a Gaussian infrared beam. Both experiments and numerical calculations show that there is a scaling law between the harmonic generation efficiency and the increase of the generation volume.
Impact of wave front and coherence optimization in coherent diffractive imaging

*Article publié en 2013*


**Réf.** : OPT EXPRESS 21 (2013), 11441-11447

**Thématiques** : Optics

We present single shot nanoscale imaging using a table-top femtosecond soft X-ray laser harmonic source at a wavelength of 32 nm. We show that the phase retrieval process in coherent diffractive imaging critically depends on beam quality. Coherence and image fidelity are measured from single-shot coherent diffraction patterns of isolated nano-patterned slits. Impact of flux, wave front and coherence of the soft X-ray beam on the phase retrieval process and the image quality are discussed. After beam improvements, a final image reconstruction is presented with a spatial resolution of 78 nm (half period) in a single 20 fs laser harmonic shot. (C) 2013 Optical Society of America

Interlaced phase stepping in phase-contrast x-ray tomography

*Article publié en 2011*

**Auteurs** : Zanette, I.; Bech, M.; Pfeiffer, F.; Weitkamp, T.

**Réf.** : APPL PHYS LETT 98 (2011), -

**Thématiques** : Physics, Applied

We report on an interlaced acquisition scheme in grating-based x-ray phase-contrast tomography in which different viewing angles are used to retrieve a single differential phase projection. This interlaced acquisition scheme is particularly beneficial for region-of-interest tomography since it substantially reduces the artifacts caused by the external region and can eliminate the need for stop-and-go motion of the tomography rotation axis. In this letter, the higher accuracy of the region-of-interest phase reconstructions obtained with the interlaced approach is demonstrated by numerical simulation and experimental results. (C) 2011 American Institute of Physics. [doi:10.1063/1.3559849]

Multimodal imaging of human cerebellum - merging X-ray phase microtomography, magnetic resonance microscopy and histology

*Article publié en 2012*
Imaging modalities including magnetic resonance imaging and X-ray computed tomography are established methods in daily clinical diagnosis of human brain. Clinical equipment does not provide sufficient spatial resolution to obtain morphological information on the cellular level, essential for applying minimally or non-invasive surgical interventions. Therefore, generic data with lateral sub-micrometer resolution have been generated from histological slices post mortem. Sub-cellular spatial resolution, lost in the third dimension as a result of sectioning, is obtained using magnetic resonance microscopy and micro computed tomography. We demonstrate that for human cerebellum grating-based X-ray phase tomography shows complementary contrast to magnetic resonance microscopy and histology. In this study, the contrast-to-noise values of magnetic resonance microscopy and phase tomography were comparable whereas the spatial resolution in phase tomography is an order of magnitude better. The registered data with their complementary information permit the distinct segmentation of tissues within the human cerebellum.

**Numerical comparison of X-ray differential phase contrast and attenuation contrast**

*Article publié en 2012*

Imagery presents a numerical tool to compare directly the contrast-to-noise-ratio (CNR) of the attenuation- and differential phase-contrast signals available from grating-based X-ray imaging for single radiographs. The attenuation projection is differentiated to bring it into a modality comparable to the differential phase projection using a Gaussian derivative filter. A Relative Contrast Gain (RCG) is then defined as the ratio of the CNR of image values in a region of interest (ROI) in the differential phase projection to the CNR of image values in the same ROI in the differential attenuation projection. We apply the method on experimental data of human breast tissue acquired using a grating interferometer to compare the two contrast modes for two regions of interest differing in the type of tissue. Our results indicate that the proposed method can be used as a local estimate of the spatial distribution of the ratio delta/beta, i.e., real and imaginary part of the complex refractive index, across a sample. (C) 2012 Optical Society of America
Protocol to study wavefront preservation capabilities of reflective X-ray optics with coherent synchrotron light

*Article publié en 2013*

_Auteurs_: Rack, A.; Weitkamp, T.; Assoufid, L.; Rack, T.; Zanette, I.; Morawe, Ch.; Kluender, R.; David, C.

_Réf._: NUCL INSTRUM METH A _710_ (2013), 101-105

_Thématiques_: Instruments & Instrumentation; Nuclear Science & Technology; Physics, Particles & Fields; Spectroscopy

Wavefront preservation of reflective X-ray optics, i.e., homogeneity and coherence properties of the reflected beam, are of crucial importance for their application in combination with high-brilliance synchrotron light sources. In order to compare the performance of optical elements in a quantitative manner, a protocol has been established using the Talbot effect to access the coherence properties of the reflective beam as well as long propagation distance imaging to study its homogeneity. The basic idea is to operate in a single-bounce geometry: a high-resolution imaging detector translated at short propagation distances along the beam is used to measure the visibility of a diffraction grating in transmission geometry placed close to the mirror under study. The change of the fringe visibility as a function of distance between the grating and the detector gives access to the angular source size. A second high-resolution imaging detector at longer propagation distances of up to several meters allows one to measure the homogeneity of the beam. This article outlines the concept as realized at beamline ID19 of the European Synchrotron Radiation Facility, gives insight into some of the technical details to be considered for implementation at other facilities and ends with an example application: the study of a W/B4C multilayer mirror. (c) 2012 Elsevier B.V. All rights reserved.

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_Auteurs_: Rack, A.; Weitkamp, T.; Assoufid, L.; Rack, T.; Zanette, I.; Morawe, Ch.; Kluender, R.; David, C.

_Réf._: NUCL INSTRUM METH A _710_ (2013), 101-105

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of the fringe visibility as a function of distance between the grating and the detector gives access to the angular source size. A second high-resolution imaging detector at longer propagation distances of up to several meters allows one to measure the homogeneity of the beam. This article outlines the concept as realized at beamline ID19 of the European Synchrotron Radiation Facility, gives insight into some of the technical details to be considered for implementation at other facilities and ends with an example application: the study of a W/B4C multilayer mirror. (c) 2012 Elsevier B.V. All rights reserved.

**Quantitative X-ray phase-contrast computed tomography at 82 keV**

*Article publié en 2013*

**Auteurs**: Willner, Marian; Bech, Martin; Herzen, Julia; Zanette, Irene; Hahn, Dieter; Kenntner, Johannes; Mohr, Juergen; Rack, Alexander; Weitkamp, Timm; Pfeiffer, Franz

**Réf.** : OPT EXPRESS 21 (2013), 4155-4166

**Thématiques** : Optics

Potential applications of grating-based X-ray phase-contrast imaging are investigated in various fields due to its compatibility with laboratory X-ray sources. So far the method was mainly restricted to X-ray energies below 40 keV, which is too low to examine dense or thick objects, but a routine operation at higher energies is on the brink of realisation. In this study, imaging results obtained at 82 keV are presented. These comprise a test object consisting of well-defined materials for a quantitative analysis and a tooth to translate the findings to a biomedical sample. Measured linear attenuation coefficients $\mu$ and electron densities $\rho(e)$ are in good agreement with theoretical values. Improved contrast-to-noise ratios were found in phase contrast compared to attenuation contrast. The combination of both contrast modalities further enables to simultaneously assess information on density and composition of materials with effective atomic numbers ($Z$) over $\tilde{Z} > 8$. In our biomedical example, we demonstrate the possibility to detect differences in mass density and calcium concentration within teeth. (C) 2013 Optical Society of America

**Single-shot Femtosecond X-Ray Holography Using Extended References**

*Article publié en 2010*

**Auteurs**: Gauthier, D.; Guizar-Sicairos, M.; Ge, X.; Boutu, W.; Carre, B.; Fienup, J. R.; Merdji, H.

**Réf.** : PHYS REV LETT 105 (2010), -

**Thématiques** : Physics, Multidisciplinary

In the context of x-ray lensless imaging, we present a recent approach for Fourier transform holography based on the use of extended references. Major advances shown here rely on a high signal efficiency and on the direct image reconstruction of the object performed by a simple linear derivative. Moreover, the extended holographic reference is easy to manufacture and can be applied to a variety of imaging experiments. Here we demonstrate single-shot imaging with a table-
top, laser-based coherent soft x-ray source. A spatial resolution of 110 nm was obtained with an integration time of 20 fs.

**Three-dimensional quantification of capillary networks in healthy and cancerous tissues of two mice**

*Article publié en 2012*

**Auteurs**: Lang, Sabrina; Mueller, Bert; Dominietto, Marco D.; Cattin, Philippe C.; Zanette, Irene; Weitkamp, Timm; Hieber, Simone E.

**Réf.**: MICROVASC RES 84 (2012), 314-322

**Thématiques**: Peripheral Vascular Disease

A key issue in developing strategies against diseases such as cancer is the analysis of the vessel tree in comparison to the healthy one. In the search for parameters that might be characteristic for tumor capillaries we study the vascularization in mice for cancerous and healthy tissues using synchrotron radiation-based micro computed tomography in absorption and phase contrast modes. Our investigations are based on absorption tomograms of casted healthy and cancerous tissues as well as a phase tomogram of a fixed tumor. We demonstrate how the voxel-based tomography data can be vectorized to assess the capillary networks quantitatively. The processing includes segmentation, skeletonization, and vectorization to finally extract the vessel parameters. The mean diameter of capillaries in healthy and cancerous tissues corresponds to (8.0 +/- 1.1) μm and (3.9 +/- 1.1) μm, respectively. Further evaluated parameters show marginal or no differences between capillaries in healthy and cancerous tissues, namely fractal dimension 2.3 +/- 0.3 vs. 23 +/- 0.2, tortuosity (SOAM) 0.18 rad/μm vs. 0.24 rad/μm and vessel length 20 μm vs. 17 μm. The bifurcation angles exhibit a narrow distribution around 115 degrees. Furthermore, we show that phase tomography is a powerful alternative to absorption tomography of casts for the vessel visualization omitting any invasive specimen preparation procedure. (C) 2012 Elsevier Inc. All rights reserved.

**Trimodal low-dose X-ray tomography**

*Article publié en 2012*

**Auteurs**: Zanette, I.; Bech, M.; Rack, A.; Le Duc, G.; Tafforeau, P.; David, C.; Mohr, J.; Pfeiffer, F.; Weitkamp, T.

**Réf.**: P NATL ACAD SCI USA 109 (2012), 10199-10204

**Thématiques**: Multidisciplinary Sciences

X-ray grating interferometry is a coherent imaging technique that bears tremendous potential for three-dimensional tomographic imaging of soft biological tissue and other specimens whose details exhibit very weak absorption contrast. It is intrinsically trimodal, delivering phase contrast, absorption contrast, and scattering (“dark-field”) contrast. Recently reported acquisition strategies for grating-interferometric phase tomography constitute a major improvement of dose efficiency and speed. In particular, some of these techniques eliminate the need for scanning of one of the gratings (“phase stepping”). This advantage, however, comes at the cost of other limitations. These can be a loss in spatial resolution, or the inability to fully separate the three imaging modalities. In
the present paper we report a data acquisition and processing method that optimizes dose efficiency but does not share the main limitations of other recently reported methods. Although our method still relies on phase stepping, it effectively uses only down to a single detector frame per projection angle and yields images corresponding to all three contrast modalities. In particular, this means that dark-field imaging remains accessible. The method is also compliant with data acquisition over an angular range of only 180 degrees and with a continuous rotation of the specimen.

X-Ray Phase-Contrast CT of a Pancreatic Ductal Adenocarcinoma Mouse Model

*Article publié en 2013*

*Auteurs*: Tapfer, Arne; Braren, Rickmer; Bech, Martin; Willner, Marian; Zanette, Irene; Weitkamp, Timm; Trajkovic-Arsic, Marija; Siveke, Jens T.; Settles, Marcus; Aichler, Michaela; Walch, Axel; Pfeiffer, Franz

*Réf.*: PLOS ONE 8 (2013), -

*Thématiques*: Multidisciplinary Sciences

To explore the potential of grating-based x-ray phase-contrast computed tomography (CT) for preclinical research, a genetically engineered mouse model of pancreatic ductal adenocarcinoma (PDAC) was investigated. One ex-vivo mouse specimen was scanned with different grating-based phase-contrast CT imaging setups covering two different settings: i) high-resolution synchrotron radiation (SR) imaging and ii) dose-reduced imaging using either synchrotron radiation or a conventional x-ray tube source. These experimental settings were chosen to assess the potential of phase-contrast imaging for two different types of application: i) high-performance imaging for virtual microscopy applications and ii) biomedical imaging with increased soft-tissue contrast for in-vivo applications. For validation and as a reference, histological slicing and magnetic resonance imaging (MRI) were performed on the same mouse specimen. For each x-ray imaging setup, attenuation and phase-contrast images were compared visually with regard to contrast in general, and specifically concerning the recognizability of lesions and cancerous tissue. To quantitatively assess contrast, the contrast-to-noise ratios (CNR) of selected regions of interest (ROI) in the attenuation images and the phase images were analyzed and compared. It was found that both for virtual microscopy and for in-vivo applications, there is great potential for phase-contrast imaging: in the SR-based benchmarking data, fine details about tissue composition are accessible in the phase images and the visibility of solid tumor tissue under dose-reduced conditions is markedly superior in the phase images. The present study hence demonstrates improved diagnostic value with phase-contrast CT in a mouse model of a complex endogenous cancer, promoting the use and further development of grating-based phase-contrast CT for biomedical imaging applications.

X-ray vector radiography for bone micro-architecture diagnostics

*Article publié en 2012*

*Auteurs*: Potdevin, Guillaume; Malecki, Andreas; Biernath, Thomas; Bech, Martin; Jensen, Torben H.; Feidenhans'l, Robert; Zanette, Irene; Weitkamp, Timm; Kenntner, Johannes; Mohr, Juergen;
Roschger, Paul; Kerschnitzki, Michael; Wagermaier, Wolfgang; Klaushofer, Klaus; Fratzl, Peter; Pfeiffer, Franz

Réf. : PHYS MED BIOL 57 (2012), 3451-3461

Thématiques : Engineering, Biomedical; Radiology, Nuclear Medicine & Medical Imaging

The understanding of large biophysical systems at the systems level often depends on a precise knowledge of their microstructure. This is difficult to obtain, especially in vivo, because most imaging methods are either limited in terms of achievable field of view, or make use of penetrating ionizing radiations such as x-rays, in which case the resolution is severely limited by the deposited dose. Here, we describe a new method, x-ray vector radiography (XVR), which yields various types of information about the local orientation, anisotropy and average size of the sample microstructures. We demonstrate the feasibility by showing first experimental XVRs of human vertebra bone samples, giving information on the trabecular structures even with a pixel resolution of half a millimetre, much larger than the structures themselves. This last point is critical for the development of low-dose measurement methods which will allow for in vivo studies and potentially in the future for new medical diagnostics methods of bone metabolic disorder diseases such as osteoporosis.

[2009-038T] DYNQG

Porteur : Georgy Shlyapnikov

Thème B

Implementing quantum algorithms in hyperfine levels of ultracold polar molecules by optimal control

Article publié en 2011

Auteurs : Pellegrini, Philippe; Vranckx, Stephane; Desouter-Lecomte, Michele

Réf. : PHYS CHEM CHEM PHYS 13 (2011), 18864-18871

Thématiques : Chemistry, Physical; Physics, Atomic, Molecular & Chemical

We numerically implement quantum algorithms in hyperfine levels of ultracold polar molecules. Logical operations are driven by pulses optimized by optimal control theory. All implementations take place in the lowest two rotational levels of the ground vibrational state of the ground \((1)\Sigma^+\) electronic state, exploiting the richness of the hyperfine energy structure and state mixing in static external fields. We show that it is possible to realize high fidelity complex logical operations with microsecond pulses. The possibility to run algorithms implemented on two interacting molecules is also demonstrated. \((41)K(85)Rb\) and \((41)K(87)Rb\) molecules are considered for the numerical simulations but the results are general and can be extended to other species.
Quantum gates driven by microwave pulses in hyperfine levels of ultracold heteronuclear dimers

*Article publié en 2011*

**Auteurs:** Pellegrini, P.; Desouter-Lecomte, M.

**Réf.:** EUR PHYS J D 64 (2011), 163-170

**Thématiques:** Optics; Physics, Atomic, Molecular & Chemical

We theoretically investigated the implementation of universal quantum gates in hyperfine levels of ultracold heteronuclear polar molecules in their lowest rotational manifolds. Quantum bits are manipulated by microwave pulses, taking advantage of the strong state mixing generated by the hyperfine interactions. Gate operations are either driven by a sequence of Gaussian pulses or by a pulse shaped by optimal control theory. Alkaline molecules of experimental interest are considered. We show that high fidelity gates can be driven by microsecond pulses. The richness of the energy structure and the state mixing offer promising perspectives for the manipulation of a large number of qubits.

Toward scalable information processing with ultracold polar molecules in an electric field: A numerical investigation

*Article publié en 2010*

**Auteurs:** Bomble, Laetitia; Pellegrini, Philippe; Ghesquiere, Pierre; Desouter-Lecomte, Michele

**Réf.:** PHYS REV A 82 (2010), -

**Thématiques:** Optics; Physics, Atomic, Molecular & Chemical

We numerically investigate the possibilities of driving quantum algorithms with laser pulses in a register of ultracold NaCs polar molecules in a static electric field. We focus on the possibilities of performing scalable logical operations by considering circuits that involve intermolecular gates (implemented on adjacent interacting molecules) to enable the transfer of information from one molecule to another during conditional laser-driven population inversions. We study the implementation of an arithmetic operation (the addition of 0 or 1 on a binary digit and a carry in) which requires population inversions only and the Deutsch-Jozsa algorithm which requires a control of the phases. Under typical experimental conditions, our simulations show that high-fidelity logical operations involving several qubits can be performed in a time scale of a few hundreds of microseconds, opening promising perspectives for the manipulation of a large number of qubits in these systems.
Controlled full adder-subtractor by vibrational computing

*Article publié en 2010*

*Auteurs*: Bomble, Laetitia; Lauvergnat, David; Remacle, Francoise; Desouter-Lecomte, Michele

*Réf.*: PHYS CHEM CHEM PHYS 12 (2010), 15628-15635

*Thématiques*: Chemistry, Physical; Physics, Atomic, Molecular & Chemical

The implementation of a quantum-controlled full adder-subtractor of two binary digits and of a "carry in" or a "borrow in" is simulated by encoding four qubits in the vibrational eigenstates of a tetra-atomic molecule (trans-HONO). The laser field of the gate is computed using optimal control theory by treating dynamics in full dimensionality. A controlled qubit enforces the addition or the subtraction. The global unitary transformation that connects the inputs to the outputs is driven by a single laser pulse. This decreases the duration of the operation and allows for a better use of the optical resources and for an improvement of the fidelity (>97%). Initialization and reading out are discussed. The timescale of the sequence initialization, gate and read out is <100 ps.

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Functionalized nanoporous track-etched beta-PVDF membrane electrodes for lead(II) determination by square wave anodic stripping voltammetry

*Article publié en 2011*

*Auteurs*: Bessbousse, Haad; Nandhakumar, Iris; Decker, Maxime; Barsbay, Murat; Cuscito, Olivia; Lairez, Didier; Clochard, Marie-Claude; Wade, Travis L.

*Réf.*: ANAL METHODS-UK 3 (2011), 1351-1359

*Thématiques*: Chemistry, Analytical; Food Science & Technology; Spectroscopy

Track-etched functionalized nanoporous beta-PVDF membrane electrodes, or functionalized membrane electrodes (FMEs), are electrodes made from track-etched, poly(acrylic acid) (PAA) functionalized nanoporous beta-poly(vinylidene fluoride) (beta-PVDF) membranes with thin porous Au films sputtered on each side as electrodes. In order to form the P-PVDF nanoporous membranes, beta-PVDF films are irradiated by swift heavy ions. After irradiation, radical tracks are left in the membranes. Etching removes some of the radical tracks revealing nanopores. The remaining
radicals initiate radio grafting of PAA from the pore walls of the nanoporous beta-PVDF. PAA is a cation exchange polymer that adsorbs metal ions, such as Pb(2+), from aqueous solutions thus concentrating the ions into the membrane. After a calibrated time, the FME is transferred to an electrochemical cell for analysis. A negative potential is applied to the Au film of the FME for a set time to reduce the adsorbed ions onto the Au film working electrode. Square-wave anodic stripping voltammetry was performed on the FME to determine the Pb(2+) ion concentration in the original solution based on calibration. The zero current intercept of the calibration for Pb(2+) is 0.13 ppb (µg L(-1)) and three times the sample blank deviation (3S/N) is 0.050 ppb.

Nanopore size tuning of polymeric membranes using the RAFT-mediated radical polymerization

*Article publié en 2013*

_Auteurs_: Barsbay, M; Guven, O; Bessbousse, H; Wade, TL; Beuneu, F; Clochard, MC

_Réf._: _J MEMBRANE SCI_ **445** (2013), 135-145

_Thématiques_: Engineering, Chemical; Polymer Science

Poly(acrylic acid) (PAA) was grafted into the nanochannel walls of track-etched beta-PVDF membranes in a controlled manner by RAFT polymerization. PAA-g-PVDF copolymers with various degrees of grafting from 5% to 63% were characterized by ATR-FTIR, X-ray photoelectron spectroscopy and atomic force microscopy (AFM). The controlled fashion of RAFT mediated grafting was demonstrated by size exclusion chromatography (SEC) and AFM. It was observed that the pore diameter decreases steadily with the degree of grafting (DOG) and pores start to be filled by the grafted PAA beyond similar to 40 wt% DOG, based on AFM measurements and similar to 15 wt% DOG, based on electrochemical analysis. The synthesized nanoporous membranes were later transformed into highly sensitive functionalized membrane electrodes (FMEs) by deposition of a thin gold (similar to 50 nm) layer onto the membrane surfaces without blocking the nanochannels. The synthesized FMEs have been found to be sensitive to sub-ppb concentrations of Pb2+ in square-wave anodic stripping voltammetry (SW-ASV) measurements. The sensitivities of RAFT mediated FMEs compared to those synthesized by conventional free-radical polymerization were found to be almost three times higher at sub-ppb concentrations of Pb2+ in SW-ASV analysis. (c) 2013 Elsevier B.V. All rights reserved.
Opening of the superconducting gap in the hole pockets of Ba(Fe1-xCox)(2)As-2 as seen via angle-resolved photoelectron spectroscopy

*Article publié en 2012*

**Auteurs:** Mansart, B.; Papalazarou, E.; Jensen, M. Fuglsang; Brouet, V.; Petaccia, L.; de' Medici, L.; Sangiovanni, G.; Rullier-Albenque, F.; Forget, A.; Colson, D.; Marsi, M.

**Réf. :** PHYS REV B 85 (2012), -

**Thématiques :** Physics, Condensed Matter

We present an angle-resolved photoelectron spectroscopy study of the changes in the electronic structure of electron-doped Ba(Fe1-xCox)(2)As-2 across the superconducting phase transition. By changing the polarization of the incoming light, we were able to observe the opening of the gap for the inner hole pocket alpha and to compare its behavior with the outer holelike band beta. Measurements along high-symmetry directions show that the behavior of beta is consistent with an isotropic gap opening, while slight anisotropies are detected for the inner band alpha. The implications of these results for the s +/- symmetry of the superconducting order parameter are discussed, in relation to the nature of the different iron orbitals contributing to the electronic structure of this multiband system.

**[2009-060T] IRAHOC-MIS**

**Porteur :** Dominique Teillet-Billy

Thème B

Enhanced H-2 catalytic formation on specific topological defects in interstellar graphenic dust grain models

*Article publié en 2010*

**Auteurs :** Ivanovskaya, Viktoria V.; Zobelli, Alberto; Teillet-Billy, Dominique; Rougeau, Nathalie; Sidis, Victor; Briddon, Patrick R.

**Réf. :** PHYS REV B 82 (2010), -

**Thématiques :** Physics, Condensed Matter

First-principles models of the formation of H-2 on interstellar media carbonaceous grains are usually concerned with processes occurring on ideal graphenic surfaces. Until now these models are unable to explain the formation of molecular hydrogen due to the presence of absorption barriers that cannot be overcome at the low temperatures of the interstellar media. We propose an approach emphasizing the role of specific topological defects for molecular hydrogen catalysis at interstellar dust grain models. Using the nudged elastic band method combined with density-functional
techniques, we obtain the full catalytic cycle for the formation of the H$_2$ molecule on complex carbon topologies involving the presence of pentagonal rings and C adatoms. Depending on structures, reaction paths can be barrierless or have adsorption barriers as low as $10^{-3}$-$10^{-2}$ eV, which might be easily overcome at the temperatures of the interstellar medium. Such low adsorption barriers indicate that specific carbon grains topological defects are preferential sites for the molecular hydrogen formation in the interstellar medium.

[2009-064T] NEXT

Porteur: Kevin Cassou

Thème 6

Enhancement of x-rays generated by a guided laser wakefield accelerator inside capillary tubes

Article publié en 2012


Réf.: APPL PHYS LETT 100 (2012), -

Thématiques: Physics, Applied

Electrons accelerated in the nonlinear regime in a laser wakefield accelerator experience transverse oscillations inside the plasma cavity, giving rise to ultra-short pulsed x-rays, also called the betatron radiation. We show that the fluence of x-ray can be enhanced by more than one order of magnitude when the laser is guided by a 10mm long capillary tube instead of interacting with a 2mm gas jet. X-rays with a synchrotron-like spectrum and associated critical energy similar to 5 keV, with a peak brightness of similar to $1 \times 10^{21}$ ph/s/mm$^2$/mrad$^2$/0.1% BW, were achieved by employing 16 TW laser pulses. (C) 2012 American Institute of Physics. [http://dx.doi.org/10.1063/1.4712594]

[2009-066T] ELIGHT

Porteur: Mathieu Kociak

Thème A
Nanometer Scale Spectral Imaging of Quantum Emitters in Nanowires and Its Correlation to Their Atomically Resolved Structure

Article publié en 2011

Auteurs : Zagonel, Luiz Fernando; Mazzucco, Stefano; Tence, Marcel; March, Katia; Bernard, Romain; Laslier, Benoit; Jacopin, Gwenole; Tchernycheva, Maria; Rigutti, Lorenzo; Julien, Francois H.; Songmuang, Rudeesun; Kociak, Mathieu


Thématiques : Chemistry, Multidisciplinary; Chemistry, Physical; Nanoscience & Nanotechnology; Materials Science, Multidisciplinary; Physics, Applied; Physics, Condensed Matter

We report the spectral imaging in the UV to visible range with nanometer scale resolution of closely packed GaN/AlN quantum disks in individual nanowires using an improved custom-made cathodoluminescence system. We demonstrate the possibility to measure full spectral features of individual quantum emitters as small as 1 nm and separated from each other by only a few nanometers and the ability to correlate their optical properties to their size, measured with atomic resolution. The direct correlation between the quantum disk size and emission wavelength provides evidence of the quantum confined Stark effect leading to an emission below the bulk GaN band gap for disks thicker than 2.6 nm. With the help of simulations, we show that the internal electric field in the studied quantum disks is smaller than what is expected in the quantum well case. We show evidence of a clear dispersion of the emission wavelengths of different quantum disks of identical size but different positions along the wire. This dispersion is systematically correlated to a change of the diameter of the AlN shell coating the wire and is thus attributed to the related strain variations along the wire. The present work opens the way both to fundamental studies of quantum confinement in closely packed quantum emitters and to characterizations of optoelectronic devices presenting carrier localization on the nanometer scale.

Visualizing highly localized luminescence in GaN/AlN heterostructures in nanowires

Article publié en 2012

Auteurs : Zagonel, L. F.; Rigutti, L.; Tchernycheva, M.; Jacopin, G.; Songmuang, R.; Kociak, M.

Réf. : NANOTECHNOLOGY 23 (2012), -

Thématiques : Nanoscience & Nanotechnology; Materials Science, Multidisciplinary; Physics, Applied

The optical properties of a stack of GaN/AlN quantum discs (QDiscs) in a GaN nanowire have been studied by spatially resolved cathodoluminescence (CL) at the nanoscale (nanoCL) using a scanning transmission electron microscope (STEM) operating in spectrum imaging mode. For the electron beam excitation in the QDisc region, the luminescence signal is highly localized, with spatial extent as low as 5 nm, due to the high band gap difference between GaN and AlN. This allows the discrimination between the emission of neighbouring QDiscs and evidencing the presence of lateral inclusions, about 3 nm thick and 20 nm long rods (quantum rods, QRods), grown unintentionally on
the nanowire sidewalls. These structures, also observed by STEM dark-field imaging, are proved to be optically active in nanoCL, emitting at similar, but usually shorter, wavelengths with respect to most QDiscs.

[2009-069T] BIGRAPH

Porteur : Natacha Kirova

Thème 1

Anisotropy of graphite optical conductivity

Article publié en 2010

Auteurs : Falkovsky, L. A.

Réf. : JETP LETT+ 92 (2010), 348-351

Thématiques : Physics, Multidisciplinary

The graphite conductivity is evaluated for frequencies between 0.1 eV, the energy of the order of the electronhole overlap, and 1.5 eV, the electron nearest hopping energy. The in-plane conductivity per single atomic sheet is close to the universal graphene conductivity e (2)/4A and, however, contains a singularity conditioned by peculiarities of the electron dispersion. The conductivity is less in the c direction by the factor of the order of 0.01 governed by electron hopping in this direction.

[2009-070T] BIRD

Porteur : Isabelle Philip

Thème 7

Higher-order photon correlations in pulsed photonic crystal nanolasers

Article publié en 2011

Auteurs : Elvira, D.; Hachair, X.; Verma, V. B.; Braive, R.; Beaudoin, G.; Robert-Philip, I.; Sagnes, I.; Baek, B.; Nam, S. W.; Dauler, E. A.; Abram, I.; Stevens, M. J.; Beveratos, A.

Réf. : PHYS REV A 84 (2011), -

Thématiques : Optics; Physics, Atomic, Molecular & Chemical
We report on the higher-order photon correlations of a high-beta nanolaser under pulsed excitation at room temperature. Using a multiplexed four-element superconducting single-photon detector we measured \( g^{(n)}(0) \) over right arrow with \( n = 2,3,4 \). All orders of correlation display partially chaotic statistics, even at four times the threshold excitation power. We show that this departure from coherence and Poisson statistics is due to the quantum fluctuations associated with the small number of photons at the lasing threshold.

Identification of the stimulated-emission threshold in high-beta nanoscale lasers through phase-space reconstruction

*Article publié en 2011*


**Réf.** : PHYS REV A *83* (2011), -

**Thématiques** : Optics; Physics, Atomic, Molecular & Chemical

Nanoscale lasers sustain a few optical modes so that the fraction of spontaneous emission beta funnelled into the useful (lasing) mode is high (of the order of \( 10^{-1} \)) and the threshold, which traditionally corresponds to an abrupt kink in the light-in-light-out curve, becomes ill defined. We propose an alternative definition of the threshold that is based on the dynamical response of the laser and is valid even for \( \beta = 1 \) lasers. The laser dynamics is analyzed through a reconstruction of its phase-space trajectory for pulsed excitations. Crossing the threshold, brings about a change in the shape of the trajectory and in the area contained in it. An unambiguous determination of the threshold in terms of this change is shown theoretically and illustrated experimentally in a photonic-crystal laser.

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[2009-072T] DESIRABLE

**Porteur** : Xavier Checoury

**Thème 7**

All-silicon photonic crystal photoconductor on silicon-on-insulator at telecom wavelength

*Article publié en 2010*

**Auteurs** : Haret, Laurent-Daniel; Checoury, Xavier; Han, Zheng; Boucaud, Philippe; Combrie, Sylvain; De Rossi, Alfredo

**Réf.** : OPT EXPRESS *18* (2010), 23965-23972
We demonstrate an all-silicon photodetector working at telecom wavelength. The device is a simple metal-semiconductor-metal detector fabricated on silicon-on-insulator. A two-dimensional photonic crystal nanocavity ($Q = 60,000$) is used to increase the response that arises from the linear and two-photon absorption of silicon. The responsivity of the detector is about 20 mA/W and its bandwidth is larger than 1 GHz. (C) 2010 Optical Society of America

Schottky MSM junctions for carrier depletion in silicon photonic crystal microcavities

*Article publié en 2013*

*Auteurs*: Haret, Laurent-Daniel; Checoury, Xavier; Bayle, Fabien; Cazier, Nicolas; Boucaud, Philippe; Combrrie, Sylvain; de Rossi, Alfredo

*Réf.*: OPT EXPRESS 21 (2013), 10324-10334

Collection of free carriers is a key issue in silicon photonics devices. We show that a lateral metal-semiconductor-metal Schottky junction is an efficient and simple way of dealing with that issue in a photonic crystal microcavity. Using a simple electrode design, and taking into account the optical mode profile, the resulting carrier distribution in the structure is calculated. We show that the corresponding effective free carrier lifetime can be reduced by 50 times when the bias is tuned. This allows one to maintain a high cavity quality factor under strong optical injection. In the fabricated structures, carrier depletion is correlated with transmission spectra and directly visualized by Electron Beam Induced Current pictures. These measurements demonstrate the validity of this carrier extraction principle. The design can still be optimized in order to obtain full carrier depletion at a smaller energy cost. (C) 2013 Optical Society of America

Norovirus Capsid Proteins Self-Assemble through Biphasic Kinetics via Long-Lived Stave-like Intermediates

*Article publié en 2013*

*Auteurs*: Tresset, G; Le Coeur, C; Bryche, JF; Tatou, M; Zeghal, M; Charpilienne, A; Poncet, D; Constantin, D; Bressanelli, S
The self-assembly kinetics for a norovirus capsid protein were probed by time-resolved small-angle X-ray scattering and then analyzed by singular value decomposition and global fitting. Only three species contribute to the total scattering intensities: dimers, intermediates comprising some 11 dimers, and icosahedral T = 3 capsids made up of 90 dimers. Three-dimensional reconstructions of the intermediate robustly show a stave-like shape consistent with an arrangement of two pentameric units connected by an interstitial dimer. Upon triggering of self-assembly, the biphasic kinetics consist of a fast step in which dimers are assembled into intermediates, followed by a slow step in which intermediates interlock into capsids. This simple kinetic model reproduces experimental data with an excellent agreement over 6 decades in time and with nanometer resolution. The extracted form factors are robust against changes in experimental conditions. These findings challenge and complement currently accepted models for the assembly of norovirus capsids.

Unusual self-assembly properties of Norovirus Newbury2 virus-like particles

*Article publié en 2013*

*Auteurs*: Tresset, G; Decouche, V; Bryche, JF; Charpilienne, A; Le Coeur, C; Barbier, C; Squires, G; Zeghal, M; Poncet, D; Bressanelli, S

*Réf.:* ARCH BIOCHEM BIOPHYS 537 (2013), 144-152

In the Caliciviridae family of nonenveloped, positive-stranded RNA viruses, Noroviruses are major causes of human and animal gastroenteritis worldwide. The Norovirus T = 3 icosahedral capsid is made of 180 copies of the VP1 protein, as exemplified in the crystal structure of the virus-like particle (VLP) of the human Norwalk virus (NV). It was previously shown that the ca 40-nm recombinant NV VLP can be disassembled and reassembled in vitro. Here we report on the disassembly and self-assembly properties for the related (VP1 sequence identity of 50%) bovine Newbury2 Norovirus (NB2) VLP. Using a panel of biophysical techniques, we show that while the NB2 VLP displays disassembly properties similar to the NV VLP, NB2-VP1 shows remarkable self-assembly properties heretofore unreported for NV-VP1 or any other calicivirus capsid protein. These properties include the capabilities of self-assembling not only into regular T = 3 capsids but also into larger VLP (up to 76 nm in diameter) and of tolerating substitution of the spike domain for that of a distantly related Calicivirus. In conditions favoring the natural, T = 3 capsid, NB2-VP1 reproducibly assembles by an apparent two-phase process. Our results establish a robust new system with which to probe the dynamics of viral capsid self-assembly. (C) 2013 Elsevier Inc. All rights reserved.
A proposal for multi-tens of GW fully coherent femtosecond soft X-ray lasers

*Article publié en 2012*


*Réf.*: NAT PHOTONICS *6* (2012), 764-767

*X-ray free-electron lasers*([1,2]) delivering up to $1 \times 10^{13}$ coherent photons in femtosecond pulses are bringing about a revolution in X-ray science([3-5]). However, some plasma-based soft X-ray lasers([6]) are attractive because they spontaneously emit an even higher number of photons ($1 \times 10^{15}$), but these are emitted in incoherent and long (hundreds of picoseconds) pulses as a consequence of the amplification of stochastic incoherent self-emission. Previous experimental attempts to seed such amplifiers with coherent femtosecond soft X-rays resulted in as yet unexplained weak amplification of the seed and strong amplification of incoherent spontaneous emission([8]). Using a time-dependent Maxwell-Bloch model describing the amplification of both coherent and incoherent soft X-rays in plasma, we explain the observed inefficiency and propose a new amplification scheme based on the seeding of stretched high harmonics using a transposition of chirped pulse amplification to soft X-rays. This scheme is able to deliver $5 \times 10^{14}$ fully coherent soft X-ray photons in 200 fs pulses and with a peak power of 20 GW.

Comparison of natural and forced amplification regimes in plasma-based soft-x-ray lasers seeded by high-order harmonics

*Article publié en 2011*

*Auteurs*: Oliva, Eduardo; Zeitoun, Philippe; Fajardo, Marta; Lambert, Guillaume; Ros, David; Sebban, Stephane; Velarde, Pedro

*Réf.*: PHYS REV A *84* (2011), -

The amplification of high-order harmonics (HOH) in a plasma-based amplifier is a multiscale, temporal phenomenon that couples plasma hydrodynamics, atomic processes, and HOH electromagnetic fields. We use a one-dimensional, time-dependent Maxwell-Bloch code to compare the natural amplification regime and another regime where plasma polarization is constantly forced by the HOH. In this regime, a 10-MW (i.e., 100 times higher than current seeded soft X-ray laser power), 1.5-mu J, 140-fs pulse free from the parasitic temporal structures appearing on the natural amplification regime can be obtained.
Optical and electrical properties of laser doped Si:B in the alloy range

*Article publié en 2012*

**Auteurs:** Bhaduri, A.; Kociniewski, T.; Fossard, F.; Boulmer, J.; Debarre, D.

**Réf.** : *APPL SURF SCI* **258** (2012), 9228-9232

**Thématiques** : Chemistry, Physical; Materials Science, Coatings & Films; Physics, Applied; Physics, Condensed Matter

We have probed the dopant activity of silicon B-doped by Gas Immersion Laser Doping (GILD). Here, we report on the comparison of optical, electrical and structural properties of Si: B, over a wide concentration range, up to $1.5 \times 10^{21}$ cm$^{-3}$ by steps of $1.5 \times 10^{19}$ cm$^{-3}$. Data obtained by reflectance FTIR spectroscopy are used within a Drude model to extract concentration, thickness and mobility. Resulting carrier concentration and conductivity are checked with 4-point probe electrical and X-ray diffraction measurements. FTIR proved to be very sensitive to the dopant distribution inside the layer, despite its thinness. It clearly reveals a moderate dopant accumulation at the interfaces. (C) 2011 Elsevier B. V. All rights reserved.

Soft x-ray plasma-based seeded multistage amplification chain

*Article publié en 2012*

**Auteurs** : Oliva, Eduardo; Fajardo, Marta; Li, Lu; Sebban, Stephane; Ros, David; Zeitoun, Philippe

**Réf.** : *OPT LETT* **37** (2012), 4341-4343

**Thématiques** : Optics

To date, plasma-based soft x-ray lasers have demonstrated experimentally 1 μJ, 1 ps (1 MW) pulses. This Letter reports extensive study using time-dependent Maxwell-Bloch code of seeding millimeter scale plasmas that store more than 100 mJ in population inversion. Direct seeding of these plasmas has to overcome very strong amplified spontaneous emission (ASE) as well as prevent wake-field amplification. Below 100 nJ injected energy, seed produces pulses with picosecond duration. To overcome this limitation, a new scheme has been studied, taking advantage of a plasma preamplifier that dramatically increases the seed energy prior to entering the main plasma amplifier leading to ASE and wake-free, fully coherent 21.6 μJ, 80 fs pulses (0.27 GW). (C) 2012 Optical Society of America

[2009-082T] FIBNANOSYNTH

**Porteur** : Franck Fortuna

Thème C
Bismuth-Catalyzed and Doped Silicon Nanowires for One-Pump-Down Fabrication of Radial Junction Solar Cells

*Article publié en 2012*

*Auteurs*: Yu, Linwei; Fortuna, Franck; O'Donnell, Benedict; Jeon, Taewoo; Foldyna, Martin; Picardi, Gennaro; Roca i Cabarrocas, Pere

*Réf.*: NANO LETT 12 (2012), 4153-4158

**Thématiques**: Chemistry, Multidisciplinary; Chemistry, Physical; Nanoscience & Nanotechnology; Materials Science, Multidisciplinary; Physics, Applied; Physics, Condensed Matter

Silicon nanowires (SiNWs) are becoming a popular choice to develop a new generation of radial junction solar cells. We here explore a bismuth- (Bi-) catalyzed growth and doping of SiNWs, via vapor-liquid-solid (VLS) mode, to fabricate amorphous Si radial n-i-p junction solar cells in a one-pump-down and low-temperature process in a single chamber plasma deposition system. We provide the first evidence that catalyst doping in the SiNW cores, caused by incorporating Bi catalyst atoms as n-type dopant, can be utilized to fabricate radial junction solar cells, with a record open circuit voltage of $V_{oc} = 0.76$ V and an enhanced light trapping effect that boosts the short circuit current to $J_{sc} = 11.23$ mA/cm$^2$. More importantly, this bi-catalyzed SiNW growth and doping strategy exempts the use of extremely toxic phosphine gas, leading to significant procedure simplification and cost reduction for building radial junction thin film solar cells.

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.*: PHYS REV B 86 (2012), -

**Thématiques**: Physics, Condensed Matter

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 $I_c$.  

↑ Haut de page

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52
Magnetic imaging by Fourier transform holography using linearly polarized x-rays

Article publié en 2012

Auteurs : Sacchi, Maurizio; Popescu, Horia; Jaouen, Nicolas; Tortarolo, Marina; Fortuna, Franck; Delaunay, Renaud; Spezzani, Carlo

Réf. : OPT EXPRESS 20 (2012), -

Thématiques : Optics

We present a method for imaging magnetic domains via x-ray Fourier transform holography at linearly polarized sources. Our approach is based on the separation of holographic mask and sample and on the Faraday rotation induced on the reference wave. We compare images of perpendicular magnetic domains obtained with either linearly or circularly polarized x-rays and discuss the relevance of this method to future experiments at free-electron laser and high-harmonic-generation sources. (c) 2012 Optical Society of America

[2009-083T] SYMTCOB2

Porteur : Henri Alloul

Thème 4

Co-59 NMR evidence for charge and orbital order in the kagome-like structure of Na2/3CoO2

Article publié en 2011

Auteurs : Mukhamedshin, I. R.; Alloul, H.

Réf. : PHYS REV B 84 (2011), -

Thématiques : Physics, Condensed Matter

We report a complete set of Co-59 NMR data taken on the x = 2/3 phase of sodium cobaltates Na_xCoO_2 for which we have formerly established the in-plane Na ordering and its three-dimensional stacking from a combination of symmetry arguments taken from Na and Co NQR/NMR data. Here, we resolve all the parameters of the Zeeman and quadrupolar Hamiltonians for all cobalt sites in the unit cell and report the temperature dependencies of the NMR shift and spin lattice relaxation T-1 data for these sites. We confirm that three nonmagnetic Co3+ (Co1) are in axially symmetric positions and that the doped holes are delocalized on the nine complementary magnetic cobalt sites (Co2) of the atomic unit cell. The moderately complicated atomic structure resumes then in a very simple electronic structure in which the electrons delocalize on the Co2 kagome sublattice of the triangular lattice of Co sites. The observation of a single temperature dependence of the spin susceptibilities indicates that a single band picture applies, and that the magnetic properties are dominated by the static and dynamic electronic properties at the Co2 sites. We evidence that they display a strong in-plane electronic anisotropy initially unexpected but which agrees perfectly with
an orbital ordering along the kagome sublattice organization. These detailed data should now permit realistic calculations of the electronic properties of this compound in order to determine the incidence of electronic correlations.

[2009-086T] ATTOS

Porteur : Myriam Pannetier-Lecoeur

Thème 5

Dual Antiferromagnetic Coupling at La0.67Sr0.33MnO3/SrRuO3 Interfaces

Article publié en 2012

Auteurs : Solignac, A.; Guerrero, R.; Gogol, P.; Maroutian, T.; Ott, F.; Largeau, L.; Lecoeur, Ph.; Pannetier-Lecoeur, M.

Réf. : PHYS REV LETT 109 (2012), -

Thématiques : Physics, Multidisciplinary

We have studied the magnetic hysteresis cycle of La0.67Sr0.33MnO3/SrRuO3 antiferromagnetically coupled bilayers, by magnetometry and polarized neutron reflectometry. A positive exchange bias as well as an unusual asymmetry are observed on the magnetic reversal process of the La0.67Sr0.33MnO3 layer. Through an extended Stoner-Wohlfarth model comprising the magnetic anisotropy of both layers, we give experimental evidence that this asymmetry originates from two different but well-defined antiferromagnetic coupling strengths at the interface between the two magnetic oxides. The possible origin of this dual coupling is discussed in view of our experimental results.

Low frequency noise in La0.7Sr0.3MnO3 based magnetic tunnel junctions

Article publié en 2012

Auteurs : Guerrero, R.; Solignac, A.; Fermon, C.; Pannetier-Lecoeur, M.; Lecoeur, Ph.; Fernandez-Pacheco, R.

Réf. : APPL PHYS LETT 100 (2012), -

Thématiques : Physics, Applied

Magnetic tunnel junctions based on manganites can exhibit a high tunneling magnetoresistance ratio due to the almost full spin polarization at the Fermi level. However, the performances of magnetic tunnel junction devices are also strongly linked to their noise characteristics. Here, we present a low frequency noise study on fully epitaxial
La0.7Sr0.3MnO3/SrTiO3/La0.7Sr0.3MnO3/La0.66Sr0.33Mn0.995Ru0.005O3 tunnel spin valves with tunneling magnetoresistance ratios larger than 100%. We evidence non-conventional low frequency noise dependence on temperature related to the magnetic fluctuations and structural phase transitions in the structure. We present also a comparison with the low frequency noise exhibited in Fe/MgO/Fe magnetic tunnel junctions.

(C) 2012 American Institute of Physics. [http://dx.doi.org/10.1063/1.3698393]

[2009-087T] XUV-PHALG

Porteur : David Garzella

Thème 6

Two-colour generation in a chirped seeded free-electron laser: a close look

Article publié en 2013

Auteurs : Mahieu, B; Allaria, E; Castronovo, D; Danailov, MB; Demidovich, A; De Ninno, G; Di Mitri, S; Fawley, WM; Ferrari, E; Frohlich, L; Gauthier, D; Giannessi, L; Mahne, N; Penco, G; Raimondi, L; Spampinati, S; Spezzani, C; Svetina, C; Trovo, M; Zangrando, M

Réf. : OPT EXPRESS 21 (2013), 22728-22741

Thématiques : Optics

We present the experimental demonstration of a method for generating two spectrally and temporally separated pulses by an externally seeded, single-pass free-electron laser operating in the extreme-ultraviolet spectral range. Our results, collected on the FERMI@Elettra facility and confirmed by numerical simulations, demonstrate the possibility of controlling both the spectral and temporal features of the generated pulses. A free-electron laser operated in this mode becomes a suitable light source for jitter-free, two-colour pump-probe experiments. (c) 2013 Optical Society of America

[2009-088T] SUPRASPIN

Porteur : Javier Villegas

Thème 4
Controllable manipulation of superconductivity using magnetic vortices

Article publié en 2011

Auteurs : Villegas, J. E.; Schuller, Ivan K.

Réf. : SUPERCOND SCI TECH 24 (2011), -

Thématiques : Physics, Applied; Physics, Condensed Matter

The magneto-transport of a superconducting/ferromagnetic hybrid structure, consisting of a superconducting thin film in contact with an array of magnetic nanodots in the so-called 'magnetic vortex state', exhibits interesting properties. For certain magnetic states, the stray magnetic field from the vortex array is intense enough to drive the superconducting film into the normal state. In this fashion, the normal-to-superconducting phase transition can be controlled by the magnetic history. The strong coupling between superconducting and magnetic subsystems allows characteristically ferromagnetic properties, such as hysteresis and remanence, to be dramatically transferred into the transport properties of the superconductor.

Equal-spin Andreev reflection and long-range coherent transport in high-temperature superconductor/half-metallic ferromagnet junctions

Article publié en 2012


Réf. : NAT PHYS 8 (2012), 539-543

Thématiques : Physics, Multidisciplinary

Conventional superconductivity is incompatible with ferromagnetism, because the magnetic exchange field tends to spin-polarize electrons and breaks apart the opposite-spin singlet Cooper pairs(1). Yet, the possibility of a long-range penetration of superconducting correlations into strong ferromagnets has been evinced by experiments that found Josephson coupling between superconducting electrodes separated afar by a ferromagnetic spacer(2-7). This is considered a proof of the emergence at the superconductor/ferromagnetic (S/F) interfaces of equal-spin triplet pairing, which is immune to the exchange field and can therefore propagate over long distances into the F (ref. 8). This effect bears much fundamental interest and potential for spintronic applications(9). However, a spectroscopic signature of the underlying microscopic mechanisms has remained elusive. Here we do show this type of evidence, notably in a S/F system for which the possible appearance of equal-spin triplet pairing is controversial(10-12): heterostructures that combine a half-metallic F (La0.7Ca0.3MnO3) with a d-wave S (YBa2Cu3O7). We found quasiparticle and electron interference effects in the conductance across the S/F interfaces that directly demonstrate the long-range propagation across La0.7Ca0.3MnO3 of superconducting correlations, and imply the occurrence of unconventional equal-spin Andreev reflection. This allows for an understanding of the unusual proximity behaviour observed in this type of heterostructures(12,13).
Hysteretic magnetic pinning and reversible resistance switching in high-temperature superconductor/ferromagnet multilayers

*Article publié en 2011*

**Auteurs:** Visani, C.; Metaxas, P. J.; Collaudin, A.; Calvet, B.; Bernard, R.; Briatico, J.; Deranlot, C.; Bouzehouane, K.; Villegas, J. E.

**Réf.:** PHYS REV B 84 (2011), -

**Thématiques:** Physics, Condensed Matter

We study a high-critical temperature superconducting (YBa(2)Cu(3)O(7-delta))/ferromagnetic (Co/Pt multilayer) hybrid that exhibits resistance switching driven by the magnetic history: depending on the direction of the external field, a pronounced decrease or increase of the mixed-state resistance is observed as magnetization reversal occurs within the Co/Pt multilayer. We demonstrate that stray magnetic fields cause these effects via (i) creation of vortices/antivortices and (ii) magnetostatic pinning of vortices that are induced by the external field.

Imprinting nanoporous alumina patterns into the magneto-transport of oxide superconductors

*Article publié en 2011*


**Réf.:** NANOTECHNOLOGY 22 (2011), -

**Thématiques:** Nanoscience & Nanotechnology; Materials Science, Multidisciplinary; Physics, Applied

We used oxygen ion irradiation to transfer the nanoscale pattern of a porous alumina mask into high-T(C) superconducting thin films. This causes a nanoscale spatial modulation of superconductivity and strongly affects the magneto-transport below T(C), which shows a series of periodic oscillations reminiscent of the Little-Parks effect in superconducting wire networks. This irradiation technique could be extended to other oxide materials in order to induce ordered nanoscale phase segregation.

Ultrathin oxide films and interfaces for electronics and spintronics

*Article publié en 2011*

**Auteurs:** Bibes, Manuel; Villegas, Javier E.; Barthelemy, Agnes

**Réf.:** ADV PHYS 60 (2011), 5-84
Oxides have become a key ingredient for new concepts of electronic devices. To a large extent, this is due to the profusion of new physics and novel functionalities arising from ultrathin oxide films and at oxide interfaces. We present here a perspective on selected topics within this vast field and focus on two main issues. The first part of this review is dedicated to the use of ultrathin films of insulating oxides as barriers for tunnel junctions. In addition to dielectric non-magnetic epitaxial barriers, which can produce tunneling magnetoresistances in excess of a few hundred percent, we pay special attention to the possibility of exploiting the multifunctional character of some oxides in order to realize ‘active’ tunnel barriers. In these, the conductance across the barrier is not only controlled by the bias voltage and/or the electrodes magnetic state, but also depends on the barrier ferroic state. Some examples include spin-filtering effects using ferro- and ferrimagnetic oxides, and the possibility of realizing hysteretic, multi-state junctions using ferroelectric barriers. The second part of this review is devoted to novel states appearing at oxide interfaces. Often completely different from those of the corresponding bulk materials, they bring about novel functionalities to be exploited in spintronics and electronics architectures. We review the main mechanisms responsible for these new properties (such as magnetic coupling, charge transfer and proximity effects) and summarize some of the most paradigmatic phenomena. These include the formation of high-mobility two-dimensional electron gases at the interface between insulators, the emergence of superconductivity (or ferromagnetism) at the interface between non-superconducting (or non-ferromagnetic) materials, the observation of magnetoelectric effects at magnetic/ferroelectric interfaces or the effects of the interplay and competing interactions at all-oxide ferromagnetic/superconducting interfaces. Finally, we link up the two reviewed research fields and emphasize that the tunneling geometry is particularly suited to probe novel interface effects at oxide barrier/electrode interfaces. We close by giving some directions toward tunneling devices exploiting novel oxide interfacial phenomena.

Vortex lattice dynamics in Nb films with competing intrinsic random and artificial periodic pinning

*Article publié en 2011*

*Auteurs :* Chiliotte, C.; Pasquini, G.; Bekeris, V.; Villegas, J. E.; Li, C-P; Schuller, Ivan K.

*Réf. :* SUPERCOND SCI TECH 24 (2011), -

Thématiques : Physics, Applied; Physics, Condensed Matter

We study vortex lattice (VL) dynamics in patterned Nb films containing dense periodic arrays of sub 50 nm magnetic nanodots or holes, by means of ac susceptibility measurements. For both types of samples, we observe matching effects within a wide temperature range, determined by the periodicity of the strong artificial pinning potential. Below a crossover reduced temperature \( t^* = 0.75 \), the ac vortex mobility and matching fields are different for increasing or decreasing fields. Low temperature field cooling experiments indicate that the hysteretic behavior is not related to different intensities of magnetic induction \( B \) in the ac penetrated region of the samples. The fact that hysteresis appears in both patterned samples when the intrinsic random pinning becomes stronger, together with the absence of hysteresis in a reference unpatterned Nb film, suggests that the interplay between random and periodic pinning, independent of its origin, induces VL metastability below \( t^* \), which leads to the observed irreversibility.