



Lausanne Centre for Ultrafast Science **Activity Report 2016-2017**

Summary:

LACUS was launched in June 2016. The present report provides an account of its activities since then.

a. Individual grants:

ERC Starting Grants: **U. Lorenz, R. Buonsanti**

ERC Consolidator Grants: **F. Carbone, J. Vanicek**

ERC Advanced Grant: **M. Chergui**

SNF Junior professorships: **U. Lorenz, R. Buonsanti**

SNSF Ambizione Fellowship: **A. Maciario** (S. Roke)

ERC Proof-of-Concept: **Y. Bellouard** (starting March 2018)

Early PostDoc Mobility SNF : **E. Baldini** (ex-PhD with Carbone and Chergui)

b. Network grants:

- Sinergia network “Mott Physics Beyond the Heisenberg Model” 2013-2018, Coord. **H. Ronnow**.
- Sinergia network “NanoSkyrmionics” (2018-2023) (Coord. Dirk Grundler), **F. Carbone** (participant).
- Horizon 2020 Marie Curie Innovative Training Network “FINESSE” 2016-2020: <http://itn-finesse.eu/>, Proposer and Coordinator: **L. Thévenaz**.
- Rothschild Caesarea Foundation (Weizmann Institute of Science - EPFL collaboration), “Understanding hydration lubrication”, **S. Roke/J. Klein**.
- EPFL-MPI collaboration (2017) : **M. Chergui/M. Wolf** (FHI-Berlin)
- SNF Grant - FemtoAnvil : **Y. Bellouard/P. Gillet**
- Current NCCR proposal QUBE “Quantum mechanics Beyond Equilibrium” (submitted): **G. Aeppli, F. Carbone, M. Chergui** (participants), **H. Ronnow** (coordinator).

c. Awards:

E. Baldini (PhD, Carbone/Chergui): Dimitris N. Chorafas Foundation PhD Award; Springer Thesis Prize.

F. Carbone: University Latsis Award 2016

M. Chergui: OSA Fellow, Al Khawarizmi International Award (Iran), elected Foreign Member of the Spanish Royal Academy of Sciences.

A. Hagfeldt: Honorary Doctorate of the Université Paris Diderot; The Björkenska Prize (Uppsala Univ.)

T. Kippenberg: APS Fellow

L. Thevenaz: IEEE Fellow

d. Selected Publications:

Y. Bellouard

Unraveling Brittle-Fracture Statistics from Intermittent Patterns Formed During Femtosecond Laser Exposure C.-E. Athanasiou, M.-O. Hongler, and Y. Bellouard, *Physical Review Applied* 8, (2017).

Laser-Induced Transition between Nonlinear and Linear Resonant Behaviors of a Micromechanical Oscillator T. Yang and Y. Bellouard, *Physical Review Applied* 7, (2017).

Plasmon-less surface enhanced Raman spectra induced by self-organized networks of silica nanoparticles produced by femtosecond lasers Y. Bellouard, E. Block, J. Squier, and J. Gobet, *Optics Express* 25, 9587 (2017).

Combination of additive and subtractive laser 3D microprocessing in hybrid glass/polymer microsystems for chemical sensing applications T. Tičkūnas, M. Perrenoud, S. Butkus, R. Gadonas, S. Rekštytė, M. Malinauskas, D. Paipulas, Y. Bellouard, and V. Sirutkaitis, *Opt. Express*, OE 25, 26280–26288 (2017).

R. Buonsanti:

CsPbBr₃ QD/AlO_x inorganic nanocomposites with exceptional stability in water, light and heat.

A. Loiudice *et al*, *Angewandte Chemie IE*. DOI: 10.1002/anie.201703703

F. Carbone:

Laser-Induced Skyrmion Writing and Erasing in an Ultrafast Cryo-Lorentz Transmission Electron G. Berruto, I. Madan, Y. Murooka, G. M. Vanacore, E. Pomarico, J. Rajeswari, R. Lamb, P. Huang, A. J. Kruchkov, Y. Togawa, T. LaGrange, D. McGrouther, H. M. Rønnow, and F. Carbone, *Phys Rev. Lett.* **Editor's suggestion**

meV Resolution in Laser-Assisted Energy-Filtered Transmission Electron Microscopy Enrico Pomarico, Ivan Madan, Gabriele Berruto, Giovanni Maria Vanacore, Kangpeng Wang, Ido Kaminer, Javier García de Abajo, Fabrizio Carbone. *ACS photonics*, DOI: 10.1021/acsp Photonics.7b01393

M. Chergui:

Laser assisted photoelectric effect from liquids

C. Arrell *et al*, *Physical Review Letters* 117 (2016) 143001

Strongly bound excitons in anatase TiO₂ single crystals and nanoparticles

E. Baldini *et al*, *Nature Communications* 8 (2017) 13

Localized holes and delocalized electrons in photoexcited inorganic perovskites: Watching each atomic actor by picosecond X-ray absorption spectroscopy

Fabio G. Santomauro *et al*, Structural Dynamics 4 (2017) 044002, **Highlight in Physics Today**

Photoaquation mechanism of Hexacyanoferrate(II) ions: Ultrafast 2D UV and transient visible and IR spectroscopies

Marco Reinhard *et al*, Journal of the American Chemical Society 139 (2017) 7335–7347

Ultrafast Interfacial Electron Injection Probed by an excitonic signature of the substrate

Edoardo Baldini *et al*, Journal of the American Chemical Society 139 (2017) 11584–11589

Revealing hole trapping in ZnO nanoparticles by time-resolved X-ray spectroscopy

Thomas J. Penfold *et al*, Nature Communications 9 (2018) 478

Clocking the Ultrafast Electron Cooling in Anatase Titanium Dioxide

Edoardo Baldini *et al*, ACS Photonics (DOI: 10.1021/acsp Photonics.7b00945)

H. Dil:

Spin polarization and attosecond time delay in photoemission from spin degenerate states of solids

Mauro Fanciulli, Henrieta Volfová, Stefan Muff, Jürgen Braun, Hubert Ebert, Jan Minár, Ulrich Heinzmann, J. Hugo Dil, Physical Review Letters 118, 067402 (2017)

Spin polarization in photoemission from the cuprate superconductor $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_{8+\delta}$

Mauro Fanciulli, Stefan Muff, Andrew P. Weber, J. Hugo Dil, Physical Review B 95, 245125 (2017)

M. Grioni:

Enhanced ultrafast relaxation rate in the Weyl semimetal phase of MoTe_2 measured by time- and angle-resolved photoelectron spectroscopy

A. Crepaldi *et al*. Phys. Rev. B 95, 041408(R) (2016) **Editor's suggestion**

C. Moser:

Three-dimensional microfabrication through a multimode optical fiber

Edgar E. Morales-Delgado, Loic Urio, Donald B. Conkey, Nicolino Stasio, Demetri Psaltis, and Christophe Moser, Optics Express 25, 7031-7045 (2017)

Single-photon three-dimensional microfabrication through a multimode optical fiber

Paul Delrot, Damien Loterie, Demetri Psaltis, and Christophe Moser

Optics Express 26, 1766-1778 (2018)

J.-E. Moser:

Charge separation and carrier dynamics in donor-acceptor heterojunction photovoltaic systems.

J. Teuscher *et al.*, Struct. Dyn. 2017, 4, 061503.

Energy and charge transfer cascade in methylammonium lead bromide perovskite nanoparticle aggregates.

M. E. F. Bouduban et al. Chem. Sci. 2017, 8, 4371-4380.

Perovskite photovoltaics: Slow recombination unveiled.

J.-E. Moser, Nat. Mater. 2017, 16, 4-6.

J.-E. Moser / A. Hagfeldt:

Dye-sensitized solar cells for efficient power generation under ambient lighting.

M. Freitag et al. Nature Photonics 2017, 11, 372-378.

11% efficiency solid-state dye-sensitized solar cells with copper(II/I) hole transport materials.

Y. Cao et al. Nature Comm. 2017, 8, 5390.

S. Roke:

What determines nanodroplet stability?

E. Zdrali, H. I. Okur, Y. Chen, S. Roke, ACS Nano, 11, 12111-12120 (2017)

Optical Imaging of Surface Chemistry and Dynamics in Confinement

C. Macias-Romero, I. Nahalka, H. I. Okur, S. Roke, Science 357, 784-788(2017)

The interfacial structure of water droplets in a hydrophobic liquid, N. Smolentsev, W. J. Smit, H. J. Bakker and S. Roke, Nature Comm. 8, 15548-1-6 (2017)

Electrolytes induce long-range orientational order and energy changes in the H-bond network of bulk water

Y. Chen, N. Gomopoulos, H. I. Okur, C. Macias-Romero, P. S. Cremer, P. B. Petersen, G. Tocci, D. Wilkins, C. Liang, M. Ceriotti, S. Roke, Science Advances, 4, e1501891, 1-8 (2016)

Intramolecular head group interaction and hydration as driving forces for membrane asymmetry

N. Smolentsev, C. Lütgebaucks, H. I. Okur, S. Roke, J. Am. Chem. Soc. 138, 4053–4060 (2016)

L. Thévenaz

Intensifying the response of distributed optical fibre sensors using 2D and 3D image restoration

M. A. Soto, J. A. Ramirez, and L. Thevenaz,

Nature Communications 7, 10870 (2016). doi:10.1038/ncomms10870

Going beyond 1000000 resolved points in a Brillouin distributed fiber sensor: theoretical analysis and experimental demonstration

A. Denisov, M. A. Soto, and L. Thevenaz

Nature Light Sci. Appl. 5, e16074 (2016). doi:10.1038/lsa.2016.74

e. New Set-ups:

U. Lorenz: Ultrafast TEM with a Field Emission Gun.

S. Roke: A new second harmonic microscope capable of 3D imaging of interfacial water and water in pores (Figure 1).

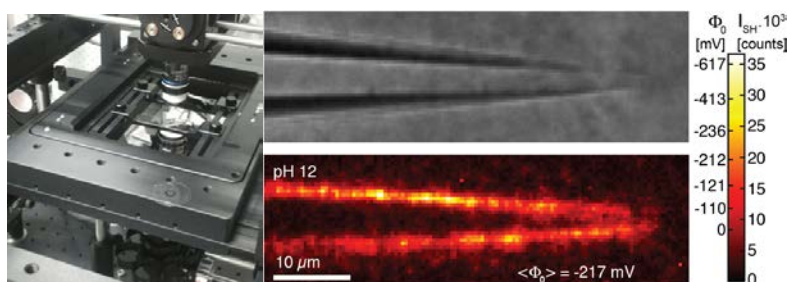


Figure 1. Picture of the second harmonic (SH) imaging system (left), Wide field phase contrast image of a micro-capillary immersed in water (right, top), and SH image (right, bottom) showing oriented interfacial water. The SH counts can be converted to surface potential values as shown on the scale bar.

J.-E. Moser/M. Chergui: Femtosecond broadband fluorescence up-conversion set-up at 1 kHz repetition rate. This set-up has been purchased by a 50-50 joint funding of the two groups.

f. New joint experiments:

M. Grioni/M. Chergui: the new beamline for Angle-Resolved-Photoemission-Spectroscopy or ARPES (ASTRA, Figure 3) has been coupled to the HARMONIUM source (Figure 2) of ultrashort vacuum ultraviolet (VUV) pulses for ultrafast ARPES studies of solids and is now fully operational. This facility has already attracted users from Zürich (Prof. J. Osterwalder) and Berkeley (Dr S. Moser), who performed experiments on it.



Figure 2. Harmonium: The High Harmonic Generation (HHG) source of pulsed vacuum ultraviolet radiation used for time-resolved photoelectron (gas, liquid solids) spectroscopies at LACUS.

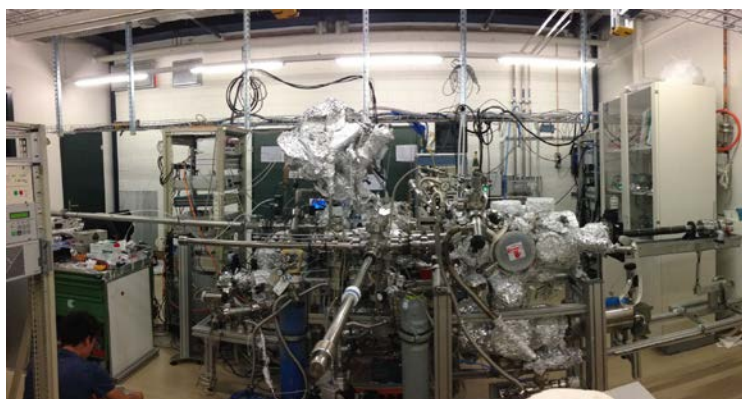


Figure 3: ASTRA set-up for time- and angle-resolved photoemission spectroscopy (trARPES) using ultrashort pulses from the Harmonium source (Figure 2).

J.-E. Moser/M. Chergui: Femtosecond broadband fluorescence up-conversion spectroscopy of molecular D- π -A organic dyes and hybrid lead halide perovskite quantized nanoparticles.

g. LACUS Seminars

Dr. Jeremy Rouxel (University of California, Irvine)

Title : *Time-resolved nonlinear signals for X-ray spectroscopy and diffraction*

Thursday 8 March 2018

Dr. Marino Marsi (Université Paris-Saclay, France)

Title : *Ultrafast study of out-of-equilibrium quantum materials*

Tuesday 20 february 2018

The LACUS Day (see detailed programme below)

Wednesday 14 February 2018

Prof. Sir Richard Friend (University of Cambridge, UK)

Title : *Molecular semiconductors for LEDs and solar cells: designing around the Coulomb interaction*

Monday 20 November 2017

Dr. Fulvio Parmigiani (University of Trieste and University of Cologne)

Title : *A Non-equilibrium approach to the optical spectroscopy of high-temperature superconductors*

Wednesday 8 November 2017

Prof. Nikolaus Ernsting (Humboldt-Universität, Berlin)

Title : *Hydration Dynamics Seen from the Inside: Possibilities of a Molecular THz Spectrometer*

Thursday 2 November 2017

Prof. Laura Herz (University of Oxford, UK)

Title : *Mechanisms limiting charge-carrier recombination and mobilities in metal halide perovskites*

Thursday 29 June 2017

Prof. Omar Mohammed (KAUST, Saudi Arabia)

Title : *Mapping Carrier Dynamics on Semiconductor Material Surfaces and at Interfaces using Laser Spectroscopy and 4D Electron Microscopy*

Thursday 22 June 2017

h. Other highlights:

1. Christoph Bostedt (Argonne National Lab and Northwestern University) has been appointed joint Paul-Scherrer-Institut/EPFL professor of Femtochemistry. He will be attached to the ISIC (Chemistry) of the EPFL.
2. The journal *Chimia* has published a special issue on the LACUS



1. The LACUS Day took place on February 14, 2018 (see poster below). Several prestigious speakers, from abroad and from the EPFL, gave lectures. This one-day event included poster presentations by the LACUS groups, as well as lab visits. The programme is given below. See also the photogallery: <https://lacus.epfl.ch/page-154185-en.html>



LACUS

The Lausanne Centre for Ultrafast Science (LACUS)
welcomes you to its annual symposium

<http://lacus.epfl.ch/>



LACUS DAY

February 14, 2018 - Auditorium CE 11, EPFL

Invited speakers:

Alfred Leitenstorfer (Konstanz)	Alberto Crepaldi (EPFL)
Sophie Canton (Szeged/Hamburg)	Andrea Marini (Rome)
Anders Hagfeldt (EPFL)	Peter Kazansky (Southampton)
Ralph Ernstorfer (Berlin)	Yves Bellouard (EPFL)
Henrik Ronnow (EPFL)	

For full program and registration: lacus.epfl.ch
Registration is free but required (includes seminars, coffee breaks and standing lunch)

Sponsors




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the LACUS Day, February 14th 2018
ROOM : CE11

Programme

08:45 - 09:00	Introductory remarks	Prof. M. Chergui - EPFL
09:00 - 9:45	Quantum Physics in all Four Dimensions	Alfred Leitenstorfer (Konstanz)
9:45-10:15	Coffee Break + Posters	
Morning Session	Chairperson	Prof. J. Moser
10:15 - 10:50	Visualizing the multiscale structural dynamics of photoexcited molecular complexes with ultrafast hard X-rays	Sophie Canton (Szeged and Hamburg)
10:50 - 11:25	The Versatility of Mesoscopic Solar Cells	Anders Hagfeldt (EPFL)
11:25 - 12:00	Accessing microscopic coupling in solids with momentum-resolving ultrafast techniques	Ralph Ernstorfer (FHI-Berlin)
12:00 - 12:35	Direct view of the out-of-equilibrium electron dynamics in topological materials	Alberto Crepaldi (EPFL), to be confirmed
12:35 - 13:45	Standing Lunch + Posters	
Afternoon Session	Chairperson	Prof. M. Chergui
13:45 - 14:20	First-principles nonequilibrium Green's function approach to the correlated electron dynamics of atoms, molecules and solids	Andrea Marini (Rome)
14:20 - 14:55	Hubbard heritage – spin waves in undoped cuprates	Henrik Ronnow (EPFL)
14:55 - 15:30	Ultrafast laser nanostructuring in glass: From geometrical phase optics to eternal memory	Peter G. Kazansky (Southampton)
15:30 - 16:05	On the use of femtosecond laser low-energy pulses on fused silica: from polymorph generation to applications in micro-engineering.	Yves Bellouard (EPFL)
16:05 - 16:15	Concluding Remarks	
from 16:15	Beer + Posters + Lab Visits	