THE PROJECT NEWSLETTER

The GO FAST project is funded by the EU Commission within the VII Framework Programme for Research and Technological Development

GO FAST-Results and milestones

Governing ultrafast the conductivity of correlated materials

The aim of this research project is to develop novel schemes to study electronic, optical and structural properties of correlated materials driven out of equilibrium, in view of achieving an ultrafast optical control of their electronic properties. In particular, we will extend the most advanced techniques for correlated systems, i.e. Dynamical Mean Field Theory (DMFT) and the Gutzwiller variational approach, to model the temporal evolution after high-energy excitations are impulsively photoinjected by ultrafast laser pulses. Realistic modeling will be achieved through validation against the outcomes of different ad-hoc time-resolved techniques. The possibility to optically switch on and off the metallic phase in a model Mott insulator (vanadium sesquioxide) and the superconducting phase in model high-temperature superconductors (cuprates) will be investigated and tested. To achieve this ambitious goal we organized a multidisciplinary network that will be coordinated by the condensed-matter theory group at S.I.S.S.A. (Trieste), with a recognized expertise in strongly correlated systems, specifically DMFT, Gutzwiller variational technique and density functional theory, and will involve well established European experimental groups in the field of ultrafast spectroscopies, with expertise in time-resolved optical and photoemission spectroscopies, time resolved X-ray and electron diffraction. The mutual and effective collaboration between the theoretical and experimental groups is mandatory to develop and validate realistic models of the ultrafast dynamics in complex materials, where the electronic, structural and magnetic degrees of freedom are strongly intertwined.

So far so good

The project is now at the beginning of the second year of its life. The first year was characterized by a set of encouraging scientific results among which we can mention:

- Formulation and implementation of numerical codes for studying the non-equilibrium dynamics of correlated electron systems within the time-dependent Gutzwiller Approximation (t-GA) and the time-dependent Dynamical Mean Field Theory (t-DMFT).
- Development of the required experimental techniques for time- and angle-resolved photoelectron spectroscopy (tr-ARPES) and time-resolved diffraction (electron and X-ray) on laser-excited superconductors (SCs).
- Development of the setup for time-resolved THz spectroscopy in the range 200 GHz-3THz (FLARE THz FEL) at high pump fluence (>100 μJ/cm2).
- Implementation of optical spectroscopies capable of studying the selectivity of the excitation process.
- Development of the experimental setup for high-fluence (>100 μJ/cm2) pump-probe angle resolved photoelectron spectroscopy, and demonstration of its capabilities with the first measurements on prototype systems.

The GO FAST project is funded by the EU Commission within the VII Framework Programme for Research and Technological Development

- Development of experimental setups for time-resolved measurements to investigate the temporal evolution of the dielectric function of prototypical superconducting cuprates.
- The distraction of metallic behaviour at the surface layer of a prototypical correlated electron model: the Hubbard model. Modelling a surface sensitive pump-probe experiment, in which it is assumed that only the surface layer is photoexcited, it has been shown by means of inhomogeneous t-GA that above a threshold fluence of the pump the surface layer turns insulating while the bulk stays metallic; a dynamical counterpart of a surface phase transition;
- The equilibrium phase diagram of a simple two-band model that seems to capture all relevant features of the actual phase diagram for V_2O_3.
- Experiments on superconductors thin films that show features not dissimilar to bulk samples, foreseeing the actual possibility of nano-size scaling in these materials;
- Microscopic characterization of the surface of V_2O_3 across the Mott transition, which in photoemission microscopy shows a complicated pattern dynamics of metallic and insulating domains.

These abovementioned significant scientific results are pointed out in the 1st Periodic Report of the GOFAST project. The 1st Periodic Report of the GOFAST project has been done at Month 18 (September 2013).

The overall evaluation highlights a **GOOD progress**: the project has achieved most of its objectives and technical goals for the period with relatively minor deviations.

The GO FAST project is funded by the EU Commission within the VII Framework Programme for Research and Technological Development

The Project is funded by the 7th Framework Programme, under the **NMP.2011.2.1-2** topic *Modelling of ultrafast dynamics in materials*.

The Project started the **1st April 2012**, involving both academics and industrial partners focused on potential application, ensuring en effective exploitation of results.

The consortium is composed by 7 partners, coming from 4 Countries: Italy, Germany, Netherlands and France.
The consortium includes 4 Universities, 2 Research Centers, and a SME.

Follow us on: **www.gofastproject.eu**

Anne DE BASS
Research Programme Officer (PO)
European Commission
DG Research & Innovation

Richard BALL
Project Technical Advisor (PTA)

The GO FAST project is funded by the EU Commission within the VII Framework Programme for Research and Technological Development

SPOTILIGHTS

24th Month Meeting

The **24th Month Meeting** will take place in **Nijmegen** (Netherlands), at the **Radboud University,** on **6th – 7th May 2014**.

All the partners, through their representatives and people in charge for scientific matters, will attend the meeting including the Project Officer and the Project Technical Advisor from the European Commission.

The meeting will be coordinated by the Project coordinator, **Michele Fabrizio** from **SISSA**. The aim of the meeting will be the presentation of the objectives achieved so far, then the overall status of the Project itself throughout a careful examination of each of the seven Work Packages, and the future activities to be performed by the Partners and the future steps of the Project.

Particular attention will be dedicated to the participation of the Project Officer that presented his comments, suggestions and recommendations for the next phase of the Project.

18th Month Meeting

The **18th Month Meeting** has been held in **Trieste** (Italy) at the **Scuola Internazionale degli Studi Superiori** (SISSA) the last **October, 18th 2013**.

The meeting day was dedicated to the presentation of the activities carried out so far by each partner and the presentation of the work performed for the Project during the first period, and the future plans for the next steps.

Beside the scientific issues, particular stress has been given to administrative/management aspects: the purpose of the Deliverables, the Dissemination activities, the visual identity of the Project.

The GO FAST project is funded by the EU Commission within the VII Framework Programme for Research and Technological Development

GOFAST recent publications

The recent publications of the GOFAST project are presented below:

- J. D. Rameau et al. *Photoinduced changes in the cuprate electronic structure revealed by femtosecond time- and angle-resolved photoemission*, **Phys. Rev. B 89**; 13 March 2014.
- F. Novelli et al. *Witnessing the formation and relaxation of massive quasi-particles in a strongly correlated electron system*, **cond-mat > arXiv:1403.1704**; 7 March 2014.
- M. Hajlaoui et al. *Tuning a Schottky barrier with transient Dirac cone charge asymmetry in a photoexcited topological insulator,* ***Nature Communications***; 6 January 2014.
- J. Faure et al. *Direct observation of electron thermalization and electron-phonon coupling in photoexcited bismuth*, **Physical Review B**, 12 August 2013.
- M. Sandri and M. Fabrizio; *Non-equilibrium dynamics in the antiferromagnetic Hubbard model*; **cond-mat > arXiv:1306.5733**; 24 June 2013.
- F. Cilento et al. *In search for the pairing glue in cuprates by non-equilibrium optical spectroscopy*, **J. Phys**.: Conf. Ser. 449 012003; 12 March 2013.
- M. Sandri et al. *Finite-temperature Gutzwiller approximation and the phase diagram of a toy-model for* V_2O_3; **cond-mat > arXiv:1403.1704**; 20 February 2013.
- F. Novelli et al. *Mixed regime of light-matter interaction revealed by phase sensitive measurements of the dynamical Franz-Keldysh effect*. **Scientific Reports** 3:1227; 6 February 2013.
- G. Coslovich et al. Competition between the Pseudogap and Superconducting States of $Bi_2Sr_2Ca_{0.92}Y_{0.08}Cu_2O_{8+\delta}$ Single Crystals Revealed by Ultrafast Broadband Optical Reflectivity. **Phys. Rev. Lett. 110**, 107003; 31 January 2013

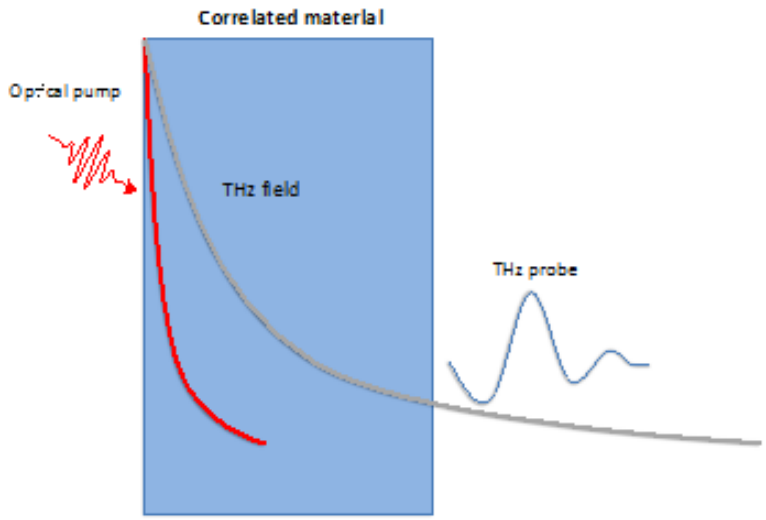
.

The GO FAST project is funded by the EU Commission within the VII Framework Programme for Research and Technological Development

Exploitation Board progress

The recent exploitation board progress consists in:

The development of the **GO-FAST TOOL** for the analysis of pump-probe THz spectroscopy is underway.
This tool, that will be possibly included in the *TeraLyzer softare*, accounts for the finite penetration depth of light and for the mismatch between the THz and visible field in time-resolved experiments. This activity is carried out in collaboration with the exploitation board and MenloSystems G.m.b.H.



Future results of the Exploitation Board will be reached during the next meeting in Nijmegen at the University of Radboud!

The GO FAST project is funded by the EU Commission within the VII Framework Programme for Research and Technological Development

Events

The recent and future dissemination activities of the GOFAST project are presented below:

UNICATT	Invited talk	Non-equilibrium optical spectroscopy: a new clue to unravel the properties of correlated materials	18/02/2013	Bochum, Germany
RU	Participation in Workshop – oral talk	"THz Focus Session"	11/04/2013	Nijmegen, Netherlands
UNICATT	Invited talk	Non-equilibrium optical spectroscopy: a new clue to unravel the properties of correlated materials	12/05/2013	Les Diablerets, Switzerland
UNICATT	Invited talk	Non-equilibrium optical spectroscopy: a new clue to unravel the properties of correlated materials	27/05/2013	Ischia, Italy
RU	Participation in conference – poster	“IMM Symposium 2013”	02/06/2013	Nijmegen,
RU	Participation in Workshop – oral talk	“Wavefront workshop”	06/06/2013	Hoenderloo,
RU	Participation in conference – oral talk	“International Symposium on Spin Waves 2013””	13/06/2013	St. Petersburg, Russia
UNICATT	Organisation of Workshops	"The new generation in strongly-correlated electron systems"	30/06/2013	Sestri Levante, Italy
UNICATT	Invited talk	Non-equilibrium optical spectroscopy: a new clue to unravel the properties of correlated materials	29/07/2013	Hamburg, Germany

The GO FAST project is funded by the EU Commission within the VII Framework Programme for Research and Technological Development

UDE	Invited talk at conference / workshop	Femtosecond laser-induced changes of the cuprate Bi2212 electronic structure	19/08/2013	Dresden, Germany
RU	Participation in conference – oral talk	"Joint European Magnetism Symposium 2013"	29/08/2013	Rhodes, Greece
CNRS	Participation to Conference	Topology, correlations and interfaces in quantum matter	16/09/2013	Orsay, France
UNICATT	Invited talk	Non-equilibrium optical spectroscopy: a new clue to unravel the properties of correlated materials	23/09/2013	Trieste, Italy
UNICATT	Organisation of Workshops	Ultrafast dynamics of correlated materials	14/10/2013	Trieste, Italy
UDE	Invited talk at conference / workshop	Ultrafast photo-induced changes in the electronic structure of Fe-pnictide and cuprate superconductors	17/10/2013	Trieste, Italy
UNICATT	Invited talk at the International Workshop	Non-equilibrium Dynamics of Correlated Electron Systems"	18/10/2013	Krvavec, Slovenija
RU	Participation in conference – oral talk	"Ultrafast Magnetism Conference 2013"	01/11/2013	Strasbourg, France
SISSA	Invited Talk	Time-resolved spectroscopy reveals the momentum-selective Mottness of the pseudo gap state of the cuprates	21/11/2013	Tokyo
SISSA	Invited Talk	Momentum- selective Mottness of the pseudo gap state of the cuprates revealed by time-resolved spectroscopy	19/12/2013	Krvavec, Slovenija
UDE	Invited talk	Non-equilibrium dynamics in photo-excited low dimensional materials	17/01/2014	Jena, Univ.
RU	Participation in conference – poster	"FOM Conference 2014"	21/01/2014	Veldhoven, Netherlands
RU	Participation in conference – poster	"Gordon Conference on Ultrafast Phenomena in Cooperative Systems 2014"	03/02/2014	Ventura, USA
UDE	Poster presentation	Time- and angle-resolved photoemission of BSCCO above Tc: Transient Fermi surface changes and scattering rate analysis	04/02/2014	Ventura, CA, USA
UDE	Invited talk at conference / workshop	Ultrafast changes in the electronic structure of solids investigated by time- and angle-resolved photoemission spectroscopy	13/03/2014	Irsee / Germany
CNRS	Participation to Conference	New Generation in Strongly Correlated Electronic Systems	16/06/2014	Nice, France
RU	Organisation of Workshops	FEMTOMAG summer school	22/06/2014	Amelander Kaap, the Netherlands
UNICATT	Invited talk at the International Workshop	"(Towards) Room Temperature Superconductivity"	30/06/2014	Leiden, Holland
UNICATT	Invited talk at the International Conference	"Low Energy Electrodynamics in Solids" (LEES2014)	29/07/2014	Loire Valley, France.

The GO FAST project is funded by the EU Commission within the VII Framework Programme for Research and Technological Development

UDE	Poster presentation	Femtosecond time- and angle-resolved photoemission spectroscopy on Bi2212 above Tc using a position-sensitive time of flight spectrometer	10/08/2014	Corsica, France
UNICATT	Invited talk at the International Conference	"Correlations and coherence" at different scales	05/10/2014	Ustroń, Poland
SISSA	Invited Talk	Time-resolved spectroscopy reveals the momentum-selective Mottness of the pseudo gap state of the cuprates	18/10/2014	Trieste
UNICATT	Invited talk at the Workshop	Probing and Understanding Exotic Superconductors and Superfluids	27/10/2014	ICTP, Trieste

The GO FAST project is funded by the EU Commission within the VII Framework Programme for Research and Technological Development

World news

Suggested publications related to the recent breakthrough relevant to the optical control of the electronic properties of correlated materials:

W. Hu et al. *Enhancement of superconductivity by redistribution of interlayer coupling in optically stimulated* $YBa_2Cu_3O_{6.5}$. *arXiv:1308.3204*

It has been suggested that ultrashort THz pulses could transiently enhance superconductivity far above Tc.

V. Guiot et al. *Avalanche breakdown in GaTa4Se8−xTex narrow-gap Mott insulators*. **Nature Communications 4**, 1722 (2013). **www.nature.com/ncomms/journal/v4/n4/full/ncomms2735.html**

Strong electric-field, impulsively applied, can drive the resistive switching of a Mott insulator, opening intruiguing technological possibilities.

L. Stojchevska et al. *Ultrafast switching to stable hidden topologically protected quantum state in an electronic crystal.* arXiv:1401.6786v2 - **http://arxiv.org/pdf/1401.6786v2.pdf**

A single ultrashort infrared/visible pulse has been used to photoinduce a novel and stable state in the correlated dichalcogenide 1T-TaS2. The new state is characterized by a large change in the resisitivity and optical conductivity that could be exploited for future applications.

The GO FAST project is funded by the EU Commission within the VII Framework Programme for Research and Technological Development

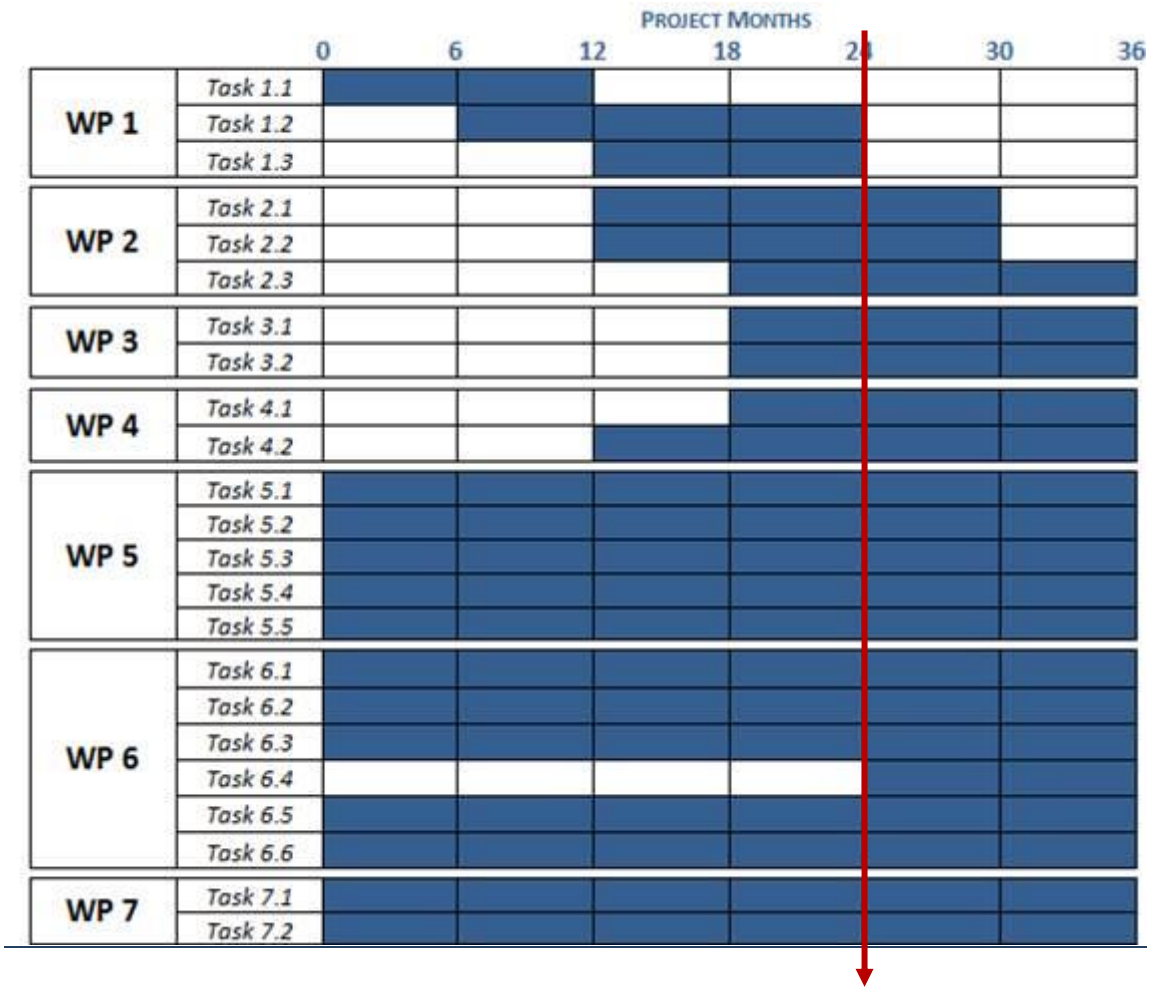
M.Eckstein and J. Mentink. *Ultrafast quenching of the exchange interaction in a Mott insulator*. arXiv:1401.5308 - **http://arxiv.org/pdf/1401.5308.pdf**

Ultrashort pulses can be used to manipulate the exchange interaction in Mott insulators, paving the way to the all-optical control of the magnetization of correlated materials.

E. Assmann et al. *Oxide Heterostructures for Efficient Solar Cells*. **Phys. Rev. Lett. 110**, 078701 (2013) - **http://journals.aps.org/prl/abstract/10.1103/PhysRevLett.110.078701**

Metal-oxide heterostructures are emerging as promising systems for solar-cells applications.

The GO FAST project is funded by the EU Commission within the VII Framework Programme for Research and Technological Development



The GO FAST project is funded by the EU Commission within the VII Framework Programme for Research and Technological Development

Project partners

Project Participants	
SISSA	**Scuola Internazionale Superiore di Studi Avanzati** *Project Coordinator* Prof. Michele Fabrizio E-mail: fabrizio@sissa.it
UNIVERSITÄT DUISBURG ESSEN	**Universitaet Duisburg-Essen** Prof. Bovensiepen Uwe E-mail: Uwe.Bovensiepen@uni-due.de
IN DEI NOMINE FELICITER	**Stichting Katholieke Universiteit** Dr. Kimel A.V. E-mail: a.kimel@science.ru.nl
elettra	**Elettra - Sincrotrone Trieste S.C.p.A** Dr. Daniele Fausti E-mail: daniele.fausti@elettra.trieste.it
cnrs	**Centre National de la Recherche Scientifique** Prof. Marsi Marino E-mail: marino.marsi@u-psud.fr
	Università Cattolica del Sacro Cuore Dr. Giannetti Claudio E-mail: c.giannetti@dmf.unicatt.it
IN FINANCING & PROJECT MANAGEMENT	**IN Srl** Ing. Laura Martinelli E-mail: l.martinelli@insrl.eu

Project EXPLOITATION BOARD	
	MICRON SEMICONDUCTOR ITALIA S.R.L. *Data storage devices based on transition metal oxides*
	MENLOSYSTEMS GMBH *THz photoconductive antennas based on transition metal oxides*

The GO FAST project is funded by the EU Commission within the VII Framework Programme for Research and Technological Development