

Final Report: Student Support for the “Frontiers in Attosecond & Ultrafast X-ray
Science” School

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1.1 Introduction

The following is the final report for DOE grant (DE-SC0017269) which supported the establishment of a new School for training young scientist in the area of attosecond and x-ray sciences. The topic of the School was well aligned with the roadmap defined by the DOE BESAC. The first-of-a-kind school entitled the “Frontiers of Attosecond and Ultrafast X-ray Science” (<http://www.eric-attosecond.it/>) (FAXS) was held during March 19-28, 2017 at the Ettore Majorana Foundation and Centre for Scientific Culture (<http://www.ccsem.infn.it/>) in Erice, Sicily. The FAXS Directors were Louis DiMauro (The Ohio State University, USA), Alicja Domaracka (CIMAP-CNRS, France) and Mauro Nisoli (Politecnico di Milano, Italy). The DOE funds were used to support the registration fee for young scientist (graduate students and postdocs) from US institutions (see attached list). The registration fee included participation, lodging and meals over the duration of the School.

1.2 The FAXS School

The tremendous and continual growth in the two emerging frontier areas of attosecond and x-ray science requires the training of young scientists who will push the technology and drive the applications. These two ultrafast areas are closely interconnected by scientific objectives and methods, thus the cross training of young scientists skilled in these disciplines is necessary to promote future growth. In addition, the future impact of these sources will be driven by broad interdisciplinary applications in atomic, molecular, condensed phase, material and structural biology. The School aimed at training young scientist in both the source technology and metrology, and the areas of emerging applications. Consequently, the primary objective was to educate the next generation of scientists who will contribute and shape the future of science. Prominent international researchers (see Sec. 2) in attosecond and x-ray science presented the lectures and the topics were chosen to be complementary covering a broad spectrum of technology and applications. Besides formal lectures, the school’s intimate environment also provided an opportunity for young scientist to network with an international group of peers and have informal discussions with the lecturers.

The “Frontiers of Attosecond and Ultrafast X-ray Science” (FAXS) School was part of the 59th International School of Quantum Electronics under the directorship of the late Prof. Sergio Martellucci (University of Rome). The FAXS Directors were Louis DiMauro (The Ohio State University, USA), Alicja Domaracka (CIMAP-CNRS, France) and Mauro Nisoli (Politecnico di Milano, Italy). The school was held March 19-28, 2017 at the Ettore Majorana Foundation and Centre for Scientific Culture (<http://www.ccsem.infn.it/>) in Erice, Sicily.

We anticipated that the FAXS School would meet on a regular basis every two years. Based on the tremendous success of the 1st School, a second School is planned for March 2019. The main topics of the course are the following: (i) attosecond science and technology, devoted to the

generation and application of attosecond pulses to the investigation of electronic dynamics in atoms, molecules, nanostructures and condensed phases and (ii) fundamentals, methods and applications of free electron lasers, synchrotron radiation, ion collisions in atomic and molecular science. All these topics are encompassed by DOE scientific interest in the Chemical Science and Material Science Directorate and particularly attosecond and XFEL science programs within the DOE AMOS program.

The inaugural school program had lectures by 21 leading experts in attosecond and x-ray science (see attached list in Section 2). The majority of lecturers delivered a series of 3 lectures (see schedule in Section 3). The lecturers were required to spend a minimum of 5 days at the school so to promote interaction with the students. The Erice Majorana Center venue can accommodate ~75 young scientist. The 1st School was completely full. The cost for student/postdoc registration was 1000€ (approx. \$1130US). The registration fee covered the cost of participating in the course, lodging and meals for the entire duration of the school. The schedule had lectures every morning and afternoon except for the Majorana Center arranged social excursions on Wednesday (3/22/17) and Saturday (3/25/17) afternoons. The evening sessions had a student/postdoc poster session and social gathering at the San Rocco Center to encourage further interaction of all participants and lecturers.

The FAXS School attracted an international group of young scientist. Financial support via scholarships for European students/postdocs was provided by a grant from the XLIC COST action (XUV/X-ray light and fast ions for ultrafast chemistry action) of the European Union and the Extreme Light Infrastructure (ELI). The funding grant from DOE was exclusively used to support approximately 6 students/postdoc from US institutions. The DOE funds were managed through the Research Foundation of The Ohio State University in the form of a reimbursement. Awarded students designated as recipients' of a DOE fellowship to cover the expense of the registration fee. Student/postdocs applying for a Fellowship were encouraged to present a poster at the FAXS School. Travel expenses to the FAXS School were the responsibility of the student/postdoc home institution.

1.3 FAXS School: a new paradigm for training US young investigators

The FAXS School is a new paradigm for cross training young researchers conducting ultrafast x-ray science research in academia and National facilities. No school exists that attempts to merge these communities into one coherent group.

Selection Process: The DOE funds were exclusive used to support young scientist from US institutions (universities or national laboratories). Young investigators interested in a fellowship applied through the FAXS School webpage, <http://www.eric-attosecond.it/>. They supplied a statement of research, list of publication and a letter of support from their advisor/supervisor. The School Directors screened the applications and awardees chosen based on scientific overlap, qualifications and diversity. Young investigators from US institutions had their funds administered through The Ohio State University Research Foundation under the direction of the PI, Prof. DiMauro.

DOE Expenses: Total expenses for this grant were \$6,780.74, which supported six students from US institution. Support covered the student's registration fee, which included lodging, and meals while at the school. All the student recipients of DOE support came from US groups that receive DOE research funding. The list of supported students and their home institutions are listed along with the specific financial support.

Breakdown of support by individual		
Institution	Individual	Support
University of Virginia	Sanjay Khatri	\$1,053.00
Stanford University	Andrei Kamalov	\$1,061.99
The Ohio State University	Tim Scarborough	\$1,150.00
The Ohio State University	Jakub Husek	\$1,233.05
The Ohio State University	Somnath Biswas	\$1,141.90
The Ohio State University	Stephen Hageman	\$1,140.80
	Total Support	\$6,780.74

1.4 Venue: Ettore Majorana Foundation and Centre for Scientific Culture

Embracing 126 Schools, covering all branches of Science, the Centre is situated in the old pre-mediaeval city of Erice where four restored monasteries (one of which was the residence of the Viceroy of Sicily during the XIV and XV Centuries) provide an appropriate setting for high intellectual endeavor. These ancient buildings are now named after great scientists and strong supporters of the ‘Ettore Majorana’ Centre. The San Francesco Monastery (former Viceroy’s residence) is now the Eugene P. Wigner Institute with the ‘Enrico Fermi’ Lecture Hall. The San Domenico Monastery is now the Patrick M.S. Blackett Institute with the ‘Paul A.M. Dirac’ Lecture Hall, ‘Robert Hofstadter’ Lecture Hall and ‘John von Neumann’ Lecture Hall. The San Rocco Monastery is now the Isidor I. Rabi Institute with the ‘Richard P. Feynman’ Lecture Hall, the Directorate and the main Secretariat of the Centre. The ‘Ciclope’ is now the Victor F. Weisskopf Institute with the ‘John S. Bell’ and ‘Richard H. Dalitz’ Lecture Halls. There are living quarters in all four Institutes for people attending the Courses at the Centre.

2. FAXS School lecturers

Lecturer	Topic
Pierre Agostini, The Ohio State University (USA)	Introduction to strong-field processes: scaling from multiphoton to tunneling.
Anne L'Huillier, Lund University (Sweden)	High harmonic generation, coherence and phase matching.
Zenghu Chang, University of Central Florida (USA)	The principles of attosecond technology: generation and metrology.
Jon Marangos, Imperial College – London (UK)	Ultrafast molecular dynamics.
Katalin Varju, University of Szeged (Hungary)	Future perspectives in attosecond science enabled by ELI-ALPS.
Phil Bucksbaum, Stanford University (USA)	XFELS: a new vista in ultrafast x-ray science.
Ken Schafer, Louisiana State University (USA)	Time-dependent approaches in attosecond science.
Luca Poletto, IFN-CNR, Padova (Italy)	Advanced XUV optics.
Fernando Martin, Universidad Autónoma de Madrid (Spain)	Control of electron dynamics with ultrashort pulses and FELs.
Reinhard Kienberger, Technical University – Munich (Germany)	Condensed-matter physics with attosecond pulses.
Dimitris Charalambidis, FORTH – Heraklion (Greece)	Nonlinear optics in the XUV.
Paul Corkum, NRC-CNRC Ottawa (Canada)	Attosecond electron wave packet self-probing of molecules and solids.
Kevin Prince, Elettra Sincrotrone – Trieste (Italy)	Large facilities. Synchrotron Radiation Light: generation and transport. FEL light; Applications of FEL radiation
Thomas Schlatholter, University of Groningen (Germany)	General instrumentation: Molecular target production, mass spectrometers, ion traps.
Antonella Cartoni, La Sapienza – Roma (Italy)	Ion-molecule chemistry.
Patrick Rousseau, Universite de Caén Normandie (France)	Production of molecular cluster beams. Large facilities: Ion beam accelerators.
Paola Bolognesi, ISM-CNR (Italy)	General instrumentation. Electron spectroscopy. Synchrotron radiation studies of systems of biological interest.
Lorenzo Avaldi, ISM-CNR (Italy)	Fundamental Processes in Atomic and Molecular Physics studied with Synchrotron Radiation.
Ottmar Jagutzki, RoentDek (Germany)	Detection systems: detectors, acquisition systems and data analysis.
Henning Schmidt, Stockholm University (Sweden)	Electrostatic storage rings for atomic and molecular physics.
Alicja Domaracka, CNRS-CIMAP (France)	Ion collisions with molecular systems: fragmentation and reactivity.

3. FAXS School schedule

	Sunday 19 March	Monday 20 March	Tuesday 21 March	Wednesday 22 March	Thursday 23 March	Friday 24 March
Breakfast						
Morning Session	Arrivals & Registration	Chair: S. Martellucci 8:30 a.m. Opening 9:00 a.m. – A. L’Huillier 9:45 a.m. – A. L’Huillier	Chair: 9:00 a.m. – P. Corkum 9:45 a.m. – P. Corkum	Chair: 9:00 a.m. – F. Martin 9:45 a.m. – F. Martin	Chair: 9:00 a.m. – Ken Schafer 9:45 a.m. – Katalin Varju	Chair: 9:00 a.m. – Phil Bucksbaum 9:45 a.m. – D. Charalambidis
Coffee Break		10:30 a.m. – 11:00 a.m.	10:30 a.m. – 11:00 a.m.	10:30 a.m. – 11:00 a.m.	10:30 a.m. – 11:00 a.m.	10:30 a.m. – 11:00 a.m.
Morning Session		Chair: 11:00 a.m. – P. Agostini 11:45 a.m. – P. Agostini	Chair: 11:00 a.m. – A. L’Huillier 11:45 a.m. – Zenghu Chang	Chair: 11:00 a.m. – P. Corkum 11:45 a.m. – P. Salieres	Chair: 11:00 a.m. – D. Charalambidis 11:45 a.m. – D. Charalambidis	Chair: 11:00 a.m. – Ken Schafer 11:45 a.m. – Ken Schafer
Lunch		12:30- 14:30				
Afternoon Session	Arrivals & Registration	Chair: 2:30 p.m. – Zenghu Chang 3:15 p.m. – Zenghu Chang	Chair: 2:30 p.m. – P. Salieres 3:15 p.m. – P. Salieres	Bus leaving from Erice parking area 1:00 p.m. Excursion to Mozia Island Box-lunch will be provided	Chair: 2:30 p.m. – Phil Bucksbaum 3:15 p.m. – Phil Bucksbaum	Chair: 2:30 p.m. – Jon Marangos 3:15 p.m. – Jon Marangos
Coffee Break		4:00 p.m. – 4:30 p.m.	4:00 p.m. – 4:30 p.m.	Bus will be back at 7:00 p.m.	4:00 p.m. – 4:30 p.m.	4:00 p.m. – 4:30 p.m.
Afternoon Session		Chair: 4:30 p.m. – R. Kienberger 5:15 p.m. – R. Kienberger	Chair: 4:30 p.m. – F. Martin 5:15 p.m. – P. Agostini		Chair: 4:30 p.m. – L. Poletto 5:15 p.m. – L. Poletto	Chair: 4:30 p.m. – O. Jagutzki 5:15 p.m. – O. Jagutzki
Dinner			POSTER		POSTER	

	Saturday 25 March	Sunday 26 March	Monday 27 March	Tuesday 28 March
Breakfast				
Morning Session	Chair: 9:00 a.m. – K. Prince (1) 9:45 a.m. – K. Prince (2)	Chair: 9:00 a.m. – T. Schlatholter (5) 9:45 a.m. – T. Schlatholter (6)	Chair: 9:00 a.m. – P. Bolognesi 9:45 a.m. – P. Bolognesi (12)	Departures
Coffee Break		10:30 a.m. – 11:00 a.m.	10:30 a.m. – 11:00 a.m.	
Morning Session	Chair: 11:00 a.m. – J. Marangos 11:45 a.m. – T. Schlatholter (4)	Chair: 11:00 a.m. – P. Rousseau (9) 11:45 a.m. – P. Rousseau (10)	Chair: 11:00 a.m. – A. Cartoni (7) 11:45 a.m. – A. Cartoni (8)	
Lunch				
Afternoon Session	Excursion to Segesta archaeological site. Bus will be back at 7:00	Chair: 2:30 p.m. – K. Prince (3) 3:15 p.m. – P. Bolognesi (11)	Chair: 2:30 p.m. – L. Avaldi (13) 3:15 p.m. – L. Avaldi (14)	
Coffee Break		4:00 p.m. – 4:30 p.m.	4:00 p.m. – 4:30 p.m.	
Afternoon Session		Chair: 4:30 p.m. – H. Schmidt (17) 5:15 p.m. H. Schmidt (18)	Chair: 4:30 p.m. – A. Domaracka (19) 5:15 p.m. – A. Domaracka (19)	
Dinner				