BENEFICIARY OF MEDEA

LUND UNIVERSITY

LUND

SWEDEN

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Scientist in charge

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Useful Links

www.medea-horizon2020.eu
www.lunduniversity.lu.se
www.lu.se
www.llc.fysik.lth.se
www.lund.se/en
www.visitlund.se/en

LUND UNIVERSITY

MEDEA

Molecular Electron Dynamics investigated by Intense Fields and Attosecond Pulses

This project has received funding from the European Union's **Horizon 2020** research and innovation programme under the Marie Skłodowska-Curie grant agreement No 641789.

Home institution

The training within MEDEA will be performed at the *Division of Atomic Physics*, part of the *Department of Physics*, Faculty of Engineering, of the *Lund University*.

With eight faculties and several research centres and specialized schools, Lund University is the largest institution of research and higher education in Sweden. The University was founded in 1666 to ensure the 'Swedification' of the provinces Sweden had captured from Denmark in 1658. It has since evolved into a modern centre of research and higher education and now enjoys a leading position, regionally, nationally and internationally. Programmes cover traditional academic disciplines as well as specialized areas like commercial aviation and the fine and performing arts. The hallmarks of Lund University are a democratic philosophy, critical thinking, concern for the global environment and ethnic and social diversity. The city of Lund is a typical student town with 100 000 habitants including more than 40 000 students. The student life in Lund is well organized and provides a pleasant environment for foreign students.

Within the Department of Physics, we benefit from interaction with the Division of Solid State Physics (Nanometer Structure Consortium) and Synchrotron Radiation Research, with expertise in electron microscopy. We also take advantage of the proximity of MAX-lab, a national synchrotron radiation facility, with a strong national and international user community. A world-class facility MAX IV, with plans for a free electron laser, is currently being built and will be inaugurated in the summer of 2016.

The Division of Atomic Physics is also part of the Lund Laser Centre, a horizontal organization at Lund University, including several divisions of the Physics and Chemistry departments, all dealing with lasers. The Lund Laser Centre is the largest unit in the Nordic countries within the field of lasers, optics and spectroscopy. Research is performed in basic atomic, molecular and optical physics and includes applications to energy, environmental, medical and information technology fields. The Lund Laser Centre has a long European tradition, and is member of the infrastructure LASERLAB-Europe, delivering access to European users.

The Division of Atomic Physics includes the Lund High-Power Laser Facility, with several state-of-the-art laser systems, in particular one of the largest 10 Hz terawatt lasers in Europe. Centered around this laser facility there is an active local research programme in the area of intense field laser/matter interaction, X-ray production, relativistic channeling, proton and electron acceleration, high-order harmonic generation and attosecond physics.

Scientist in charge

Name: Per Johnsson
Nationality: Swedish
Date of birth: 22 November 1978

Short CV:

2002: MSc in Engineering Physics, Lund University, Sweden

2006: PhD in atomic physics, Lund University, Sweden

2006-2008: Postdoctoral fellow at the FOM Institute for Atomic and Molecular Physics, Amsterdam, the Netherlands

Current position: Associate professor in Physics, Atomic Physics Division, Lund University, Sweden

I completed my Master of Science in Engineering Physics at the Lund University in Sweden with a partly experimental Master's project on femtosecond laser pulse shaping. Through this project, I got a glimpse of ultrafast experimental physics with lasers, and wanted more.

Thus, I decided to stay as a PhD student in the field. My PhD project involved the generation, characterization and application of attosecond pulses. During my time as a PhD student we built up the attosecond laboratory at the Lund High-Power Laser Facility where, at that time, the shortest attosecond pulses in the world were generated in 2003.

Following this I spent two years as a postdoctoral fellow at the FOM Institute for Atomic and Molecular Physics (AMOLF) in Amsterdam, switching gears by changing my previous focus on electron dynamics in atoms to electron dynamics in molecules. In Amsterdam we designed and built up an attosecond pump-probe setup as well as a velocity map imaging spectrometer tailored for experiments on attosecond dynamics in molecules. The main effort during my postdoctoral time was however to initiate, plan and coordinate an experimental programme at the free electron laser (FEL) in Hamburg (FLASH), aiming to study structural dynamics in molecules using novel pump-probe techniques together with photoelectron diffraction and interference in XUV photionization of laser-aligned molecules.

In 2009 I returned to Sweden and Lund University for a position as a Research Associate. In the years that followed I received two national grants which made it possible for me to start building my own research group, and in 2013 I got a qualification as Associate Professor in Physics, and obtained a position as University Lecturer.

The aim of my current research is to perform combined imaging of charge localization and molecular structure, seeking to study the interplay between electron dynamics and changes in the molecular structure. Currently, my group focuses on experiments carried out at the high-intensity HHG beamline of the Terawatt laser system at the Lund High-Power Facility. Intense efforts on beamline development during the last few years, as well as an expansion of the laboratory, have led to an optimized HHG source where, at the moment, harmonic pulse energies in the microjoule range can be achieved, and where we have recently managed to observe two-photon double ionization of neon, indicative of intensities in the range needed for realizing XUV pump-XUV probe experiments.

My group collaborates with the groups of Anne L'Huillier, Mathieu Gisselbrecht and Johan Mauritsson within the **Lund Attosecond Science Centre (LASC)**, with a broad approach to attosecond physics in different systems, e.g. atoms, molecules, surfaces and clusters. In addition to the high-intensity HHG beamline mentioned above, LASC routinely operates sources of attosecond pulse trains at 1 kHz and uses them for attosecond physics, e.g. in interferometric measurements of photoemission time delays. The latest addition to LASC is an optical parametric chirped pulse amplification (OPCPA) system delivering few-cycle CEP-stable laser pulses at 200 kHz. These pulses are used to drive an HHG attosecond source ideal for experiments requiring low peak powers and high repetition rates, e.g. surface studies and applications with detection based on coincidence techniques.

Offered training

Research Training Modules (RTMs)

A. Optimization of HHG (see next pages for details)

B. Optical ray-tracing (see next pages for details)

Scientific Courses of the Physics Department

Optics and optical design: *The course aims at providing knowledge about the basic principles of optics and practical knowledge on optical design, with the help of a ray tracing program.*	Anne L'Huillier, Cord Arnold
Lasers: *The course aims at providing knowledge about the physical principles of lasers as well as to give an orientation of the different laser types and laser techniques.*	Jörgen Larsson, Anne L'Huillier
Advanced optics and lasers: *The course aims at providing knowledge about basic as well as advanced techniques for manipulating and controlling laser light and laser pulses. This involves controlling intensity, frequency distribution, temporal profiles in order to design advanced optical systems for specialized tasks in industry as well as research*	Jörgen Larsson
Light-matter interaction: *The aim of the course is to give the student an advanced knowledge in atomic physics and especially on the interaction between light and matter. An introduction to several exciting research fields such as atoms in strong laser fields, laser cooling and trapping of atoms, quantum computers will be given.*	Anne L'Huillier
Atomic and molecular spectroscopy: *The aim of the course is to provide theoretical and practical knowledge on the many powerful methods provided by modern atomic- and molecular spectroscopy regarding basic studies as well as practical applications.*	Stefan Kröll

Transferable skills Modules (TSMs)

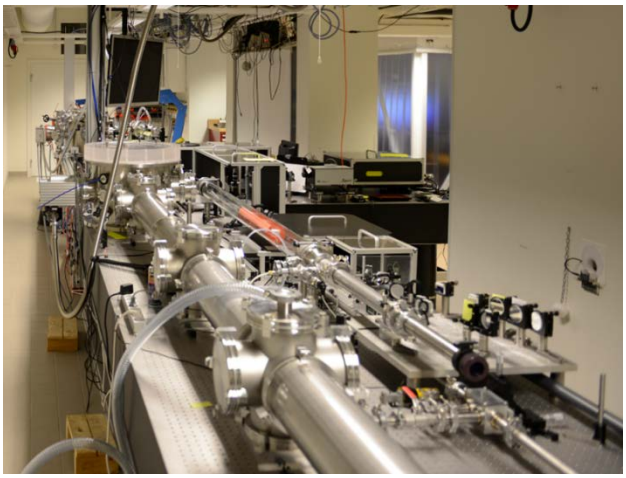
Technical writing for publication
Introduction to teaching and learning in higher education

More information about PhD studies at the Faculty of Engineering, LTH at this link:

www.lth.se/english/education/phd-studies/

For all courses recognition of credits must be discussed with the supervisor

A. Optimization of HHG



Objective

The goal of the RTM is to learn the experimental basics of high-order harmonic generation (HHG) and the theoretical background necessary to understand and control the HHG process. Different aspects of optimization of HHG will be treated, with focus on e.g. short pulse duration, high flux, high repetition rate, etc.

Equipment

The ESRs will be trained at the existing HHG beamlines at the Lund Attosecond Science Centre (LASC).

Implementation

The training will have a series of intermediate milestones and objectives:

- Introduction to the basics of high-order harmonic generation.
- Introduction to the different experimental beamlines.
- Introduction to phase-matching.
- Preparation and characterization of the generating laser pulses.
- Design of focusing and generation geometry based on the goal of the optimization.
- Introduction to XUV pulse measurement techniques (pulse duration, pulse energy, spectrum).
- Characterization of the generated XUV pulses.
- Study of the dependence of the XUV pulse properties on the generation conditions.
- Modeling of the HHG process and comparison with the experimental results.

Duration

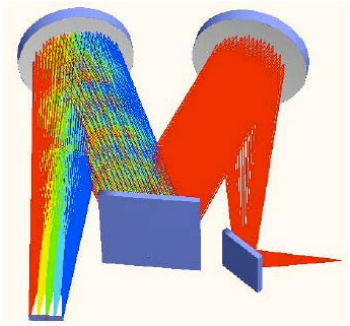
For the complete RTM a period of four weeks is planned, divided in one week of introduction, two weeks of experiments and one week of analysis.

The period for the participation to the RTMs should be agreed upon with the tutors.

RTM at a glance

Title	*Host institution*	*Objective*	*Duration/ Period*	*Tutors*
Optimization of HHG	**LUND**	Control and optimization of the process of high-order harmonic generation. *Experimental activity*	4 weeks / to be discussed	Per Johnsson per.johnsson@fysik.lth.se Piotr Rudawski piotr.rudawski@fysik.lth.se

B. Optical ray-tracing



Objective

The goal of the RTM is to learn how to use modern ray-tracing software for advanced optical design tasks. The RTM will include using advanced features like e.g. scripting. The focus is on optical design and ideally the student enters the project with a real-life design task from his/her home laboratory that is completed during the RTM.

Equipment

The ESRs will be provided with a computer and all the necessary software. The project will use FRED, which is a modern nonsequential ray-tracing program frequently used in industry.

For more information about the program FRED, see:

www.photonengr.com

Implementation

The training will have a series of intermediate milestones and objectives:

- Introduction to ray-tracing techniques.
- Introduction to FRED.
- Tutorial: Light sources, focusing and aberrations.
- Introductory project: Design of a Czerny-Turner spectrometer.
- Intermediate project: Design of a Ti:Sapphire oscillator.
- Advanced project: To be decided depending according to the needs of the ESR.

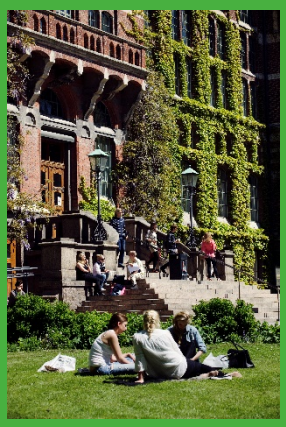
Duration

For the complete project a period of four weeks is planned.

The period for the participation to the RTMs should be agreed upon with the tutors.

RTM at a glance

Title	*Host institution*	*Objective*	*Duration/ Period*	*Tutors*
Optical ray-tracing	**LUND**	Use of advanced ray-tracing software for optical design tasks. *Computer-based activity*	4 weeks /to be discussed	Chen Guo chen.guo@fysik.lth.se Miguel Miranda miguel.miranda@fysik.lth.se



About the life in Lund

The city of Lund is situated in the center of the attractive and expansive Öresund region in southern Sweden and is one of the oldest cities in Sweden with a history more than one thousand years old. Over the centuries it has earned a reputation for being a place where people meet, and, today, more than ever, Lund is a meeting place for ideas and creativity. Lund offers a rich selection of leisure activities, from swimming and fishing to youth recreation centers, community group activities and much more. Lund also provides a broad range of cultural experiences in art, music, dance, theatre, literature and film.

Lund is a small city, with a big student population. This can mean that it is sometimes difficult to live exactly where you want, and that you start arranging your accommodation as early as possible, in particular around the times when the new semesters start.

The city of Lund has a special website for expats, where you can find information about living, transport, studying and more:

www.lund.se/en

In addition, the Lund Tourist Office has a website called "Visit Lund", where you can find a lot of information about places to visit and things to do in Lund:

www.visitlund.se/en

You can also visit the Lund Tourist Center at Botulfsgatan 1A, or get in contact via phone (+46 (0)46-35 50 40) or e-mail (turistbyran@lund.se).

The International Office at Lund University

As an international student at Lund University, you will find a lot of useful information at the homepage of the Lund University International Office:

www.lunduniversity.lu.se

You can also follow the International Desk on Facebook:

www.facebook.com/internationaldesk