EuPRAXIA FEL Pilot User Application Workshop

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Lifestyle VOI Donna Camilla Savelli Hotel - Via Garibaldi 27, 00153 Rome

BOOK OF ABSTRACTS

EuPRAXIA is a conceptual design study for a "European Plasma Research Accelerator with eXcellence In Applications" aiming to generate electron beams of 1 to 5 GeV energy across multiple beamlines using plasma accelerator technology. Among other radiation and particle sources, it is intended to offer two short-wavelength Free Electron Laser beamlines. The facility is envisioned to be a distributed infrastructure with two main machine sites: one in Germany focusing on laser-driven plasma electron acceleration, and another one in Italy based on particle-driven plasma electron accelerator technology. This workshop gathers a selection of potential pilot users of these future Free Electron Laser sources with the aim to discuss the current facility design, potential opportunities and possible more specific requests.

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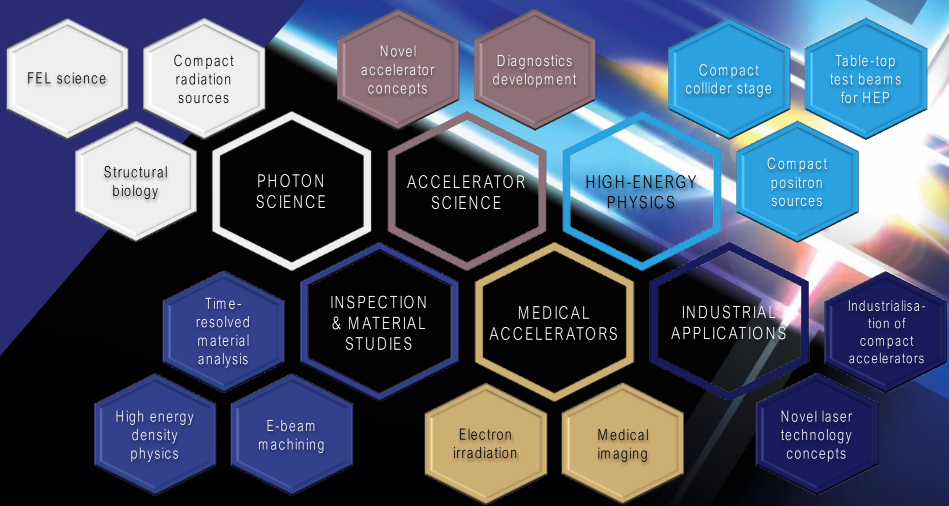
EuPRAXIA – Innovative Accelerator Technology for Compact Applications

The future EuPRAXIA research infrastructure will enable ground-breaking applications based on highly compact, novel accelerator technology. Currently in its conceptual design phase, this innovative facility will offer a compact GeV-scale plasma electron accelerator, high power lasers, a Free-Electron Laser in the UV to X-ray range and other features. The preliminary specifications include both initial facility parameters as well as possible machine upgrades, which will be refined in the final EuPRAXIA Conceptual Design Report published in 2019.



High-energy, ultrashort electron beams		
Energy	[GeV]	1 – 5
Energy spread	[%]	0.1 – 5
Beam duration	[fs]	3 – 20
Beam charge / no. of electrons	[pC / -]	5 – 50 / $3x10^7$ – $3x10^8$
Typical transverse beam size*	[µm]	2 – 100
Repetition rate	[Hz]	1 – 100
Ultrashort Free-Electron Laser radiation pulses		
Wavelength	[nm]	0.05 – 10
No. of photons per pulse	[-]	10^{10} – 10^{12}
Pulse duration	[fs]	3 – 35
Bandwidth	[%]	0.1 – 0.5
Three main high power laser systems		
Wavelength	[nm]	800
Energy on target	[J]	5 – 100
Pulse duration	[fs]	20 – 60
Repetition rate	[Hz]	20 – 100

** with a normalised transverse beam emittance of 0.5 – 1.5 µm*

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 653782.

EuPRAXIA design study project

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The Horizon 2020 Project EuPRAXIA (European Plasma Research Accelerator with eXcellence In Applications [1]) is producing a conceptual design report for a highly compact and cost-effective European facility with multi-GeV electron beams accelerated using plasmas. EuPRAXIA will be set up as a distributed Open Innovation platform with two construction sites, one with a focus on beam-driven plasma acceleration (PWFA) and another site with a focus on laser-driven plasma acceleration (LWFA). User areas at both sites will provide access to FEL pilot experiments, positron generation and acceleration, compact radiation sources, and test beams for HEP detector development. Support centres in four different countries will complement the pan-European implementation of this infrastructure.

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EuPRAXIA-LPA - A EuPRAXIA Construction Site Based on Laser-Driven Plasma Acceleration

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EuPRAXIA (European Plasma Research Accelerator with eXcellence In Applications) is a conceptual design study for a compact European accelerator infrastructure producing 5 GeV electron beams based on plasma acceleration [1]. The concept foresees two main construction sites, one focused on beam-driven plasma acceleration (PWFA), possibly in Italy, and another based on laser-driven plasma acceleration (LWFA), potentially in Germany, both of which will be supported by four centres of excellence across Europe. In this talk we focus on the site centred around laser-driven plasma acceleration, which will implement both external and internal injection LWFA mechanisms. In the external case, an RF injector based on S-band technology will be used to generate and pre-accelerate the electron beam (reaching electron energy up to 250 MeV [2,3]) before it is injected into a laser plasma accelerator (LPA) stage. As an alternative to the RF injector, a plasma injector (with electron energy up to 150 MeV [4]) can be used. A single-stage plasma accelerator, both generating and accelerating the electron beam, will also be built alongside the staged approach to reach the 5 GeV energy target. A hybrid option, in which an LPA produces an electron beam which in turn is used to drive a PWFA stage, is foreseen as a future development option [5]. This accelerator design will cater to multiple applications, including a Free-Electron Laser, a compact X-ray source based on betatron radiation and other types of particle beams.

[1] P A Walker, P D Alesini, A S Alexandrova, M P Anania, N E Andreev, I Andriyash, A Aschikhin, R W Assmann, T Audet, A Bacci, I F Barna, A Beaton, A Beck, A Beluze, A Bernhard, S Bielawski, F G Bisesto, J Boedewadt, F Brandi, O Bringer, R Brinkmann, E Bründermann, M Büscher, M Bussmann, G C Bussolino, A Chance, J C Chanteloup, M Chen, E Chiadroni, A Cianchi, J Clarke, J Cole, M E Couprie, M Croia, B Cros, J Dale, G Dattoli, N Delerue, O Delferriere, P Delinikolas, J Dias, U Dorda, K Ertel, A Ferran Pousa, M Ferrario, F Filippi2, J Fils, R Fiorito, R A Fonseca, M Galimberti, A Gallo, D Garzella, P Gastinel, D Giove, A Giribono, L A Gizzi, F J Grüner, A F Habib, L C Haefner, T Heinemann, B Hidding, B J Holzer, S M Hooker, T Hosokai, A Irman, D A Jaroszynski, S Jaster-Merz, C Joshi, M C Kaluza, M Kando, O S Karger, S Karsch, E Khazanov, D Khikhlukha, A Knetsch, D Kocon, P Koester, O Kononenko, G Korn, I Kostyukov, L Labate, C Lechner, W P Leemans, A Lehrach, F Y Li, X Li, V Libov, A Lifschitz, V Litvinenko, W Lu, A R Maier, V Malka, G G Manahan, S P D Mangles, B Marchetti, A Marocchino, A Martinez de la Ossa, J L Martins, F Massimo, F Mathieu, G Maynard, T J Mehrling, A Y Molodozhentsev, A Mosnier, A Mostacci, A S Mueller, Z Najmudin, P A P Nghiem, F Nguyen, P Niknejadi, J Osterhoff, D Papadopoulos, B Patrizi, R Pattathil, V Petrillo, M A Pocsai, K Poder, R Pompili, L Pribyl, D Pugacheva, S Romeo, A R Rossi, E Roussel, A A Sahai, P Scherk, U Schramm, C B Schroeder, J Schwindling, J Scifo, L Serafini, Z M Sheng, L O Silva, T Silva, C Simon, U Sinha, A Specka, M J V Streeter, E N Svystun, D Symes, C Szwaj, G Tauscher, A G R Thomas, N Thompson, G Toci, P Tomassini, C Vaccarezza, M Vannini, J M Vieira, F Villa, C-G Wahlström, R Walczak, M K Weikum, C P Welsch, C Wiemann, J Wolfenden, G Xia, M Yabashi, L Yu, J Zhu and A Zigler, “Horizon 2020 EuPRAXIA design study”, J. Phys.: Conf. Ser. 874, 012029 (2017).
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EuPRAXIA@SPARC_LAB: opportunities and perspectives

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On the wake of the results obtained so far at the SPARC_LAB test-facility at LNF, we are currently investigating the possibility to design and build a new multi-disciplinary user-facility, equipped with a soft X-ray Free Electron Laser (FEL) driven by a ~1 GeV high brightness linac based on plasma accelerator modules. It is in fact widely accepted by the international accelerator scientific community that a fundamental milestone towards the realization of a plasma driven future Linear Collider (LC) will be the integration of the new high gradient accelerating plasma modules in a FEL user facility (see the H2020 approved Design Study EuPRAXIA). This fundamental goal will be integrated in the LNF facility by using a high gradient X-band RF linac and the high power laser FLAME to drive Plasma Oscillations in the accelerator module. This activity is performed in synergy with the EuPRAXIA design study. In this talk we report about the recent progresses in the ongoing design study of the new facility and about opportunities and perspectives for international FEL community.

Free electron laser performance within the EuPRAXIA facility

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Over the last 90 years, particle accelerators have evolved into powerful and widely used tools for basic research, industry, medicine and science. A new type of accelerator that uses plasma wakefields promises gradients as high as some tens of billions of electron volts per meter. This would allow much smaller accelerators that could be used for a wide range of fundamental and applied research applications. One of the target applications is a plasma-driven Free Electron Laser (FEL), aiming at producing tunable coherent light using electrons traveling in the periodic magnetic field of an undulator. In this work, the plasma based electron beams with the most promising qualities, designed in the framework of EuPRAXIA, are analyzed in terms of the FEL performance.

A photon beamline for the water window FEL at EuPRAXIA@SPARC_LAB

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A proposal for building a Free Electron Laser, EuPRAXIA@SPARC_LAB, at the Laboratori Nazionali di Frascati, is at present under consideration [1]. This FEL facility will exploit plasma acceleration to produce ultra-bright photon pulses with durations of few femtoseconds down to a wavelength between 2 and 4 nm, in the so called “water window”.
The photon beamline [2] will deliver the photon beam from the undulators to the experimental area, optimizing the beam for the running experiment to allow a fine tune of the beam characteristics. The FEL radiation will be in SASE regime, at least for the first phase of the project, so it will present strong shot-to-shot fluctuations in intensity, spectrum and position. The radiation diagnostics are therefore chosen to be single-shot and not-intercepting whenever possible. The beam will be characterized by measuring its dimensions, coherence and positions both in transverse and longitudinal directions, its spectrum and its intensity. The main class of experiments that will be performed at the EuPRAXIA@SPARC_LAB FEL will include coherent diffraction imaging, soft X-ray absorption spectroscopy, Raman and photofragmentation measurements [3].

[1] M. Ferrario et al., Nucl. Instr. Met. Phys. A 909 (2018) 134-138.
[2] F. Villa et al., Nucl. Instr. Met. Phys. A 909 (2018) 294-297.
[3] A. Balerna et al., Cond. Matt. 4 (2019) 30.

A Coherent Imaging XUV-FEL users end-station for the EuPRAXIA@SPARC_LAB Free Electron Laser

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A proposal for building a Free Electron Laser, EuPRAXIA@SPARC_LAB, at the Laboratori Nazionali di Frascati, is at present under consideration [1]. This FEL facility will exploit plasma acceleration to produce ultra-bright photon pulses with durations of few femtoseconds down to a wavelength between 2 and 4 nm, in the so called "water window". The project is now focused on machine development, but it will host a user end-station to allow performing photon experiments in different areas [2].
The advent of FELs opened up the way for an unprecedented, wide class of experiments exploiting the peculiar features of these radiation sources. Key elements are the high peak brilliance and the short pulse duration, which is of the order of tens of femtoseconds. FELs can therefore allow high time resolution measurements and may provide a high signal-to-noise ratio.

The main class of experiments that will be performed at the EuPRAXIA@SPARC_LAB FEL will include coherent diffraction imaging, soft X-ray absorption spectroscopy, Raman and photofragmentation measurements (Figure 1). These techniques will allow studying a variety of samples, both biological and inorganic, providing information about their structure and dynamical behavior. In this context, the possibility of inducing changes in samples via pump pulses leading to the stimulation of chemical reactions or the generation of coherent excitations would tremendously benefit from pulses in the soft X-ray region. High power synchronized optical lasers and a TeraHertz radiation source will indeed be made available for THz and pump-probe experiments. Moreover, a split-and-delay station will allow performing XUV-XUV pump-probe experiments (see Figure 2 for a schematic layout of the machine) .
In order to perform the widest possible class of experiments, from coherent imaging, to diffraction and spectroscopy, emission, absorption, a top class experimental end-station, including a dedicated section with beam diagnostics and focusing devices and a highly flexible experimental chamber will be built [3]. In this talk an overview of the user end-station including details about sample delivery, data collection, analysis and data storage will be given.

[1] M. Ferrario et al., Nucl. Instr. Met. Phys. A 909 (2018) 134-138.
[2] A. Balerna et al., Cond. Matt. 4 (2019) 30.
[3] F. Villa et al., Nucl. Instr. Met. Phys. A 909 (2018) 294-297.

Novel XUV sources for Physical Chemistry Chemical Physics

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Electronic structure investigation of matter continuously profits from advances in laser and synchrotron radiation instrumentation. At the Elettra synchrotron radiation laboratory (Trieste, I), for the last 2 decades, the research activity in the field of atomic, molecular and cluster physics has been centred around the Gas Phase Photoemission beamline [1], where thorough studies of isolated system can be carried out by means of photoionization techniques and inner-shell electron photoionization, even with low density targets such as molecular vapours [2] or clusters [3]. But more recently the interest of the physical chemistry-chemical physics community has been attracted by the opportunity of exploring also the temporal dynamics of isolated systems by means of novel state-of-the-art light ultrafast X-ray radiation and vacuum ultraviolet (XUV) sources. For this purpose two new beamlines capable of delivering fs-XUV photon pulses have been commissioned and opened to Users in the framework of the FERMI Free Electron Laser (FEL) facility [4]: the Low Density Matter beamline at FERMI [5] and CITIUS [6], a state-of-the-art laboratory source, based on laser High Harmonic Generation on rare gases.

I will thus outline research opportunities opened in the field of atomic and molecular physics by these novel ultrafast light sources at Elettra, Trieste. In particular I will discuss recent pump-probe experiments, which on one side are used for characterizing our novel VUV light sources [6-9], and on the other side are also paving the way for thorough investigations of electron dynamics in molecular excited states and for femtochemistry application of ultrafast XUV radiation.

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[9] A. Ciavardini et al. Journal of Physical Chemistry A **123** (2019) 1295

Probing the structure and ultrafast dynamics of matter from molecules to nanoparticles using tunable FEL radiation in the VUV to the hard X-ray range

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In spite of the massive initial investments and large operation costs, the very unique characteristics of coherence, briefness and ultrahigh intensity of the Free Electron Laser (FEL) pulses have allowed a wealth of novel research directions to emerge, and keep attracting an increasingly large community of scientists. Indeed, whereas FLASH, the first EUV FEL facility has started operation in Germany in the early 2000s, wider user-oriented research opportunities with short-wavelength, tunable FEL radiation have become available only recently. They were triggered by the start of user operation overseas of LCLS@SLAC in the USA in 2010, followed shortly by SACLA@SPring-8 in Japan and more recently in Europe, the first seeded XUV FEL FERMI@ELETTRA in Trieste (IT), followed last year by the European XFEL in Hamburg (DE).

Time permitting, in this talk I will briefly highlight a few examples of research undertaken in the last 5 years within large international collaborations at the LCLS [1], SCSS test facility [5] and SACLA [2-4][6-8]. They show the scientific potential of FELs along several key scientific directions.

On the one hand the stability and ultrafast dissociation dynamics of model isolated species such as C_{60} [1], of a nucleobase analogue [2] and of halogenated linear [3] or cyclic [4] molecules have been investigated to reveal fundamental molecular mechanisms underlying the action of radiation therapies or the time dependence of sample stability under exposure to ultrashort and ultraintense X-ray pulses. On the other hand, new collective electronic decay mechanisms [5] and complex charge transfer and oligomer formation events [6] have been shown to drive the relaxation of rare-gas clusters in interaction with XFEL pulses. Moreover, using XFEL and NIR conventional laser pulses combined in a pump-probe arrangement, it was possible to reveal the *birth* of a nanoplasma [7], while the structure of single nanoparticles has been shown to be extractable even from low-quality single-shot coherent diffraction data using optimized structure reconstruction algorithms [8].

In the context of global XFEL beamtime scarceness due to the high user demand and limited availability at the facilities under operation, EuPRAXIA has the potential drive the emergence of disruptive technologies with reduced costs, possibly leading to enhanced access capabilities or even a democratization of this valuable research tool. The opportunity to conduct pilot user experiments at the forthcoming EuPRAXIA short-wavelength FEL beamlines is therefore most exciting.

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Single-shot x-ray absorption at soft x-ray free-electron-laser facilities: what we may learn

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This communication is largely based on our previous experience in the TIMEX proposal [1] and during the commissioning phase of the TIMEX beamline at Fermi@Elettra, the Italian seeded free-electron-laser (FEL) facility. Within the TIMEX project [1] we have performed several pilot pump-probe experiments with ultrafast lasers and some of the first soft x-ray absorption experiments with FEL pulses. One of the main advantages of performing x-ray absorption spectroscopy (XAS) experiments at FEL facilities like Fermi@Elettra or at the prospected EuPRAXIA@SPARC_LAB is the number of photons per pulse which may exceed 10^{12} photons/pulse, thus being still significantly higher than that currently achievable at the more compact HGG sources. The high intensity of the FEL pulses allows us acquiring data with a good signal-to-noise ratio from single-shot measurements.
In this context, X-ray Absorption Spectroscopy (XAS) can be used as a tool to directly observe the local structure of the specimen with typical subpicosecond time resolution. In particular, either by tuning the undulators to the appropriate energy, or exploiting the natural FEL bandwidth generated in SASE mode, the experiments performed at EuPRAXIA@SPARC_LAB can allow measurements of the informative, low-energy portion of the XAS spectrum, the so-called XANES (X-ray Absorption Near Edge Spectroscopy) region. Quantitative analysis tools of XANES data are nowadays available including those based on first principles calculations and can provide detailed information on the evolution of the local structure.
Therefore, FEL-XAS measurements will become a powerful tool to provide unique information on the local geometry (as well as on electron and spin states) around selected atomic species. Soft X-rays as the ones that will be produced by EuPRAXIA@SPARC_LAB are well suited for soft x-ray absorption studies in the water window region. This region includes the K edge of elements such as C, N and O, and the L edge of several elements. Examples of pioneering soft L-edge FEL-XAS transmission experiments include measurements of Al, Ge and Ti thin films for variable fluence (see, for example, [2–4] and refs. therein). In those experiments, ultrafast electron heating pumping matter at extremely high temperatures, as well as saturable absorption effects were observed. FEL experiments were found to be extremely useful to explore highly uniform warm dense matter (WDM) conditions, a regime exceedingly difficult to reach in present laboratory studies, but relevant to various fields, including high-pressure and planetary science, astrophysics, and plasma production. Various FEL-based ultrafast techniques can be used to probe WDM properties at electron temperatures in the 1–10 eV range and beyond. Those previous results naturally call for further challenging experiments at the EuPRAXIA@SPARC_LAB FEL as well as for parallel developments of suitable interpretation schemes for modeling and understanding the X-ray absorption cross section under high-fluence conditions (see [5] and refs. therein).

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The synergy between novel sources and novel experiments: The experience at the Low Density Matter beamline

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The development of new radiation sources and that of innovative spectroscopies proceed in parallel, and with a strongly synergistic approach. In this context, atomic and molecular physics has always played a pioneering role in the discovery and understanding of new phenomena on the one hand, and in the characterization and development of the new sources on the other hand. This fortunate position is crucially due to the possibility of investigating targets well isolated from any perturbing environment, and simple enough to be amenable to a quantitative theoretical description. While the temporal dimension—and the related high intensities—have long been accessible to laboratory lasers, only recently have Free Electron Lasers (FELs) made them available for ionizing radiation.

Among all short-wavelength FELs operating worldwide, the FERMI facility in Trieste does not rely on Self Amplified Spontaneous Emission (SASE) and is instead seeded by a UV laser; this gives it superior spectral properties among which, uniquely, full longitudinal coherence [1]. The Low Density Matter Beamline (LDM, [2]) at FERMI, which caters to the atomic-, molecular-, and cluster-science community, has fully exploited these unique characteristics to perform precision nonlinear spectroscopy [3], explore the behavior of atoms and clusters under intense fields [4], and study the dynamics of photoexcited molecules [5].

The LDM beamline has also represented a versatile instrument to characterize the properties of FERMI and explore new modes of operation [6], prompting the full exploitation and control of its longitudinal coherence for breakthrough experiments [7].

I will present the research opportunities offered by LDM at FERMI in the above fields, along with some recent results, and future perspectives.

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Time-resolved coherent Raman experiments

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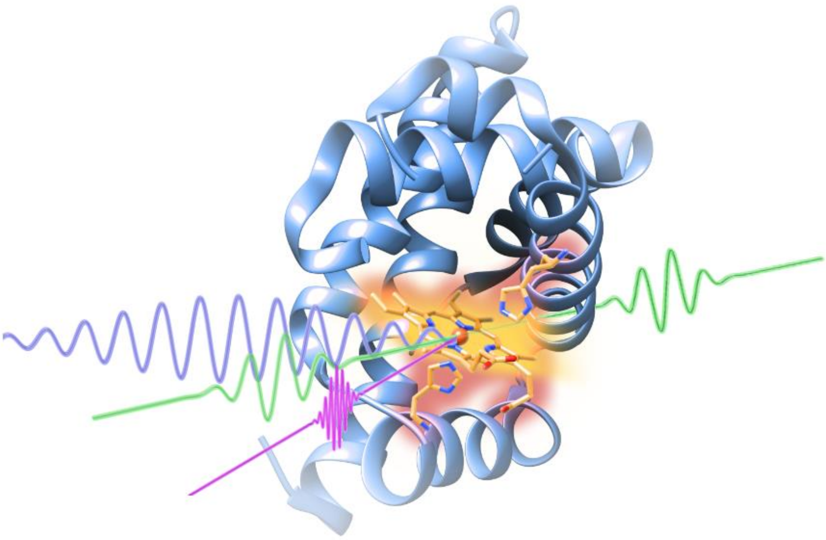
Photophysical and photochemical reactions are dominated by molecular vibrations. Hence, structural and geometrical properties of transient reacting species are typically investigated using vibrational spectroscopy. I will review recent pump-probe experiments performed using time-resolved, coherent Raman-based spectroscopies with femtosecond temporal resolution [1,2].

Paralleling such experimental protocols developed in the visible, X-ray pulses have been suggested as the natural candidate for stimulating chemical reactions or for generating coherent excitations in a specific atomic moiety [3]. In striking analogy, they may also be employed as a selective probe to monitor the evolution from reactant to photoproduct, taking advantage of the single atom perspective. In fact, tuning a X-ray pulse resonant with the absorption edge of a given electronic transition allows isolating molecular vibrations involving a desired atomic species.

I will discuss the potential advantages of such an extension to the X ray domain.



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High-Intensity Terahertz and Mid-Infrared Radiation at EUPRAXIA: Production and Opportunities in Condensed Matter

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Terahertz (THz) and Mid-Infrared (MIR) radiation, ranging from 0.5 meV to 1 eV, are in resonance with most of the fundamental excitations in condensed matter, allowing to measure, in steady-state linear-response spectroscopy, both their characteristic energy and lifetime. Recently, the developping of new high-intensity, sub-fs pulsed radiation sources emitting in the THz-MIR spectral region, has open a new scenario for condensed matter, allowing not only to excite those excitations but also to modulate and control their behavior in time and frequency.
This is particular important in Quantum Materials, where exotic excitations like Dirac and Weyl electrons, charge-phonons, spinons and skyrmions, with a complex texture of spin, lattice and electronic degrees of freedom, affect their low-energy transport and electrodynamics.
Here, we discuss the planned THz-MIR high-intensity, sub-fs pulsed source at EUPRAXIA and possible pilot experiments in Quantum Systems.

Will Cars Ever Endanger Airplanes? Tabletop X–ray Lasers in a Nutshell

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In the 1980s, in the cold war period, immense funding was made available for the rapid development of X-ray *lasers* that were meant for the "Star Wars" against the Soviet Union. Although tremendous progress was accomplished, in both fundamental understanding of plasma-lasing[1–3] as well as instrumentation capabilities, the plasma-driven X-ray laser never served for military purposes or "homeland security". In the 1990s ingenious concepts helped to further shrink the footprint to a tabletop or a large room setup[4], i.e. reducing the pumping requirements from kJ to less than a J, and make it a handy research platform. A summary of the last 30-40 years development will be given.

In the 2000s the international scientific community had a paradigm shift, as it began referring to "X-ray Lasers" meaning accelerator-based coherent sources, which were indeed in the (soft/hard) X-ray domain. In fact, the plasma-driven setups never really made it to demonstrate lasing in the -*strictly speaking*- X-ray domain: the shortest saturated outputs were below the few nm wavelength[5]. The reason why plasma lasers will ever hardly be *fully X-ray* lasers, rather EUV lasers, is now clear[6]. Nevertheless a number of practical applications have been shown[7–9] and its utility is imposing.

Still a part of the funding agencies argue today that because of the wavelength limitation, tabletop plasma "X-ray" lasers are obsolete, *meanwhile* a few acceleratorists fear that the underlying "competition" will end-up putting the expensive and hardly accessible facilities out of business. Fact is that the two architectures do address complementary needs, as much as cars and airplanes are not contending technologies[10]. In the talk we will consolidate this concept based on a number of parameters, results, and specifications.

Further, we will show a vision for possible development and utilization of tabletop setups to fill the gap, i.e. thanks to specific advances in data processing, i.e. the utilization of compact and large source is absolutely synergistics.

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Laser Plasma Accelerator’s Challenges for FEL Application

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In this review presentation, I’ll report on the last activities on Laser Plasma Accelerator (LPA) development. I’ll discuss the different schemes that have been explored and that allow to produce high quality electron beam in a reliable way. I’ll share the experience we got from pioneered experiments on using them for FEL applications by establishing a list of issues that we need to consider for demonstrating such ambitious goal. These issues concern many aspects, including technical one (laser performances, target, etc…), scientific one (diagnostic for beam parameters, beam performances and injection schemes), but also human aspects that appear when scientists from different background (engineer, technician, researchers) are going to work together. When summarizing all together the general progress done by the communities involved in this challenge, such ambitious appears more and more feasible with the demonstration of FEL radiation emitted in the UV range in the next two years, and later on in the X ray range in the context of the EuPRAXIA project.

ESFRI Roadmap and Next Steps

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The Horizon2020-project EuPRAXIA (European Plasma Research Accelerator with eXcellence In Applications) is a conceptual design study for a compact European accelerator infrastructure producing high-energy electron beams up to 5 GeV based on plasma acceleration. Now in its fourth and final year, the current project phase of EuPRAXIA will come to an end in October 2019 with the publication of a Conceptual Design Report. This talk is focused on the plans and future strategies for the project collaboration beyond this milestone. One important step for the continuation of EuPRAXIA towards the future implementation of a research facility will be an application to the ESFRI Roadmap in 2021. This exercise, carried out by the European Strategy Forum on Research Infrastructures (ESFRI), identifies a European strategy for large research facilities to be run or built within the next 10 to 20 years and provides successful candidates both with political support and funding opportunities through the European Commission [1].
Further emphasis on the scientific side of the EuPRAXIA project will be placed on the execution of a successful technical design phase. Focused on prototyping and R&D experiments, it will be essential to optimise and validate the various novel technologies that EuPRAXIA aims to introduce for its facility design.

[1] ESFRI, https://www.esfri.eu/esfri-roadmap.