MO-O-01

Chaos Studies on the Super-ACO Free Electron Laser

Marie E. Couprie (CEA)

When a gain modulation is applied on the Super-ACO free electron laser detuning by means of a change of the rf frequency, different macrotemporal structures can be observed such as 1-T regime in which the laser is pulsed at the modulation period, 2T, chaos and so on. Such transitions can also be measured on the free electron laser micropulse position. Bifurcation diagrammes and attractors have also been recorded. Comparisons with simulations will be also given.

MO-O-02

Two-Color Experiments with Infrared Lasers

Jean-Michel Ortega (LURE)

Molecular species generally exhibit a typical infrared absorption that constitutes their "chemical signature." This is also the case for various other systems such as elementary excitations in solids or pseudo-atoms made by artificial nanostructures. Infrared spectroscopy is, therefore, an essential tool in many fields of science. Linear spectroscopy can be performed by thermal sources or, in some cases, by synchrotron radiation. But the study of the dynamics and the nonlinear spectroscopy of these systems can be performed only by tunable high-power short-pulse infrared lasers. These lasers can be either tunable classical lasers or infrared free-electron lasers or, preferably, a combination of two or more of them. Dynamic studies are made by pump-probe and photon-echo techniques, which require absorption of two photons by the same system. In pump-probe experiments, it is often more interesting to be able to tune independently the frequency of the two beams, which can be made with a two-color FEL or by a combination or different lasers. "Nonlinear" spectroscopy is particularly interesting to perform "linear" spectroscopy of very dilute systems; in these cases the nonlinearity is used to drastically enhance the sensitivity of the spectrometry. For example, multiphoton ionization of molecules allows us to detect the products with the extremely sensitive technique of FT-ICR-MS (Fourier Transform Ion Cyclotron Resonant Mass Spectrometer), and SFG (Sum Frequency Generation) at surfaces allows us to detect less than a multilayer of molecules. SFG is more powerful when doubly resonant, with both laser beams tunable, and kinetics can be performed, with three colors. Various examples are given.

MO-O-03

First Lasing at SDL

T. Shaftan

MO-O-04

Other First Lasings

TBD

MO-O-05

Issues and Subtleties in Numerical Simulation of X-ray FELs*

William M. Fawley (LBNL)

Part of the overall design effort for x-ray FELs such as the LCLS and TESLA projects has involved extensive use of particle simulation codes to predict their output performance and underlying sensitivity to various input parameters (e.g., electron beam emittance). This talk discusses some of the physics and numerical issues that must be addressed by simulation codes in this regime. We first give a brief overview of the standard approximations and simulation methods adopted by time-dependent (i.e., polychromatic) codes such as GINGER and GENESIS, followed by details as to how shot noise is introduced as needed for modelling the underlying statistical fluctuations of self-amplified spontaneous emission (SASE), including several subtleties for dealing with higher harmonics and maintaining self-consistency with the eikonal approximation. We conclude with various numerical results concerning (a) the accuracies and inaccuracies of these codes in predicting incoherent synchrotron emission (i.e., the extremely low-gain regime); (b) the build-up of longitudinal coherence and transverse mode evolution in the "early" SASE regime; (c) the development of nonlinear microbunching at the higher harmonics and their expected longitudinal coherence and spectral bandwidth properties; and (d) some predicted statistics of radiation power in the nonlinear regime for a high gain FEL, including the effects of input seed fluctuations, monochromator sections, and tapered undulator sections at and beyond "first" saturation.

MO-O-06

MOPA Optical Klystron FELs and Coherent Harmonic Generation

Giuseppe Dattoli, Luca Giannessi, Pier Luigi Ottaviani (ENEA)

The master oscillator power amplifier (MOPA) FEL configuration, when combined with the harmonic generation mechanism, can be used to extend the tunability range of a free-electron-laser oscillator. In such a configuration an oscillator FEL operating at a given wavelength is used as the seed of an amplifier FEL operating at a harmonic of the first. This well-known configuration is affected by the problem of early saturation in the amplifier, due to the energy spread induced by the saturation process occurring in the oscillator. In this communication a different undulator scheme based on an optical klystron has been analysed. Such a scheme solves the problem of the early saturaton by limiting saturation in the oscillator. The result is an increased stability of the source, a reduced rise time of the signal, and an increased efficiency.

MO-O-07

Electron Beam Conditioning for FEL Applications*

Bahman Hafizi, Daniel F. Gordon (Icarus Research, Inc.); Charles W. Roberson (ONR); Phillip Sprangle (NRL)

Operation of an FEL is sensitively dependent on the axial velocity spread on the electron beam. To reduce this spread one can improve the beam quality at the source using, for example, a photocathode. Photocathodes are capable of generating electron beams with small emittance and energy spread. A complementary approach is to attempt to reduce the axial velocity spread after the beam leaves the gun. There are at least two methods for reducing the axial velocity spread. In the first instance, beam conditioning employs a combination of rf cavities to impart varying amounts of energy to electrons in the beam. It has been numerically demonstrated that by this means the axial velocity spread can be reduced significantly [1,2]. The second method makes use of the self-electric field associated with an electron beam. It turns out that there is an equilibrium flow inside a wiggler in which the effects of wiggler gradients (manifested by betatron oscillations) tend to be compensated by the self-electric field associated with the beam, effectively reducing the axial velocity spread [3,4]. This equilibrium flow is similar to the Brillouin flow in a solenoid. We shall discuss and present numerical results to illustrate these two methods in detail and their potential applications.

* Work supported by ONR.

[1] A.M. Sessler, D.H. Whittum, and L.H. Yu, Phys. Rev. Lett. 68, 309 (1992).
[2] P. Sprangle, B. Hafizi, G. Joyce, and P. Serafim, Phys. Rev. Lett. 70, 2896 (1993).
[3] B. Hafizi and C.W. Roberson, Phys. Plasmas 3, 2156 (1996).
[4] D.F. Gordon, B. Hafizi, C. W. Roberson and P. Sprangle, in Non-neutral Plasma Physics IV, AIP Proceedings 606, 218 (2002).

MO-O-08

Start-up of an FEL Oscillator from Shot Noise

Vinit Kumar, Srinivas Krishnagopal (CAT)

In FEL oscillators, as in SASE, the build-up of intracavity power starts from shot noise resulting from the discreteness of charge in the electron bunch. It is important to do the start-up analysis for the build-up of intracavity power in order to fix the macropulse width from the electron accelerator, such that the system reaches saturation. In this paper we show that one can use the time-independent oscillator code TDAOSC to perform this analysis. Our approach [1] is similar to the one followed by L.-H. Yu [2] for start-up in the SASE configuration and is extended here to the oscillator configuration. We present results of this analysis for the parameters of a far-infrared FEL oscillator under design at CAT.

[1] V. Kumar and S. Krishnagopal, Phys. Rev. E 65, 016503 (2001).
[2] L.-H. Yu, Phys. Rev. E 58, 499 (1998).

MO-O-09

First Demonstration of Energy-Recovery Operation in the JAERI Superconducting Linac for a High-Power Free-Electron Laser

Ryoichi Hajima, Toshiyuki Shizuma, Masaru Sawamura, Ryoji Nagai, Nobuyuki Nishimori, Nobuhiro Kikuzawa, Eisuke J. Minehara (JAERI)

An energy-recovery linac (ERL) for a high-power FEL has been designed and constructed at JAERI (Japan Atomic Energy Research Institute). The construction of the ERL was completed and the first energy-recovery operation was demonstrated in February 2002. The parameters of the ERL are: injection energy of 2.5 MeV, recirculating energy of 17 MeV, average current of 5 mA, bunch repetition of 10 MHz, rf frequency of 500 MHz, and so on. The injector will be reinforced to generate 40-mA beam current for a 10-kW FEL. We present the design overview and the performance of the JAERI-ERL. Future plans towards a 10-kW FEL are also presented.

MO-O-10

Possibility of a MW-Class High-Gain Amplifier FEL

Dinh C. Nguyen (LANL); Henry P. Freund (SAIC)

High-gain amplifier FELs offer many unique advantages such as robust operation without a high-Q optical cavity and potentially high extraction efficiencies with the use of tapered wigglers. Although a high-average-power, CW amplifier FEL has not been demonstrated, many key physics issues such as electron beam brightness requirements, single-pass gains, saturation, etc. have been resolved. In this paper, we study the feasibility of a MW-class FEL based on the high-gain amplifier FEL concept. We show that with suitable electron beam parameters, i.e., high peak current, low emittance, low energy spread, and a sufficient tapered wiggler length, peak output power of 1 GW and optical pulse energies of 20 mJ can be achieved. With a realizable micropulse repetition rate of 50 MHz, a MW-class high-gain amplifier FEL is possible. We will study key technical difficulties and outline a possible configuration of a MW-class FEL demonstration using today's rf linac technologies.

MO-O-11

Upgrade of a Compact FIR FEL Driven by a Magnetron-Based Microtron for the Wavelength Range of 100-300 μm

Young Uk Jeong, Grigori M. Kazakevitch, Byung Cheol Lee, Sung Oh Cho, Jaegwon Yoo (KAERI); Nikolai G. Gavrilov, Vitaly V. Kubarev (BINP)

A compact FIR FEL driven by a magnetron-based microtron [1] has been upgraded to extend the wavelength range from 100-160 μm to reach 300 μm. The energy of the electron beam from the microtron is variable from 6.5 to 4.3 MeV by changing the position of an rf cavity inside the microtron. We have extracted macropulse current of the electron beam more than 50 mA for 5.4 MeV and the lasing signals in the wavelength range of 160-280 μm have been successfully observed with the electron beam. The radiation is transported to an experimental stage through a 10-m-long vacuum pipe with a collimating lens and gold-coated mirrors. The measured spatial distribution of the transported radiation shows small diverging angle less than 1 mrad and spot size (FWHM) less than 20 mm. The pulse width and macropulse power of the lasing signals measured at the experimental stage are approximately 3 μs and 10 W, respectively. Main features of the FEL have been investigated and discussed in this report. The application experiments of the FEL to the molecular spectroscopy and solid-state physics are under preparation.

[1] Y. U. Jeong et al., Nucl. Instrum. Methods A 483, 195 (2002).

MO-O-12

Electron Beam Properties and Radiation Performance of a Smith-Purcell Radiator

Kwang-Je Kim (ANL), Yin-e Sun, Oscar H. Kapp, Albert Crewe (UofC),*

A Smith-Purcell radiator [1] using electron beams from a scanning electron microscope (SEM) is potentially very attractive as a compact source of coherent radiation in the far infrared region [2]. We discuss important issues in developing such a device. The requirement on electron beam emittance is stringent even for spontaneous emission mode, since the beams should be placed sufficiently close to the grating surface without striking it. Spontaneous Smith-Purcell radiation in SEM-based radiators is brighter by an order of magnitude compared to the black body radiation, and has been experimentally observed [2,3]. Higher power may be achieved via an amplification process similar to a free electron laser (FEL). We discuss recent progress in theoretical analysis [4] and experimental status of Smith-Purcell radiators in FEL mode.

* Work supported by U.S. Department of Energy, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-38.

[1] S.J. Smith and E. M. Purcell, Phys. Rev. 92, 1069 (1953).
[2] J. Urata et al., PRL 80 (3), 516 (1998).
[3] O. H. Kapp, these proceedings.
[4] K.-J. Kim and S.-B. Song, Nucl. Instrum. Methods A475, 158 (2001).

MO-O-13

Four-Channel Planar FEM for High-Power mm-Wave Generation (Theoretical and Experimental Problems)

Andrei V. Arzhannikov, Vladimir B. Bobylev (BINP); Naum S. Ginzburg (Institute of Applied Physics, Russia); Petr V . Kalinin (BINP); Nikolai Yu. Peskov, Aleksandr S. Sergeev (Institute of Applied Physics, Russia); Stanislav L. Sinitsky, Vasilii D. Stepanov (BINP)

Achieving the level of tens GW power of mm-wave is possible by an increase in the width of a sheet beam in a planar FEM up to 1-2 meters [1]. Such a device so strongly elongated in the transverse direction is not attractive from an engineering and technological point of view. So we propose to construct a multichannel FEM that consists of a number of 20-cm-wide planar FEM oscillators that closely adjoin each other [2,3]. Problems for the construction of such devices will be discussed in this presentation. Theoretical problems include: computer simulations for the operation of 4-beam accelerator diode, analytical description and numerical simulation for unit 4-planar FEM oscillators at 75 GHz in a single device with a good co-phased operation of the oscillators, and computer simulations for summing power going out from 4 generating channels. Results of theoretical studies and computer simulations of these problems will be presented in the paper. Construction and experimental testing of main components of this 4-channel generator will be also described. A components list contains the magnetic system of the device with four maser channels, a magnetically insulated diode to generate 4-sheet beams at a voltage of 1 MV, combined Bragg resonators of separate channels with waveguides to unite them in a uniform 3-dimensional electrodynamic structure, electrodynamic system to output generated 4-mm radiation and, finally, a collector to absorb the utilized e-beams.

[1] A.V. Arzhannikov, N.S. Ginzburg, N.Yu. Peskov et al., Nuclear Instrum. Methods A358 (1995) 189-192.

[2] N.S. Ginzburg, N.Yu. Peskov, A.S. Sergeev et al., Pis'ma v Zhurnal Tekhnicheskoi Fiziki, 27, #6 (2001) 58-61.

[3] A.V. Arzhannikov, N.S. Ginzburg, V.G. Ivanenko et al., Pulse Power Plasma Science 2001, Las Vegas, Nevada, p. 565.

TU-O-01

Mirrors Issues for FELs

David Garzella (CEA and LURE)

Most of the FELs operating in the world are optical resonator-based devices. According to the covered spectral range and the purposes of the FEL, the mirrors composing the optical cavity must gather different major characteristics, some of them revealed to be at the edge of the most advanced technology. Thus, for storage-ring-driven UV/VUV FELs in the small-signal small-gain regime, the lowest absorption and scattering losses are searched in order to obtain the laser oscillation and to insure the highest output power with the longest mirror lifetime. On the other hand, the thermal load that the high-power FELs based on linac devices are submitted to call for an accurate modelization and mirror design and control for preventing considerable losses on the extracted power and the laser instabilities.

This talk will focus mainly on these two aspects, by reviewing some major results and attempting to give some possible research paths. In addition, a few issues on special resonator configurations for the long-wavelength FELs and on the general requirements for transporting and focusing mirrors at very short wavelengths will be addressed.

TU-O-02

Permanent Magnet Systems for FELs*

S. C. Gottschalk (STI Optronics Inc.); D. Dowell (SLAC); D. Quimby (STI Optronics Inc.)

We will review uses of permanent magnets (PMs) in FELs. PMs have been used for FEL undulators for many years. Recently PMs have been considered to replace many of the electromagnet dipoles, quadrupoles, and sextupoles in FEL beamlines and linear collider quadrupoles. PM beamline optics offer several advantages over electromagnets [1]. They are more compact, need no power, and do not require cooling water. In addition, adjustable-strength quadrupoles may have a precisely tunable magnetic centerline. High pole tip fields (1.5 T in dipoles and 1.2 T in quadrupoles) are easily achieved. PM technology opens up new bend design possibilities. We will describe a new, high performance, all-PM bend, the Ballard bend, that is first-order isochronous and doubly achromatic. It is suitable for use in the exhaust beam leg of an energy recovery FEL. We have designed and built a compact, high field sector PM dipole. Measured field profiles agree to 10 ppm of predictions. Compact PM quadrupoles were also designed and built. Measurements of field strength, axial profile, magnetic centerline tuning, and passive temperature compensation of strength and centerline shift agreed very well with predictions. Scaling laws and long-term tests of centerline shift will also be presented.

* JTO contract NBCHC010026, DOE grant DE-FG03-01ER83305.

[1] S.C. Gottschalk, "New Type of Permanent Magnet Beamline Optics," PAC2001, 3218-3220 (2001).

TU-O-03

Radiation Exposure and Magnetic Performance of the Undulator System for the VUV FEL at the TESLA Test Facility Phase I after Almost Three Years of Operation

Joachim Pflueger, Bart Faatz, Claas Heidmann, Markus Tischer, Thorsten Vielitz (DESY-Hamburg)

Radiation damage to undulator systems made of permanent magnet materials like NdFeB or SmCo is a critical issue in SASE projects. It is moreover of special interest in high duty cyle machines using superconducting accelerators such as the TESLA Test Facility (TTF) or the TESLA X-FEL. This paper reports real experience made in TTF Phase I, which ended on May 6, 2002 after almost three years of successful operation. The radiation exposure of the undulator was recorded in a meticulous way over the whole installation period of the undulator system in the TTF linac. We report on these dosage measurements and in addition on recent magnetic measurements performed on the undulator segments after deinstallation. A comparison with the data made before installation is made. Based on TTF experience, recommendations for passive protection systems for future projects such as TTF Phase II and the TESLA X-FEL will be given.

TU-O-04

LCLS Prototype Undulator*

Isaac B. Vasserman, Shigemi Sasaki, Roger J. Dejus, Elizabeth R. Moog, Emil Trakhtenberg, Oleg Makarov (ANL); Nikolai Vinokurov (BINP)

A 30-mm-period Linac Coherent Light Source (LCLS) prototype undulator has been constructed. The prototype is a 3.4-m-long hybrid-type undulator with a fixed gap of 6 mm. This project has demanding requirements for the field quality along the undulator axis. Tuning of field quality should be as precise as possible to provide proper trajectory straightness (< 2 μm). A set of 500 magnets received from Shin-Etsu has been investigated. For some magnets, the strength and direction of magnetization were measured using a Helmholtz-coil system, and our results were compared with vendor"s results to confirm the validity. Hall probe measurements were performed for all magnets while they were mounted in a specially designed fixture with Vanadium-Permendur poles [1]. The magnets were sorted using these data to minimize field errors. The sorted magnets were put into slots between poles and assembled into the LCLS prototype support frame. Measured field profiles and the field integrals were in good agreement with the predictions based on the measurements of individual magnets and met the LCLS undulator tolerances. A variety of measurement results will be presented and discussed.

*Supported by the U.S. Department of Energy, Office of Science, BES, under contract No. W-31-109-ENG-38.

[1] I. Vasserman, S. Sasaki, R. Dejus, E. Moog, E. Trakhtenberg, N. Vinokurov, Proceedings 23rd International FEL Conference, Darmstadt, Germany, 2001.

TU-O-05

Study of the Transverse Coherence at the TTF Free Electron Laser

Rasmus Ischebeck (RWTH Aachen); Josef Feldhaus, Christopher Gerth, Evgeny Saldin (DESY-Hamburg); Peter Schmüser (Universität Hamburg); Evgeny Schneidmiller, Barbara Steeg, Kai Tiedtke (DESY-Hamburg); Manfred Tonutti (RWTH Aachen); Rolf Treusch, Mikhail Yurkov (DESY-Hamburg)

Double slits with different separations and crossed slits, as well as circular apertures have been used to study the transverse coherence of the VUV light of the SASE free electron laser at the TESLA Test facility at DESY. The resulting diffraction patterns are converted to visible light by a CeYAG crystal and imaged by a high-resolution CCD camera. The height contrast of the diffraction patterns indicates a high degree of transverse coherence. Measurements have been taken at various operating modes and wavelengths of the FEL. A numeric simulation code (FAST) has been used to calculate the wavefronts of the FEL light at the exit of the undulator. By propagating the wavefronts through the optical set-up, the diffraction at the double slits is simulated (GLAD) and found to be in good agreement with the measurements.

TU-O-06

Design of the Jefferson Lab IR Upgrade FEL Optical Cavity*

M. D. Shinn, G. R. Baker, C. P. Behre, S. V. Benson, M. E. Bevins, L. A. Dillon-Townes, H. F. Dylla, J. F. Gubeli, R. D. Lassiter, G. R. Neil (TJNAF)

Jefferson Lab is in the process of upgrading the Free-Electron Laser Facility to provide higher output power as well as broader wavelength and timing flexibility. As part of the upgrade, a new optical cavity is being constructed. Using a near-concentric configuration, it will provide high average power (~ 10 kW) output using one of three sets of dielectrically-coated mirrors. A fourth mirror set will provide broadband tuning throughout the mid-IR, but at a lower average power of ~ 1 kW. The new optical cavity offers unique features such as *in vacuo* active stabilization of the mirror orientation and deformable high reflector mirrors. The status of the construction of the optical cavity and a review of its capabilities will be presented.

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TU-O-07

Evidence for Transverse Dependencies in COTR and Microbunching in a SASE FEL*

A. H. Lumpkin, Y. C. Chae, J. W. Lewellen, W. J. Berg, S. G. Biedron, R. J. Dejus, M. Erdmann, Z. Huang, K.-J. Kim, Y. Li, S. V. Milton, E. R. Moog (ANL); D. W. Rule (NSWC); M. Borland, V. Sajaev, B. X. Yang (ANL)

The basic models of electron-beam microbunching in a SASE FEL describe the density modulation in the longitudinal distribution of the micropulse at the fundamental wavelength of the FEL. Using coherent optical transition radiation (COTR) techniques, we have observed transverse dependencies of COTR and, by extension, of microbunching. The experimental observations include the z-dependent e-beam sizes obtained by using a 500-nm shortpass filter to sort broadband OTR versus the narrow-band COTR at 530 nm. We can explain a 30% narrowing of the observed beam size using COTR by its dependence on the square of the number of microbunched particles. However, additional effects are needed to explain our observations of beam size reductions by factors of 2-3 as we proceed in z down the undulators. Localized beam structure or an effective core in some parameters is predicted as a result of bunch compression in a chicane, and such a beam core would be reflected in the COTR properties. In addition to the near field imaging, we report the complementary evidence from the far-field COTR interferometer images and the evidence from the imaging spectrometer for x-dependent spectra. The possibility for microbunching transverse dependence is considered as one explanation for these effects as the bunching fraction evolves.

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TU-O-08

FEL R&D at SLAC's Short Pulse Photon Source

P. Krejcik, L. Bentson, P. Bolton, E. Bong, P. Emma, J. Galayda, J. Hastings, C. Rago, J. Rifkin, C. Spencer (SLAC)

An upgrade project to the SLAC linac allows ultra-short electron bunches to be interleaved with the routine high-energy physics program operation, for use with an undulator to produce short-pulse, high-brightness x-rays. The linac upgrade comprises the installation of a bunch compressor chicane, of similar design to the Linac Coherent Light Source (LCLS) project, and is being installed in summer 2002. A final compression stage in the high-energy Final Focus Test Beam (FFTB) line compresses the 28-GeV, 3.4-nC electron bunch to 80 femtoseconds FWHM, where a 5-m section of undulator (K=4.45) will produce 1.5-Å x-rays with 3×10^7 photons per pulse and a peak brightness of 4×10^{24} photons mm^{-2} mrad^{-2} s^{-1} (0.1% BW). The facility will allow us to test the dynamics and associated technology of bunch compression and gain valuable experience for the LCLS using the SLAC linac. New ultra-short electron bunch diagnostic techniques will be developed hand in hand with the same ultra-fast laser technology to be used for LCLS. Issues of high peak power (27 GW) x-ray transport and optics can be addressed at this facility as well as pump-probe and ultra-fast laser timing and stability issues.

TU-O-09

New Results and Prospects for Harmonic Generation in Storage Ring FELs*

Vladimir Litvinenko, Igor Pinayev, Samadrita Rovchowdhury (DUKE)

In this paper we review new results and prospects for harmonic generation in storage ring (SR) FELs. Traditionally high harmonics were generated in storage ring FELs using conventional (IR or visible) pulsed lasers as a driver [1]. Discovery of super-pulses with GW levels of intra-cavity peak power [2] provided for new ways of generating coherent harmonics in the VUV and X-ray ranges [3]. Super-pulses have been generated in the OK-4/Duke SR FEL since 1998 using the gain modulation technique [4]. As we reported at the previous FEL conference, the intra-cavity power on the OK-4 FEL was sufficient for effective generation of third and higher harmonics of the fundamental FEL wavelength. The tunability of the FEL wavelength provides for natural tunability of the harmonic radiation.

We present recent experimental results of the UV and VUV harmonic generation in the OK-4/Duke SR FEL. We describe the experimental set-up including the XUV monochromator (30-200 nm) and the optical cavity with the hole out-coupling for coherent harmonic radiation. We compare the experimental results with our theoretical predictions and recent results from VUV SASE FELs.

We discuss the prospects of the intra-cavity short-wavelength harmonic generation in SR FEL and compare them with other techniques.

* Work is supported by the Dean of Natural Sciences, Duke University.

[1] R. Prazeres et al., Nucl. Instrum. Methods A304, 72 (1991).
[2] V.N. Litvinenko et al., Nucl. Instrum. Methods A358, 334 (1995).
[3] V.N. Litvinenko, "X-ray storage ring FELs: New Concepts and New Directions," Proc. of 10th ICFA Beam Dynamics Panel Workshop "4th Generation Light Sources," January 1996, Grenoble, WG6-16.
[4] I.V. Pinayev et al., Nucl. Instrum. Methods A475, 222 (2001).

TU-O-10

The UV European FEL at ELETTRA at 1.5 GeV: Towards Compatibility of Storage Ring Operation for FEL and Synchrotron Radiation

M. Trovò, G. De Ninno, M. Danailov, M. Marsi, E. Karantzoulis, B. Diviacco (ELETTRA); R. Walker (Diamond Light Source); R. Bartolini, G. Dattoli, L. Giannessi, L. Mezi (ENEA); M.E. Couprie (CEA-Saclay, LURE); A. Gatto, N. Kaiser (Fraunhofer Institut); S. Gunster, D. Ristau (Laser Zentrum Hannover)

The European FEL at ELETTRA has recently increased its operating energy up to 1.5 GeV, the highest electron beam energy used so far for a FEL. This is an important improvement in the performance of the source, increasing the extracted power at wavelengths around 200 nm and providing better beam stability and lifetime. Furthermore, this development represents a first step towards the solution of a crucial issue - the compatibility of FEL and normal synchrotron radiation operation at a user facility like ELETTRA. In this paper we discuss the most important aspects of this issue; in particular, we show that the properties of the electron beam in FEL mode can match the needs of normal synchrotron radiation experiments that require a few bunch filling of the storage ring. Future plans will be also discussed, aimed at developing the FEL as a source for experiments in the context of an existing user community.

TU-O-11

Storage Ring Free Electron Laser Dynamics: Longitudinal Detuning Study

Cyrille A. Thomas, Jan I.M. Botman (TU-E); Marie-Emmanuelle Couprie (CEA/SPAM/LURE); Giuseppe Dattoli (ENEA); Giovanni De Ninno (ELETTRA)

The Storage Ring Free Electron Laser (SRFEL) dynamical system is nonlinear and needs a numerical model to be investigated. The complex dynamical interaction between the laser pulse and the stored electron beam can be described on the longitudinal phase space as a function of the longitudinal detuning, i.e., the pass-to-pass synchronisation between the laser pulse and the electrons. In order to investigate the dynamics of the SRFEL as a function of the detuning, the results from a numerical code coupling the free-electron laser (FEL) and the electron beam equations are compared to experimental measurements on two SRFELs: Super-ACO FEL and ELETTRA FEL. In the code the FEL equation gives by integration the evolution of the complex laser electric field and is coupled with the electron bunch energy spread equation and to an equation representing the microwave instability. In this paper we present the experimental results on the SRFEL dynamics as a function of the detuning, and we discuss the results from the numerical codes.

WE-O-01

Overview of High-Brightness, High-Average-Current Photoinjectors for FELs

Steven J. Russell (LANL)

We are now nearing the end of the second decade since the inaugural photoinjector experiments were carried out at Los Alamos National Laboratory in 1985. The interim period has seen a dramatic increase in the number of photoinjectors in operation around the world, in our physical understanding of their operation, and, consequently, the brightness of their beams. For some time now, photoinjectors have been the solution of choice for electron beam applications requiring very high quality electron beams, such as free electron lasers (FELs). In recent years, there has been a renewed interest in high-average-power FELs and, as a result, high-average-current photoinjectors. Here, we present an overview of photoinjector development with particular emphasis on high-average-current devices in FEL applications.

WE-O-02

Femtoseconds Kiloampere High-Brightness Electron Beam

X.J. Wang, X.Y. Chang (BNL)

One of the most challenging issues in X-ray FEL and TeV linear collider R&D is to produce short electron bunches. Recent experimental results and theoretical studies have shown that coherent synchrotron radiation (CSR) will lead to significant beam degradation using a magnetic chicane bunch compressor. We will present simulation and initial experimental results of ultrashort (10 fs rms) kiloampere electron bunch production from a photocathode injector. The electron beam is produced by a 8-ps (FWHM) frequency quadrupled Nd:YAG laser from a photocathode rf gun injector operating at the longitudinal emittance compensation mode [1,2]. The measured electron beam bunch length at the rf gun exit is about 800 fs (rms). It is further compressed down to 10 fs (rms) using rf focusing in the 3-meter-long linac. The measured transverse emittance is about 1.5 mm-mrad (rms).

[1] X.J. Wang, X. Qiu and I. Ben-Zvi, Phys. Rev. E 54, R3121-3124 (1996).
[2] X.J. Wang and I. Ben-Zvi, Proc. of 1997 Particle Accelerator Conference, BNL-64468, p. 2793 (1997).

WE-O-03

First Operation of a Superconducting RF Electron Gun

Hartmut Büttig, Pavel Evtushenko, Michael Freitag, Dietmar Janssen (FZR); Sergey Konstanitnov, Jaroslav Kruchkov (BINP); Axel Martheisen (DESY-Hamburg); Peter Michel (FZR); Wolf-Dietrich Möller (DESY-Hamburg); Oleg Myskin (BINP); Michael Pekeler (ACCEL); Victor Petrov (BINP); Torsten Quast, Bertram Reppe (FZR); Peter vom Stein (ACCEL); Jochen Teichert (FZR); Alexey Tribendis, Vladimir Volkov (BINP); Ingo Will (MBI Berlin)

In the last year at the Forschungszentrum Rossendor, in cooperation with the Budker Institute Novosibirsk, DESY, the Max Born Institut Berlin, and ACCEL, a superconducting rf photoelectron gun (SRF gun) has been developed [1]. On March 5, 2002 this gun is going into successful operation. A half-cell niobium cavity has been cooled down to 4 K. In this cavity a $CsTe_2$ photocathode is installed, isolated electrically and thermally by a vacuum gap. The Q value and the accelerating field strength in the cavity have been measured. For 4 K, $Q=2\times10^8$ and an accelerating field of 14 MV/m have been obtained. This value did not change during four weeks of operation time. The energy of the electron beam is 0.62 MeV and the bunch charge is 26 pC. The laser works with a duty factor of 25% and with a repetition rate of 26 MHz inside the macropulse. The average laser power in the macropulse is 1.5 W (λ=260 nm), and the length of the micropulse is 5 ps FWHM. This corresponds to an average electron current of 170 μA and 680 μA in the macropulse. The isolated cathode allows the separate measurement of the cathode current and the current inside the beam dump as a function of the laser phase. The next measurements are planned for late May.

[1] E. Barthels et al., Nucl. Instrum. Methods A445, p. 408 (2000).

WE-O-04

Theory and Simulation of CSR Microbunching in Bunch Compressors*

Zhirong Huang, Michael Borland (ANL); Paul Emma (SLAC); Kwang-Je Kim (ANL)

A microbunching instability driven by coherent synchrotron radiation (CSR) in bunch compressors is discovered by start-to-end simulations of the Linac Coherent Light Source (LCLS) [1] and is studied using an iterative solution of the integral equation that governs this process [2]. In this paper we discuss the amplification mechanism of CSR microbunching and compare analytical results with numerical simulations. These results are applied to evaluate the stability of the LCLS bunch compressors.

* Work supported by the U. S. Department of Energy, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-38.

[1] M. Borland et al., in PAC2001 Proceedings, 2707 (2001); and to be published in FEL2001 Proceedings.
[2] Z. Huang and K.-J. Kim, submitted to Physical Review Special Topics - Accelerators and Beams, 2002.

WE-O-05

Scheme for Attophysics Experiments at an X-ray SASE FEL

Evgueni Saldin, Evgueni Schneidmiller (DESY-Hamburg); Mikhail Yurkov (JINR)

We propose a concept for production of high-power coherent attosecond pulses in the X-ray range. An approach is based on generation of 8th harmonic of radiation in a multistage HGHG FEL configuration starting from shot noise. Single-spike phenomena occur when the electron bunch is passed through a sequence of four relatively short undulators. The first stage is a conventional "long" wavelength (0.8 nm) SASE FEL which operates in the high-gain linear regime. The 0.1-nm wavelength range is reached by successive multiplication in a stage sequence (0.8 nm - 0.4 nm - 0.2 nm - 0.1 nm). Our study shows that the statistical properties of the high-harmonic radiation from the SASE FEL, operating in the linear regime, can be used for selection of radiation pulses with a single spike in the time domain [1]. The duration of the spikes is in the attosecond range. Selection of single-spike high-harmonic pulses is achieved by using a special trigger in the data acquisition system. The potential of X-ray SASE FEL at TESLA at DESY for generating attosecond pulses is demonstrated. Since the design of the XFEL laboratory at TESLA is based on the use of long SASE undulators with tunable gap, no special place or additional FEL undulators are required for attophysics experiments. The use of 10-GW-level attosecond X-ray pulses at the X-ray SASE FEL facility will enable us to track processes inside atoms for the first time.

[1] E. Saldin, E. Schneidmiller, M. Yurkov, DESY 02-070, May 2002.

WE-O-06

Multi-Beam Free-Electron Lasers*

Henry P. Freund (SAIC); Patrick G. O'Shea, M. Virgo (UMD)

Most free-electron lasers (FELs) are based on laser-driven photocathodes relying on bunch compression for the high peak currents required for high-gain operation. However, short-bunch FELs are subject to slippage effects that limit the output energy. In addition, bunch compression is limited by coherent synchrotron radiation (CSR) causing beam breakup and emittance increases. These limitations pose fundamental constraints on FEL design. These constraints can be circumvented, in principle, by the use of multiple electron beams. This scheme uses the beams from multiple injectors that are combined to form an aggregate beam with partial overlap of the individual beams, and a total charge that is increased beyond the norm for such FELs. Because substantially less bunch compression is needed for comparable peak currents, this has two advantages over single-beam operation: specifically, it minimizes the deleterious effects of CSR and slippage. Further, since the bunch length is longer than for a single beam, the total energy extraction is increased. We study the effects of multiple beams on the FEL interaction using the MEDUSA simulation code [1]. Simulations addressing the dynamics of combining multiple beams are discussed.

* Work supported by the JTO and ONR.

[1] H.P. Freund et al., IEEE J. Quantum Electron., 36, 275 (2000).

WE-O-07

Design Considerations of the LCLS

Cecile G. Limborg (SLAC)

The Linac Coherent Light Source (LCLS) is a single-pass X-ray FEL designed to produce very short (~80 fs) and very high-power (8 GW), short-wavelength (1.5 Ångstrom) pulses. This new facility, to be built at SLAC as a multi-laboratory collaboration, will have peak brilliance performances exceeding by 10 orders of magnitude those obtained presently in third-generation synchrotron radiation sources. The LCLS has successfully passed the first two critical decisions for approval. Construction is planned to start in late 2005 for the injector and 2006 for the main accelerator and undulator. In this paper, the accelerator physics challenges related to the production of a 1.2-mm.mrad emittance, 1-nC, 80-fs rms, 15-GeV electron beam are discussed. Advances recently made on photoinjectors are reported. The issues of coherent synchrotron radiation produced in the bunch compressors and undulator vacuum chamber wakefields are discussed.

WE-O-08

Status of SPring-8 Compact SASE Source FEL Project

*Tsumoru Shintake, Takahiro Inagaki, Kazuaki Togawa, Yujong Kim, Hideo Kitamura,
Tetsuya Ishikawa, Takashi Tanaka, Toru Hara (RIKEN); Hiroshi Matsumoto (KEK)*

The SPring-8 Compact SASE Source (SCSS), started in 2001, aims to generate coherent soft-X-ray beam at 3.6 nm with 1-GeV beam energy. SCSS has several unique designs that make the system compact: (1) a high-gradient 40-MV/m C-band rf system as the main accelerator, (2) a short-period 15-mm undulator of in-vacuum design, and (3) a pulsed high-voltage gun using a single crystal cathode to generate low emittance beam. The current status of the project will be reported.

TH-O-01

Overview of Proposed VUV and Soft X-Ray Projects in the World

Giuseppe Dattoli, Alberto Renieri (ENEA)

The status of the art of the VUV-X ray FEL sources, the limit of the relevant technologies and the future perspectives are analysed. Possible strategies aimed at developing the design of a road map toward very short wavelengths, very high brilliance and very short pulses are discussed. Within such a framework we report and comment on the proposed devices.

TH-O-02

A Cascaded Optical Klystron on an Energy Recovery Linac - Race Track Microtron

Mikael Eriksson, Lars-Johan Lindgren, Erik Wallén, Sverker Werin (MAXLab)

We propose a device generating coherent radiation down in the Ångström region, sub-ps pulses, and CW in a relatively compact set-up. By placing a cascaded optical klystron (OK) in the return path of a Race Track Microtron (RTM) and utilising the fact that there are electron bunches with different energies present at the same time, harmonic generation can be performed in several stages in parallel. A 4-stage OK can generate Ångström radiation from a 212-nm seed laser. The demands on the electron optics are severe, but if realised, an RTM with an Energy Recovery Linac will give the possibility of CW operation. The layout of a possible facility is presented and the basic concepts are discussed.

TH-O-03

The MIT Bates X-Ray Laser Project

Townsend Zwart (MIT)

MIT and the Bates Laboratory are exploring the construction of a SASE based x-ray laser facility. As expected, the facility would provide x-ray beams with peak brilliance some eight orders or so greater than are presently available at today's synchrotron sources. This facility would span the wavelength range between 100 and 0.5 nm in the fundamental, move into the hard x-ray regime in the third harmonic, and preserve the possibility of an upgrade to even shorter wavelengths. The complex would include a high brightness electron gun, a 3-4 GeV electron linac, and would support multiple undulators and x-ray beamlines. Preliminary design considerations for such a facility are being prepared as part of a three-year design study.

TH-O-04

X-ray Optics Research for Free Electron Lasers: Study of Material Damage under Extreme Fluxes*

Jaroslav Kuba, Alan Wootton, Richard M. Bionta, Ronnie Shepherd (LLNL); Ernst E. Fill (Max-Planck Institut fur Quantenoptik, D-85748 Garching, Germany); Todd Ditmire, Gilliss Dyer (Univ. of Texas, Austin); James Dunn, Raymond F. Smith, Richard A. London, Vyacheslav N. Shlyaptsev, Sasa Bajt, Michael D. Fajt, Rick Levesque (LLNL)

Free electron lasers operating in the 0.1- to 1.5-nm wavelength have been proposed for the Stanford Linear Accelerator Center. The unprecedented brightness and associated fluence (up to 30 J cm^{-2}) predicted for pulses < 300 fs pose new challenges for optical components. A criterion for optical component design is required, implying an understanding of x-ray/material interactions at these extreme conditions. In our experimental effort, the extreme conditions are simulated by the currently available sources ranging from optical lasers, through x-ray lasers (at 14.7 nm) down to K-alpha sources (~0.15 nm). In this paper we present an overview of the computer modeling and preliminary results from both the COMET tabletop high brightness ps x-ray laser and a K-alpha experimental campaign carried out at the JanUSP laser facility at Lawrence Livermore National Laboratory.

* This work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under contract No. W-7405-ENG-48.

WS-O-01

Ultrasensitive Gas Phase IR Photodissociation Spectroscopy by Using an FTICR Ion Trap Coupled to a Free Electron Laser

Philippe Maître, Sophie Le Caër, Aude Simon, Joël Lemaire, Hélène Mestdagh, Michel Heninger, Gérard Mauclaire, Pierre Boissel (LCP); Jean-Michel Ortega, Rui Prazeres, François Glotin (CLIO-LURE)

We present the first example of a direct structural characterisation of polyatomic ions by coupling a Fourier Transform Ion Cyclotron Resonance Mass Spectrometer (FTICR-MS) with an infrared free electron laser (FEL). Ultrasensitive measurements of the infrared vibrational spectra of ionic reactive intermediate selectively prepared is allowed by the association of the high peak power of the FEL, its wide tunability, and the flexibility of FTICR-MS, where several mass selection and ion reaction steps can be combined. These possibilities are demonstrated in the case of Fe cation complexes of hydrocarbons, where the photofragment ($FeC_4H_6^+$) differs with the parent ion $FeC_4H_8^+$ by only two mass units. The resulting infrared spectrum is satisfactorily predicted by *ab initio* electronic structure calculations.

WS-O-02

Coulomb Explosion of Rare Gas Clusters Irradiated by Intense VUV Pulses of a Free Electron Laser

T. Laarmann, H. Wabnitz, P. Gürtler, A. R. B. de Castro, R. Döhrmann, W. Laasch, J. Schulz, A. Swiderski, T. Möller, L. Bittner, B. Faatz, A. Fateev, J. Feldhaus, C. Gerth, U. Hahn, E. Saldin, E. Schneidmiller, K. Sytdev, K. Tiedtke, R. Treusch, M. Yurkov (DESY-Hamburg)

This contribution reports on initial results of the interaction of intense VUV pulses with clusters. So far, all work with intense pulses was restricted to the visible and infrared spectral range. Very recently the free electron laser (FEL) at DESY/Hamburg has reached a gain of $\sim 10^6$ and provides gigawatt pulses of $\sim$ 100 fs length below 100 nm wavelength [1]. This wavelength regime is particularly interesting because the photon energy of 12.4 eV is above the ionisation threshold of a large number of atoms, molecules, and clusters. Rare gas clusters were irradiated with focused FEL radiation with a power density of up to 10^{14} W/cm^2. Multiple ionisation of clusters is observed, which leads to Coulomb explosion.

[1] V. Ayvazyan et al., Phys. Rev. Lett. 88, 104802 (2002).

WS-O-03

Interaction of Intense, Femtosecond Soft X-ray Pulses with Solids: Desorption, Ablation and Plasma Formation by TTF FEL SASE Radiation

Jacek Krzywinski (Polish Academy of Science); Ryszard Sobierajski (Warsaw Univ. of Technology); Andrzej Andrejczuk, Marek Jurek (Polish Academy of Science); Bart Faatz (DESY - Hamburg); Anna Kauch (Warsaw Univ.); Jerzy B Pelka (Polish Academy of Science); Evgueni Saldin, Evgueni Schneidmiller (DESY - Hamburg); Marcin Sikora (Univ. of Mining and Metallurgy); Josef Feldhaus, Rolf Treusch (DESY - Hamburg)

For the first time interaction of ultrashort (~50 fs), high-intensity VUV ($\lambda \sim 85$ nm) pulses with solid targets has been experimentally investigated. Experiments were carried out at different intensity levels (10^{11}-10^{14} W/cm^2). Ions and clusters of atoms leaving the irradiated samples have been detected and analysed with respect to their masses, energies, and charge states. Desorption, ablation, and creation of plasma have been studied for different materials (insulators, semiconductors, and metals). Emission of small clusters at lower intensities has been often observed. At high intensities creation of plasma and multiple ionisation (charge states up to 5) occurs. Kinetic energy of ions increases with charge state and reaches keV range for highly charged ions. Experimental results will be presented. The role of nonthermal processes in the interaction of intense VUV radiation with matter will be evaluated.

WS-O-04

Novel Process of Isotope Separation of Silicon by Use of IR FEL

Keiji Nomaru (SUT); Andrei V. Chernyshev, Alexandr K. Petrov (Institute of Chemical Kinetics and Combustions); Haruo Kuroda (SUT)

Isotopically pure silicon is expected to be useful for future electronic devices. An infrared free electron laser (IR FEL) is an ideal light source for studying isotope separation utilizing the multiphoton dissociation of gaseous molecules. Attempts at silicon isotope separation by use of IR FEL have been reported by several authors. But Si_2F_6 has been the only working substance used in this kind of study. This seems to be not a good choice of working substance because Si_2F_6 contains two silicon atoms in a molecule. We systematically investigated the possibility of utilizing SiF_4 derivatives for the isotope separation by use of the IR FEL light beam and found that the isotope separation of Si could be very effectively performed when mono-phenyl derivative of SiF_4 was used as the working substance. The chemical processes following the multiphoton dissociation of this molecule yields gaseous SiF_4 and solid powders of the by-product substances. By tuning the frequency of the IR FEL at 935 cm^{-1}, the ^{28}Si has successfully been enriched in the residual working substance up to above 98%. Further, the enrichment of the minority isotopes ^{29}Si and ^{30}Si also can be done by tuning the frequency of the IR FEL at 965 cm^{-1}. This finding will open the possibility of establishing a new and effective isotope separation process for silicon.

WS-O-05

Ultrafast and Nonlinear Spectroscopy of Semiconductors with Small Energy Photons

Junichiro Kono (Rice University)

This talk will review our recent experiments on bulk and quantum-confined semiconductors using intense, coherent, and tunable mid-infrared (MIR) and far-infrared (FIR) radiation from free-electron lasers (FELs) and optical parametric amplifiers (OPAs). These experiments include: THz sideband generation [1], FIR spectroscopy of transient plasmas and magneto-plasmas [2], picosecond time-resolved cyclotron resonance [3,4], the dynamical Franz-Keldysh effect [5], MIR high-order multiple-photon processes [6,7], and ionization dynamics of quantum well excitons [8]. Most of these experiments were carried out by using a synchronized FEL/Ti:Sapphire system, which allowed us to couple with intra- and inter-band transitions simultaneously. Some of the nonlinear optical experiments were made possible by taking advantage of the small-energy (or long-wavelength) photons, which help minimize interband absorption and sample damage while employing the low dispersion existing at longer wavelengths and maximizing the ponderomotive potential.

[1] M. A. Zudov, J. Kono, A. P. Mitchell, and A. H. Chin, Phys. Rev. B - Rapid Commun. 64, 121204 (2001).
[2] M. A. Zudov, A. P. Mitchell, A. H. Chin, and J. Kono, unpublished.
[3] J. Kono, A. H. Chin, A. P. Mitchell, T. Takahashi, and H. Akiyama, Appl. Phys. Lett. 75, 1119 (1999).
[4] G. A. Khodaparast, D. C. Larrabee, J. Kono, D. S. King, S. J. Chung, and M. B. Santos, submitted to Phys. Rev. B.
[5] A. H. Chin, J. M. Bakker, and J. Kono, Phys. Rev. Lett. 85, 3293 (2000).
[6] A. H. Chin, O. G. Calderón, and J. Kono, Phys. Rev. Lett. 86, 3292 (2001).
[7] O. G. Calderón, A. H. Chin, and J. Kono, Phys. Rev. A 63, 053807 (2001).
[8] A. H. Chin, J. Kono, and G. S. Solomon, Phys. Rev. B - Rapid Commun. 65, 121307 (2002).

WS-O-06

Pump/Probe Experiments with FEL and SR Pulses at UVSOR

Masahito Hosaka, Tatsuo Gejo, Eiji Shigemasa, Eiken Nakamura, Akira Mochihashi, Masahiro Katoh, Jun-ichiro Yamazaki, Kenji Hayashi, Yoshifumi Takashima (Institute for Molecular Science); Shigeru Koda (Saga University); Hiroyuki Hama (TohokuU)

Storage Ring Free Electron Laser (SRFEL or FEL) has been developed as a powerful light source owing to its high power, high coherence, and unique temporal feature. At UVSOR, we have carried out the two-photon double-resonant excitation on Xe atoms, utilizing a SR pulse as a pump and an FEL pulse as a probe light. In the first experiment, the two-photon double-resonant excitation of the Xe* $5p^5nf$ autoionization states using the combination of FEL around 570 nm and the undulator radiation have been demonstrated. We are planning to carry out similar experiments in the shorter wavelength region (around 400 nm) of FEL, where higher Rydberg series of the Xe* $5p^5nf$ states via the Xe* $5p^55d$ intermediate state are accessible. In the presentation, the latest experimental result will be reported.

WS-O-07

Resonant Desorption of Small Molecules from Surfaces

Britta Redlich (FOM and Westfälische Wilhelms-Universität Münster); Helmut Zacharias (Westfälische Wilhelms-Universität Münster); Boris Sartakov (RAS); Gerard Meijer, Gert von Helden (FOM)

In this study, the infrared laser induced desorption of small molecules from insulator surfaces is examined. A selective excitation of a specific internal or external vibration is desirable to gain insight in the energy flow within the adsorbed layer, and its coupling to the substrate as well as to the desorption coordinate. Most ideally, this excitation of the molecule occurs resonantly, requiring a widely tunable laser system. The Free Electron Laser for Infrared eXperiments (FELIX), with a tuning range from 3-250 μm, is uniquely suited for this kind of experiment.

First experiments demonstrate the feasibility to perform such measurements using FELIX. The desorption induced by resonant excitation of intramolecular vibrations of small molecules (like e.g., CO, CH_4, CD_3F and N_2O) condensed on the NaCl(100) single-crystal surface is studied. For the systems under study desorption is observed after resonant excitation of different internal vibrational modes of the molecule. The observed wavelength dependence is in agreement with that found in linear absorption spectroscopy, and unambiguously demonstrates the resonant character of the underlying desorption process. Analysis of the time-of-flight spectra yields translational temperatures well above the substrate temperature. Implications for the excitation and desorption mechanism are discussed, and results of model calculations of the desorption process will be presented.

WS-O-08

Threshold Time-Resolved Surface Magnetometry of Low-Dimensional Systems

Herve Cruguel, Marsi Marino (ELETTRA); Sirotti Fausto (LURE)

The magnetization reversal process is essential to magnetic recording technology. The advancement in these fields motivates research in magnetization reversal at very short time scales below the nanosecond level on artificial structures of reduced lateral dimensions to increase the recording density. In high data rate magnetic recording, for instance, the data rate approaches 60 MB/s and thus magnetization reversal is induced on the ns time scale. Recording media magnetic properties are based on thin films, multi-layers, and small particles systems because of the significant difference to bulk behavior.

A surface science approach based on a Mott scattering experiment detecting the spin polarization of electrons emitted at photoemission threshold is well adapted to the study properties of low-dimensional surface and interface systems. The time structure and the tunabilty in threshold photoemission of the Elettra Free Electron Laser will be used in the frame of the EUFELE project [1] to study surface magnetization dynamics in the 10 picosecond time scale and with micron lateral resolution.

I will present the project started at the end of 2001 and the first results obtained at threshold using the experiment now installed on the FEL beamline at Elettra. The principle of the technique will be introduced with experiments we performed on iron nanoclusters using the SuperACO experimental setup [2] operated in the same time-resolved mode.

[1] Eufele, HPRI-CT-2001-50025.
[2] F. Sirotti et al., Phys. Rev. B61, Vol. 14, R9221-R9224 (2000).

WS-O-09

Femtosecond Magnetism with the BESSY SASE FEL

Florian Kronast, Hermann A. Dürr, Wolfgang Eberhardt (BESSY)

Magnetism is a collective phenomenon involving correlated electrons. The relevant interactions in magnetic solids such as exchange, spin-orbit, and electron-phonon coupling are of various strength and lead to different characteristic time scales for energy transfer between orbital, spin, and lattice degrees of freedom. Presently pump-probe experiments using optical fs-lasers offer the only possibilities to investigate the ultra-fast spin dynamics following a fs excitation of the electronic system. Such studies are of direct relevance for establishing the ultimate time scale for magnetic switching in future data storage devices. The availability in the near future of fs soft x-ray pulses offering element and orbital sensitivity is expected to revolutionize this field. We will give an overview of anticipated experiments at the proposed BESSY SASE free electron laser.

WS-O-10

Status Report and Biomedical Applications of the Institute of FEL, Osaka University

Kunio Awazu, Manabu Heya, Makoto Asakawa, Natsuro Tsubouchi, Hiroshi Horiike (Osaka University)

A linac-driven Free Electron Laser (FEL) system covering a wide range of wavelengths from ultraviolet to infrared has been transferred from the Free Electron Laser Research Institute, Inc (FELI) to the Institute of Free Electron Laser (IFEL), Osaka University in 2000. At present, the width of the macropulses is still about 15 μs and the repetition rate is 10 Hz. The separation between micropulses is 45 ns. The width of the micropulses is estimated to be shorter than the bunch length of the electron beam, which has been measured to be 10 ps in the accelerator operation condition for the mid-IR range. The peak power of a micropulse is on the order of MW. Although the peak power is very high, the duty factor is as low as 3×10^{-8}. Thus, the average power is very low (20-50 mW), and the influence of thermal effects is avoided in power transmission. The tunability and short pulse structure of the FEL have afforded new applications in such areas as biotechnology and semiconductors. Especially the FEL can find users in medical science, in procedures like cutting tissues or proteins by photothermal effect, ablating hard tissues by photomechanical effect, and also modifying surfaces by photochemical effect. In this talk, some application topics and projects in our institute are presented.

WS-O-11

The LCLS: Short X-Ray Pulses Open a Window for New Scientific Opportunities

J. B. Hastings (SSRL/SLAC)

X-rays have contributed in no small measure to our understanding of the equilibrium structure of matter with atomic resolution. They provide a probe that is sensitive to electron density variations at the Ångstrom-length scale, appropriate for studying the structures of gases, liquids, and amorphous and crystalline solids. X-rays from synchrotron sources are now being used to study not only static structures, but also equilibrium dynamics, complementing and extending the capabilities of the traditional dynamical probes: light scattering and neutron scattering. The new x-ray free-electron lasers hold the promise to extend the role of x-rays to understand the static and dynamic behavior of matter at the Ångstrom-length scale. With their high intensity and subpicosecond pulse length, x-ray FELs such as the LCLS at Stanford could be used to determine the structures of single biomolecules and small aggregates, study the nonequilibrium dynamics of chemical reactions, probe the structure and dynamics of warm dense matter (the state of matter in the core of large planets and cool stars), and study the equilibrium dynamics of polymers. The opportunities afforded by LCLS will be presented with an emphasis on the unique source characteristics that will make these studies possible.

WS-O-12

Two-Color Experiments in Protein Dynamics

Robert Austin (Princeton University); Aihua Xie (Oklahoma State University);
Lex van der Meer (FOM); Fred Dylla, Michelle Shinn (TJNAF)

We will discuss two-color pump/probe experiments done at FELIX and our plans to develop a related series of experiments at TJNAF. The FELIX experiments use a ps/fs visible pump pulse synchronized to the IR and FIR output of FELIX and explore the evolution of the electronic excitation energy in a protein chromophore into the collective modes of a protein. The TJNAF part will discuss preliminary experiments there and plans for experiments as the upgrade is commissioned, using the UV and IR beamlines, and the THZ radiation used as a probe.

FR-O-01

Science with Soft X-ray Free Electron Lasers

Wolfgang Eberhardt, BESSY

In the talk a brief overview over the basic design and performance parameters for the soft x-ray FELs being planned worldwide will be presented. Based on the expected performance of such devices, the future scientific opportunities emerging from the availability of such instruments will be discussed. The combination of femtosecond time structure, high brightness, high power and full transverse coherence over a large energy range in the VUV and soft x-ray region allows to address new scientific questions in many areas of physics, chemistry, biology, medicine and materials science. In many cases, entirely new experiments will become possible. Examples such as "femtochemistry", "electronic structure of clusters and complex materials", "magnetization dynamics on the nanometer scale", "dynamics of biological systems", and "coherent scattering and imaging" will be discussed.

FR-O-02

Status of the Jefferson Lab IR/UV High Average Power Light Source*

George R. Neil, S. V. Benson, G. Biallas, J. Boyce, L. A. Dillon-Townes, D. Douglas, H. F. Dylla, R. Evans, A. Grippo, D. Gruber, J. Gubeli, C. Garcia-Hernandez, K. Jordan, M. Kelley, G. Krafft, R. Li, L. Merminga, J. Mammosser, J. Preble, M. Shinn, T. Siggins, R. Walker, G. Williarms, B. Yunn, S. Zhang (TJNAF)

Jefferson Lab is in the process of building an upgrade to our Free-Electron Laser Facility with broad wavelength range and timing flexibility. The facility will have two CW free-electron lasers, one in the infrared operating from 1 to 14 microns [1] and one in the UV/VIS operating from 0.25 to 1 micron. In addition, there will be beamlines for Thompson-backscattered femtosecond X-rays and broadband THz radiation. The average power levels for each of these devices will exceed any other available sources by at least two orders of magnitude. Timing of the available laser pulses can be continuously mode-locked at at least four different repetition rates or in macropulse mode with pulses of a few microseconds in duration with a repetition rate of many kHz. The status of the construction of this facility and a review of its capabilities will be presented.

*This work supported by the Office of Naval Research, the Joint Technology Office, the Commonwealth of Virginia, the Air Force Research Laboratory, and by DOE Contract DE-AC05-84ER40150.

[1] D. Douglas et al., Proceedings of the 2001 Particle Accelerator Conference, Chicago, IL, 249 (2001).

FR-O-03

Demonstration of Gain Saturation and Controlled Variation of Pulse Length at the TESLA Test Facility FEL

Jörg Rossbach (DESY-Hamburg)

We report on experimental evidence that the free-electron laser at the TESLA Test Facility has reached the maximum power gain of 10^7 while operating in the self-amplified spontaneous emission mode. Following the request of first scientific users, the TTF FEL has been tuned in the wavelength range between 80 and 120 nm (vacuum ultraviolet, VUV), and saturation has been achieved in this entire wavelength range. At saturation the FEL emits short pulses with GW peak power and a high degree of transverse coherence. Also, the paper reports on the demonstration of controlled pulse-length variation between 30 fs and 100 fs and on detailed intensity fluctuation studies in this operation mode.

FR-O-04

Table-Top Soft X-Ray Lasers Based on Capillary Discharges

J. J. Rocca, E. Hammersten, J. Filevich, A. Rahman, B. Luther, E. Jankovska, M. Grisham, M. C. Marconi (Colorado State University);V. N. Shlyaptsev (University of California, Davis)

Significant progress has been achieved in the past several years in the development of compact soft x-ray lasers. A table-top discharge-pumped soft x-ray laser operating at a wavelength of 46.9 nm achieved gain saturation in 1996, and compact saturated laser-pumped soft x-ray lasers followed soon after. In this talk we review the recent progress in the development and utilization of compact soft x-ray lasers with emphasis on discharge-pumped devices. High repetition rate soft x-ray lasers based on capillary discharge excitation have demonstrated average powers of several mW, millijoule-level pulse energy, peak spectral brightness several orders of magnitude larger than a synchrotron beam line, and excellent spatial coherence. Results of the use of a capillary discharge soft x-ray laser in dense plasma diagnostics, soft x-ray reflectometry for the determination of optical constants, characterization of diffraction gratings, laser ablation of materials, and plasma generation will be described.