

Laser system design for table-top X-ray light source

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Abstract

We present possible conceptual designs of a laser system for driving table-top free-electron lasers based on terahertz acceleration. After discussing the achievable performances of laser amplifiers with Yb:YAG at cryogenic and room temperature and Yb:YLF at cryogenic temperature, we present amplification modules with available results and concepts of amplifier chains based on these laser media. Their performances are discussed in light of the specifications for the tasks within the table-top light source. Technical and engineering challenges, such as cooling, control, synchronization and diagnostics, are outlined. These concepts for the laser layout feeding the accelerator are eventually derived and presented.

Keywords: concept; free-electron laser; lasers; optics

1. Introduction

Several laser facilities for strong-field physics experiments such as generation of attosecond pulses^[1], electron acceleration^[2], proton acceleration^[3, 4] or X-ray generation^[5], have been or are currently being built around the world. These facilities contribute to numerous advances in science, including physics, chemistry, biology, medicine and material science. Their development constantly faces technological and engineering challenges to reach the desired peak power, pulse energy, average power and lifetime.

The ‘table-top’ free-electron laser (FEL) powered by terahertz (THz) radiation proposed in the project ANSIS (Frontiers in attosecond X-ray science: imaging and spectroscopy) in 2016^[6] is part of the current intense research on alternative technologies to traditional, radio frequency (RF) based FELs^[7–8], which are very powerful but complex, large and expensive structures. These devices are thus few in number, resulting in very high demand and very limited access. The scientific community greatly benefits from alternative light sources with reduced size, cost and infrastructure needs. This demand has instigated extensive research efforts aiming

the realization of ‘table-top’ light sources^[9–12]. Nonetheless, all the proposed solutions, either directly or indirectly, take advantage from the recent progress in high-energy optical lasers, which are complex facilities.

Building an X-ray light source or other types of light sources entirely based on optical lasers requires a system capable of producing a multitude of diverse laser beams with various characteristics like center wavelength, spectrum, pulse duration and energy to serve as both drivers and diagnostic tools. In particular, for the ANSIS project, ultra-short ultraviolet (UV) pulses are required for electron generation, multiple beams of high-energy picosecond pulses are required for single-cycle THz generation and high-energy nanosecond (ns) pulses, with tailorable, tunable spectral and temporal profiles, are required for multi-cycle THz generation. In addition, the facility should run at high repetition rates with femtosecond level synchronization and stabilization. Such a system is highly complex and requires a combination of different laser technologies, some of which must be developed or customized. The right choice of technologies is crucial to its successful implementation and operation.

In this paper, we will first present the ANSIS project and derive the requirements of the driving laser system. Second, the available laser technologies will be reviewed. The third

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Symmetry Teen-Hang Meen, Charles Tijus, Jih-Fu Tu, 2020-12-15 The International Institute of Knowledge Innovation and Invention IIKII <http://www.iikii.org> promotes the exchange of innovations and inventions and establishes a communication platform for international innovations and research. In 2019 IIKII cooperates with the IEEE Tainan Section Sensors Council to hold IEEE conferences such as IEEE ICIASE 2019 IEEE ECBIOS 2019 IEEE ICKII 2019 ICUSA GAME 2019 and IEEE ECICE 2019. This Special Issue entitled *Selected Papers from IIKII 2019 conferences* aims to showcase outstanding papers from IIKII 2019 conferences including symmetry in physics, chemistry, biology, mathematics, and computer science etc. It selected 21 outstanding papers from 750 papers presented in IIKII 2019 conferences on the topic of symmetry. The main goals of this Special Issue are to encourage scientists to publish their experimental and theoretical results in as much detail as possible and to discover new scientific knowledge relevant to the topic of symmetry.

Lasers Charles Blain, 2002. Developments in lasers continue to enable progress in many areas such as eye surgery, the recording industry, and dozens of others. This book presents citations from the book literature for the last 25 years and groups them for ease of access, which is also provided by subject author and titles indexes.

Topics On Chaotic Systems: Selected Papers From Chaos 2008 International Conference Christos H Skiadas, Ioannis Dimotikalis, Charilaos Skiadas, 2009-05-13. This volume includes the best papers presented at the CHAOS 2008 International Conference on Chaotic Modeling, Simulation, and Applications. It provides a valuable collection of new ideas, methods, and techniques in the field of nonlinear dynamics, chaos, fractals, and their applications in general science and in engineering sciences. It touches on many fields such as chaos, dynamical systems, nonlinear systems, fractals, and chaotic attractors. It also covers mechanics, hydrofluid dynamics, chaos in meteorology and cosmology, Hamiltonian and quantum chaos, chaos in biology and genetics, chaotic control, and chaos in economy and markets, and chaotic simulations, thus containing cutting edge interdisciplinary research with high interest applications. These contributions present new solutions by analyzing the relevant data and through the use of recent advances in different fields, especially in chaotic simulation methods and techniques.

Selected papers from the 2019 IEEE International Workshop on Metrology for AeroSpace Pasquale Daponte, Eulalia Balestrieri, 2021-04-21. This book is devoted to recent developments of instrumentation and measurement techniques applied to the aerospace field. It includes 23 selected papers from the 2019 IEEE International Workshop on Metrology for AeroSpace. Measurements are essential for obtaining a deeper knowledge of a phenomenon or an asset, as well as for making proper decisions and proposing new and efficient solutions, and this is especially true in environments as complex as aerospace. The research contributions included in the book can raise the interest of a wide group of researchers, operators, and decision makers from metrology and aerospace fields by presenting the most innovative solutions in this field from the scientific and technological points of view.

Analysis, Design and Evaluation of Man-Machine

Systems 1988 J. Ranta, 2014-06-28 This volume provides a state of the art review of the development and future use of man machine systems in all aspects of business and industry The papers cover such topics as human computer interaction system design and the impact of automation in general and also by the use of case studies describe a wide range of applications in such areas as office automation transportation power plants machinery and manufacturing processes and defence systems Contains 73 papers *Fundamentals of Electro-Optic Systems Design* Sherman Karp, Larry B. Stotts, 2013 Presents practical electro optical applications in the context of the fundamental principles of communication theory thermodynamics information theory and propagation theory Combining systems issues with fundamentals of communications this is an essential reference for all practising engineers and academic researchers in optical engineering Nonlinear Control Systems Design 1989 A. Isidori, 2014-05-23 In the last two decades the development of specific methodologies for the control of systems described by nonlinear mathematical models has attracted an ever increasing interest New breakthroughs have occurred which have aided the design of nonlinear control systems However there are still limitations which must be understood some of which were addressed at the IFAC Symposium in Capri The emphasis was on the methodological developments although a number of the papers were concerned with the presentation of applications of nonlinear design philosophies to actual control problems in chemical electrical and mechanical engineering *Proceedings of SAE-China Congress 2014: Selected Papers* Society of Automotive Engineers, 2014-12-19 These Proceedings gather outstanding papers submitted to the 2014 SAE China Congress the majority of which are from China the most dynamic car market in the world The book covers a wide range of automotive topics presenting the latest technical achievements in the industry Many of the approaches it presents can help technicians to solve the practical problems that most affect their daily work **Selected Works of Professor Herbert Kroemer** C. K. Maiti, 2008 Information technology has changed our society radically Just as the integrated circuits have been the prime mover for electronics high speed transistors and semiconductor lasers based on heterostructures are now playing the same role in modern telecommunications Professor Kroemer s conceptual work on heterostructures began in the early 1950s as he was looking for a way to improve transistor speed and performance In the 1960s he applied the same principles to the development of lasers and light emitting diodes showing that they could achieve continuous operation at room temperature OCo something thought impossible at that time His deep fundamental scientific work has had a profound effect on technology and society transforming and improving our lives This reprint collection brings together Professor Kroemer s most important papers presenting a comprehensive perspective of the field It covers topics ranging from substrate materials electronic properties process technology and devices to circuits and applications This reprint collection will help the reader identify the key stages in the development of heterostructure devices and lasers from early research through to its integration in current manufacturing Devoted to R D engineers and scientists who are actively involved in extending the nano and microelectronics roadmap mainly via heterostructure engineering this volume may also

serve as a reference for postgraduate and research students

High-resolution Seafloor Survey and Applications Ziyin Wu, Fanlin Yang, Yong Tang, 2020-12-07 This book focuses on the survey technology post processing technology mapping technology and scientific application of the submarine topography and geomorphology in detail High resolution submarine geomorphology is a frontier branch of marine geology and marine surveying and mapping which provides a direct basis to study the seabed surface to understand the tectonic movement and submarine evolution In the past two decades high resolution submarine geomorphology with high precision multi beam echo sounding side scan sonar and sub bottom profiler as the major techniques is developing very quickly and is one of the frontiers of international marine science and technology These high techniques promote the traditional submarine geomorphology to high resolution and quantitative research At present high resolution submarine geomorphology is widely used in the delimitation of the continental shelf the international seabed resources survey marine engineering and marine military applications In order to facilitate readers to understand how to acquire and apply scientific research based on submarine topographic data it highlights the combination of theory technology and scientific application This book is useful as a reference for professional and technical personnel in related fields and also as a textbook for both graduate and undergraduate students as well

Advances In Information Storage Systems: Selected Papers From The International Conference On Micromechatronics For Information And Precision Equipment (Mipe '97) (Volumes 9 & 10) Bharat Bhushan, Kyosuke Ono, 1999-01-04 Advances in Information Storage Systems AISS volumes 9 10 are special volumes which contain selected papers regarding not only information storage but also information equipment in general and related technologies The papers were presented at the International Conference on Micromechatronics for Information and Precision Equipment MIPE 97 MIPE 97 was held in Tokyo Japan from 20 to 23 July 1997 as one of the memorial events of the Centennial Grand Congress of the Japan Society of Mechanical Engineers Information and precision equipment is fast changing high technology and is necessary for the development of an international multimedia society and essential for the innovation of conventional machines as well as the creation of new sophisticated machines for future medical biological and cosmic industries in the 21st century Information and precision equipment can improve their performances by analyzing designing fabricating controlling and then utilizing a smaller and smaller world in space and time Micromechatronics is not only a major interdisciplinary engineering but also the principle of innovation in such machines In the light of this the scope of MIPE 97 ranged from the micromechanics and micromechatronics of information storage input output devices and precision equipment to microtechnologies related to information equipment The papers in AISS special volumes are mainly related to information storage particularly magnetic recording storage But some of them are related to printer paper feeding mechanism and micromachine technologies which will directly or indirectly contribute future information devices The papers contained in this series are of international archival quality and are refereed according to rigorous journal standards Volume 9 contains papers on the mechanics and

tribology of magnetic recording storage systems mainly hard disk drives while papers on the micromechatronics of the head positioning system in magnetic disk storage are compiled in Volume 10 together with papers on optical disk storage and others *Technology for Large Space Systems*, 1983

Introduction to Instrumentation and Measurements Robert B. Northrop, 2005-06-28 Knowledge of instrumentation is critical in light of the highly sensitive and precise requirements of modern processes and systems Rapid development in instrumentation technology coupled with the adoption of new standards makes a firm up to date foundation of knowledge more important than ever in most science and engineering fields Understanding this Robert B Northrop produced the best selling Introduction to Instrumentation and Measurements in 1997 The second edition continues to provide in depth coverage of a wide array of modern instrumentation and measurement topics updated to reflect advances in the field See What's New in the Second Edition Anderson Current Loop technology Design of optical polarimeters and their applications Photonic measurements with photomultipliers and channel plate photon sensors Sensing of gas phase analytes electronic noses Using the Sagnac effect to measure vehicle angular velocity Micromachined vibrating mass and vibrating disk rate gyros Analysis of the Humphrey air jet gyro Micromachined IC accelerometers GPS and modifications made to improve accuracy Substance detection using photons Sections on dithering delta sigma ADCs data acquisition cards the USB and virtual instruments and PXI systems Based on Northrop's 40 years of experience Introduction to Instrumentation and Measurements Second Edition is unequalled in its depth and breadth of coverage

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Program Solicitation, 2002 *Scientific and Technical Aerospace Reports*, 1992-11

Encyclopedia of Optical Engineering: Las-Pho, pages 1025-2048 Ronald G. Driggers, 2003 Compiled by 330 of the most widely respected names in the electro optical sciences the Encyclopedia is destined to serve as the premiere guide in the field with nearly 2000 figures 560 photographs 260 tables and 3800 equations From astronomy to x ray optics this reference contains more than 230 vivid entries examining the most intriguing technological advances and perspectives from distinguished professionals around the globe The contributors have selected topics of utmost importance in areas including digital image enhancement biological modeling biomedical spectroscopy and ocean optics providing thorough coverage of recent applications in this continually expanding field

Applied Mechanics Reviews, 1985 *Geophysical Abstracts*, 1970

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