

Nonlinear Optics of Semiconductor Lasers

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Nonlinear Optics Of Semiconductor Lasers

Jianquan Yao, Yuyue Wang



Nonlinear Optics Of Semiconductor Lasers:

The Nonlinear Optics of Semiconductor Lasers Nikolai Gennadievich Basov, 1987 Nonlinear Optics Of Semiconductor Lasers **Nonlinear Optics and Dynamics in Semiconductor Lasers**, 1994 Semiconductor laser output characteristics including output spectra and dynamics are strongly influenced by nonlinear optical interactions Theory and experiments are combined to show that a single mode model of laser dynamics gives a consistent and quantitatively accurate description of the noise and optical interaction characteristics of a quantum well laser diode The nonlinear optical interaction between the oscillating field of a semiconductor laser and a weak optical probe can be used to determine key dynamical characteristics of the laser With these characteristics known the noise spectra of a free running semiconductor laser can be quantitatively modeled When a stronger optical probe is injected into the laser diode we observe nonlinear dynamics including deterministic chaos which can be understood with the single mode model The model and experimental techniques used here are applicable to a wide variety of semiconductor lasers Nonlinear Photonics in Mid-infrared Quantum Cascade Lasers Louise Jumpertz, 2017-08-31 This thesis presents the first comprehensive analysis of quantum cascade laser nonlinear dynamics and includes the first observation of a temporal chaotic behavior in quantum cascade lasers It also provides the first analysis of optical instabilities in the mid infrared range Mid infrared quantum cascade lasers are unipolar semiconductor lasers which have become widely used in applications such as gas spectroscopy free space communications or optical countermeasures Applying external perturbations such as optical feedback or optical injection leads to a strong modification of the quantum cascade laser properties Optical feedback impacts the static properties of mid infrared Fabry Perot and distributed feedback quantum cascade lasers inducing power increase threshold reduction modification of the optical spectrum which can become either single or multimode and enhanced beam quality in broad area transverse multimode lasers It also leads to a different dynamical behavior and a quantum cascade laser subject to optical feedback can oscillate periodically or even become chaotic A quantum cascade laser under external control could therefore be a source with enhanced properties for the usual mid infrared applications but could also address new applications such as tunable photonic oscillators extreme events generators chaotic Light Detection and Ranging LIDAR chaos based secured communications or unpredictable countermeasures *Nonlinear Optics and Nonlinear Dynamics in Semiconductor Lasers Subject to External Optical Injection*, 2000 This Phase II SBIR effort investigates novel output characteristics of semiconductor lasers that can be induced by external optical injection Specific interest is in characteristics relevant to the control of microwave and millimeter wave electronics through enhanced modulation characteristics characterization of vertical cavity surface emitting laser VCSEL arrays and analysis of chaotic dynamics that can be induced by optical injection Under external optical injection all semiconductor lasers tested conventional edge emitting Fabry Perot laser diodes VCSELs and distributed feedback DFB laser diodes exhibited periodic oscillation of the optical power due to an instability in the

coupling between the circulating optical field and the semiconductor gain medium The instability could be locked to a microwave reference by simultaneously injecting a weak modulation current at the appropriate frequency i e double locking to both microwave and optical references Phase locked operation with sub Hz linewidth and 125 dBc Hz residual phase noise was measured values that compare favorably with other published reports A compact configuration using relatively inexpensive optical components was demonstrated All laser types could be accurately modeled using a lumped element coupled equation model for the circulating optical field and free carrier density The model showed good agreement with a mapping of the types of nonlinear dynamics observed experimentally

Nonlinear Optics of Circular-grating

Distributed-feedback Semiconductor Lasers (PHD). Keith John Kasunic,1997 *Optical Nonlinearities and Instabilities in Semiconductors* Hartmut Haug,2012-12-02 *Optical Nonlinearities and Instabilities in Semiconductors* deals with various aspects of nonlinear optical phenomena and related optical instabilities in semiconductors Measurements and explanations of the optical nonlinearities of various semiconductor materials and structures are presented along with optical bistability and diode laser thresholds self oscillations and chaos This text consists of 17 chapters and begins with an introductory chapter to the historical background of investigations of the resonance enhanced nonlinear optical properties of semiconductors and their manifestations in optical instabilities The discussion then turns to the experimentally observed optical nonlinearities in homogeneous semiconductors and the microscopic theory of the optical band edge nonlinearities This book considers the studies of the spectral region close to the band gap meant to exploit the resonance enhancement of the nonlinear optical behavior The remaining chapters focus on nonlinear optical properties of semiconductor quantum wells dense nonequilibrium excitations in gallium arsenide optical decay and spatial relaxation and optical bistability in semiconductor laser amplifiers A chapter that describes instabilities in semiconductor lasers concludes the book This book is intended for research students and active research workers who are interested in the basic physics or in the device applications of optical nonlinearities and instabilities in semiconductors

Nonlinear Optics and Solid-State Lasers Jianquan Yao,Yuyue

Wang,2012-01-14 This book covers the complete spectrum of nonlinear optics and all solid state lasers The book integrates theory calculations and practical design technology experimental schemes and applications With the expansion and further development of Laser technology the wavelength spectrum of Lasers had to be enlarged even to be tunable which requires the use of nonlinear optical and Laser tunable technology It systematically summarizes and integrates the analysis of international achievements within the last 20 years in this field It will be helpful for university teachers graduate students as well as engineers

Semiconductor Lasers Junji Ohtsubo,2012-10-05 This third edition of *Semiconductor Lasers Stability Instability and Chaos* was significantly extended In the previous edition the dynamics and characteristics of chaos in semiconductor lasers after the introduction of the fundamental theory of laser chaos and chaotic dynamics induced by self optical feedback and optical injection was discussed Semiconductor lasers with new device structures such as vertical cavity

surface emitting lasers and broad area semiconductor lasers are interesting devices from the viewpoint of chaotic dynamics since they essentially involve chaotic dynamics even in their free running oscillations. These topics are also treated with respect to the new developments in the current edition. Also the control of such instabilities and chaos control are critical issues for applications. Another interesting and important issue of semiconductor laser chaos in this third edition is chaos synchronization between two lasers and the application to optical secure communication. One of the new topics in this edition is fast physical number generation using chaotic semiconductor lasers for secure communication and development of chaos chips and their application. As other new important topics the recent advance of new semiconductor laser structures is presented such as quantum dot semiconductor lasers, quantum cascade semiconductor lasers, vertical cavity surface emitting lasers and physical random number generation with application to quantum key distribution. Stabilities, instabilities and control of quantum dot semiconductor lasers and quantum cascade lasers are important topics in this field.

Nonlinear Fiber Optics Govind P. Agrawal, 2013-10-22 The field of nonlinear fiber optics has grown substantially since the First Edition of *Nonlinear Fiber Optics* published in 1989. Like the First Edition, this Second Edition is a comprehensive tutorial and up to date account of nonlinear optical phenomena in fiber optics. It synthesizes widely scattered research material and presents it in an accessible manner for students and researchers already engaged in or wishing to enter the field of nonlinear fiber optics. Particular attention is paid to the importance of nonlinear effects in the design of optical fiber communication systems. This is a completely new book containing either new sections or major revisions in every chapter. Major changes in Soliton based Communication Systems, New section on Photonic Switching, New section on the Nonlinear Fiber loop Mirror, Section on Second harmonic Generation will be expanded to include new research material. Two new chapters have been added on Fiber Amplifiers and Fiber Lasers, two major research areas which have grown significantly during the last 4-5 years. All references have been completely updated.

Nonlinear Optics Robert W. Boyd, 2003-01-07 The Optical Society of America (OSA) and SPIE The International Society for Optical Engineering have awarded Robert Boyd with an honorable mention for the Joseph W. Goodman Book Writing Award for his work on *Nonlinear Optics*. 2nd edition. Nonlinear optics is essentially the study of the interaction of strong laser light with matter. It lies at the basis of the field of photonics, the use of light fields to control other light fields and to perform logical operations. Some of the topics of this book include the fundamentals and applications of optical systems based on the nonlinear interaction of light with matter. Topics to be treated include mechanisms of optical nonlinearity, second harmonic and sum and difference frequency generation, photonics and optical logic, optical self action effects including self focusing and optical soliton formation, optical phase conjugation, stimulated Brillouin and stimulated Raman scattering and selection criteria of nonlinear optical materials. Covers all the latest topics and technology in this ever evolving area of study that forms the backbone of the major applications of optical technology. Offers first rate instructive style making it ideal for self study. Emphasizes the fundamentals of non linear optics rather than focus on particular

applications that are constantly changing **Nonlinear Laser Dynamics** Kathy Lüdge, 2012-04-09 A distinctive discussion of the nonlinear dynamical phenomena of semiconductor lasers The book combines recent results of quantum dot laser modeling with mathematical details and an analytic understanding of nonlinear phenomena in semiconductor lasers and points out possible applications of lasers in cryptography and chaos control This interdisciplinary approach makes it a unique and powerful source of knowledge for anyone intending to contribute to this field of research By presenting both experimental and theoretical results the distinguished authors consider solitary lasers with nano structured material as well as integrated devices with complex feedback sections In so doing they address such topics as the bifurcation theory of systems with time delay analysis of chaotic dynamics and the modeling of quantum transport They also address chaos based cryptography as an example of the technical application of highly nonlinear laser systems **Ultrafast Nonlinear Optics and Semiconductor Lasers** , 2001 The Final Proceedings for Ultrafast Nonlinear Optics and Semiconductor Lasers 5 September 2001 8 September 2001 This is an interdisciplinary conference Topics include techniques for the generation of ultrashort pulses propagation phenomena interaction of ultrashort pulses with matter formation of **Nonlinear Optics** Natalia Kamanina, 2012-02-29 Rapid development of optoelectronic devices and laser techniques poses an important task of creating and studying from one side the structures capable of effectively converting modulating and recording optical data in a wide range of radiation energy densities and frequencies from another side the new schemes and approaches capable to activate and simulate the modern features It is well known that nonlinear optical phenomena and nonlinear optical materials have the promising place to resolve these complicated technical tasks The advanced idea approach and information described in this book will be fruitful for the readers to find a sustainable solution in a fundamental study and in the industry approach The book can be useful for the students post graduate students engineers researchers and technical officers of optoelectronic universities and companies *Compact Blue-Green Lasers* W. P. Risk, T. R. Gosnell, A. V. Nurmikko, 2003-01-09 William Risk Timothy Gosnell and Arto Nurmikko have brought together their diverse expertise from industry and academia to write the first fully comprehensive book on the generation and application of blue green lasers This volume describes the theory and practical implementation of three techniques for the generation of blue green light nonlinear frequency conversion of infrared lasers upconversion lasers and wide bandgap semiconductor diode lasers In addition it looks at the various applications that have driven the development of compact sources of blue green light and reflects on the recent application of these lasers in high density data storage color displays reprographics and biomedical technology *Compact Blue Green Lasers* is suitable for graduate level courses or as a reference for academics and professionals in optics applied physics and electrical engineering **Nonlinear Fiber Optics** Govind P. Agrawal, 2012-10-10 Since the 4e appeared a fast evolution of the field has occurred The 5e of this classic work provides an up to date account of the nonlinear phenomena occurring inside optical fibers the basis of all our telecommunications infrastructure as well as

being used in the medical field Reflecting the big developments in research this new edition includes major new content slow light effects which offers a reduction in noise and power consumption and more ordered network traffic stimulated Brillouin scattering vectorial treatment of highly nonlinear fibers and a brand new chapter on supercontinuum generation in optical fibers Continues to be industry bestseller providing unique source of comprehensive coverage on the subject of nonlinear fiber optics Updated coverage of intrapulse Raman scattering four wave mixing and Harmonic Generation Includes a new chapter exclusively devoted to supercontinuum generation in optical fibers

Applications of Nonlinear Fiber Optics

Govind P. Agrawal, 2020-08-11 Applications of Nonlinear Fiber Optics Third Edition presents sound coverage of the fundamentals of lightwave technology along with material on pulse compression techniques and rare earth doped fiber amplifiers and lasers The book's chapters include information on fiber optic communication systems and the ultrafast signal processing techniques that make use of nonlinear phenomena in optical fibers This book is an ideal reference for R D engineers working on developing next generation optical components scientists involved with research on fiber amplifiers and lasers graduate students and researchers working in the fields of optical communications and quantum information Presents the only book on how to develop nonlinear fiber optic applications Describes the latest research on nonlinear fiber optics Demonstrates how nonlinear fiber optics principles are applied in practice

Nonlinear Optical Response of Simple Molecules and Two-photon Semiconductor Lasers Matthew Reichert, 2015 This dissertation investigates two long standing issues in nonlinear optics complete characterization of the ultrafast dynamics of simple molecules and the potential of a two photon laser using a bulk semiconductor gain medium Within the Born Oppenheimer approximation nonlinear refraction in molecular liquids and gases can arise from both bound electronic and nuclear origins Knowledge of the magnitudes temporal dynamics polarization and spectral dependences of each of these mechanisms is important for many applications including filamentation white light continuum generation all optical switching and nonlinear spectroscopy In this work the nonlinear dynamics of molecules are investigated in both liquid and gas phase with the recently developed beam deflection technique which measures nonlinear refraction directly in the time domain Thanks to the utility of the beam deflection technique we are able to completely determine the third order response function of one of the most important molecular liquids in nonlinear optics carbon disulfide This allows the prediction of essentially any nonlinear refraction or two photon absorption experiment on CS₂ Measurements conducted on air N₂ and O₂ and gaseous CS₂ reveal coherent rotational revivals in the degree of alignment of the ensemble at a period that depends on its moment of inertia This allows measurement of the rotational and centrifugal distortion constants of the isolated molecules

Nonlinear Optical

Diagnostics of Laser-excited Semiconductor Surfaces Sergei Aleksandrovich Akhmanov, Nikolaï Ivanovich Koroteev, Igor' Leonidovich Shumaï, 1989 **Soviet Science and Technology**, 1987 *Laser Optics of Condensed Matter* E. Garmire, A.A. Maradudin, K.K. Rebane, 2012-12-06 The Fourth USA USSR Symposium on The Physics of Optical Phenomena and Their Use

as Probes of Matter was held in Irvine California January 23-27 1990. Participating in the Symposium were 22 scientists from the USSR and 29 from the USA. In addition to provide an international dimension to this Symposium without however compromising significantly its essentially binational character 7 non-US and non-USSR scientists were invited to take part in it. The present volume is the proceedings of that Symposium and contains all manuscripts received prior to August 1 1990 representing scientific contributions presented. A few manuscripts were not received but for completeness the corresponding abstract is printed. Three previous USA-USSR Binational Symposia on related topics have been held viz Theory of Light Scattering in Condensed Matter Moscow 1975 Light Scattering in Solids New York 1979 and Laser Optics of Condensed Matter Leningrad 1987. These meetings were evaluated by the participants as highly successful and provided invaluable opportunities for researchers to exchange information and to initiate collaborative work which led to research visits by US physicist to Soviet laboratories and vice versa and which continue to the present day.

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