Dear colleague,

Now in its 78th year of publication as a prestigious source of authoritative review articles in all areas of physics, *Reports on Progress in Physics* continues to fulfil a vital role in serving the needs of graduate students, researchers entering new fields and experts alike.

On behalf of the Editorial Board for *Reports on Progress in Physics*, I am pleased to present a special print collection of article summaries, showcasing all of the review content published in the journal in 2009 and 2010.

Reflecting the broad scope of the journal, the 82 articles listed inside cover topics extending across the whole spectrum of physics including superconductivity, semiconductor physics, nanoscience, surface science, cold atoms, quantum information, biophysics, laser physics, gravitation, cosmology, particle physics and atmospheric physics. There is even an article discussing the physics of music!

Guided exclusively by my prestigious colleagues on the Editorial Board, *Reports on Progress in Physics* will continue to commission articles in the most vital areas of physics, maintaining its long-standing reputation as an essential resource for physicists at all stages of their careers. We therefore look forward to publishing yet more content that surveys other essential topics in physics in the near future.

In recognition of this year’s centenary year of superconductivity you can look forward to a specially compiled Back History Collection of articles showcasing how *Reports on Progress in Physics* has served the superconductivity community over the years – all articles will be freely available until the end of 2011. In addition, we will be publishing a very special issue of invited reviews on the topic of ‘Iron-Based Superconductors’ (edited by George Crabtree, Peter Johnson and me) featuring articles from all of the leading experts working on this rapidly evolving new family of superconductors.

I would like to thank all of the authors featured inside for their vital contributions to the journal. I hope that you find the articles listed of interest to you and your ongoing research.

*Laura H Greene*

Editor-in-Chief

*Professor Laura H Greene*

*University of Illinois at Urbana-Champaign, USA*
Journal scope

Published monthly (12 issues per year) and covering all branches of physics, Reports on Progress in Physics (ROPP) is a prestigious journal for the publication of reviews surveying the development of selected topics, typically over the previous decade, within a wider context. Articles combine a critical evaluation of the field for established workers with a reliable and accessible introduction for newcomers and specialists in other fields.

Reports on Progress in Physics has 10 key subject sections and an international board dedicated to subject-specific interests covering:

- Atomic, molecular and optical physics
- Astrophysics and cosmology
- Condensed matter and materials
- Earth sciences
- Instrumentation
- Mathematical and quantum physics
- Medical physics
- Nuclear physics
- Particle physics
- Soft condensed matter and biological physics

More information on each of these sections can be found at iopscience.org/ropp.
Reviewing the future of physics

Prestige
Authored by eminent leaders in the field, many of the review articles published in ROPP are directly invited by members of our international board. Each presents a scholarly and exhaustive analysis of a mature and significant development in physics while being accessible to a broader non-specialist readership. The research covered is of wide interest to multiple disciplines and has already achieved broad consensus among the scientific community.

Diversity
Annual Collections represent the breadth, scope and remarkable quality of the journal’s content. The variety of research included also reflects the range of topics represented by dedicated members of our international Editorial Board.

Depth
ROPP’s Back History Collections highlight key areas of physics and present a timeline of papers charting the progress and evolution of that particular field. These chronologies illustrate the journal’s extensive and fluid evaluation of important developments and its long history at the forefront of reviewing crucial ideas and advances in physics.

Cutting-edge
Reports on Progress articles recount the current status of a rapidly evolving field of intense current interest, providing a survey of the latest research results, even if these results and their interpretation are not in universal accord.

Debate
Key Issues Reviews address burning questions in developing areas of physics with particular emphasis on results and analysis whose significance is currently in hotly contested dispute among leading thinkers in the field. These articles include arguments and citations that support wholly personal standpoints of eminent authors and offer contrasting and even controversial perspectives opening the door to key advances in physics as they unfold.

Contour plots of occupied spectral intensity (top) and momentum resolved radio frequency spectra (bottom) for an ultracold Fermi gas. Taken from the article Qijin Chen et al 2009 Rep. Prog. Phys. 72 122501.

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**BACK HISTORY COLLECTION**

**Astrophysics and Cosmology**

Look out in 2011 for a special, free-to-read Back History Collection of articles from the archive of *Reports on Progress in Physics* on the theme of astrophysics and cosmology.

iopscience.org/ropp
Terahertz Josephson plasma waves in layered superconductors: spectrum, generation, nonlinear and quantum phenomena

Sergey Savel’ev1,2, V A Yampol’skii1,2, A L Rakhmanov2,3 and Franco Nori1,5
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2010 Rep. Prog. Phys. 73 026501

Thermal Josephson plasma waves are one of the possible mechanisms for the generation of Terahertz (THz) waves. This review focuses on the theoretical and experimental aspects of these waves. The emphasis is on nonlinear transport phenomena and the interplay between Josephson and microwave superconducting devices, as well as the most recent experimental achievements.

More than 301 000 downloads in 2010

Emergence of magnetism in graphene materials and nanostructures

Oleg V Yazyev
Department of Physics, University of California, Berkeley, CA 94720, USA and Materials Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA

2010 Rep. Prog. Phys. 73 056501

Magnetic materials and nanostructures based on carbon offer unique opportunities for future technological applications such as spintronics. This article reviews graphene-derived systems in which magnetic correlations emerge as a result of reduced dimensions, disorder and other possible scenarios. In particular, zero-dimensional graphene nanofragments, one-dimensional graphene nanoribbons and defect-induced magnetism in graphene and graphite are covered. Possible physical mechanisms of the emergence of magnetism in these systems are illustrated with the help of computational examples based on simple model Hamiltonians. In addition, this review covers spin transport properties, proposed designs of graphene-based spintronic devices and magnetic ordering at finite temperatures as well as the most recent experimental achievements.
Local polarization dynamics in ferroelectric materials

Sergei V Kalinin1,4, Anna N Morozovska1, Long Qing Chen3 and Brian J Rodríguez4

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2 V. Lashkaryov Institute of Semiconductor Physics, National Academy of Sciences of Ukraine, 41, pr. Nauki, 03028 Kiev, Ukraine
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4 Conway Institute of Biomolecular and Biomedical Research, University College Dublin, Belfield, Dublin 4, Ireland

2010 Rep. Prog. Phys. 73 056502

Ferroelectrics and multiferroics have recently emerged as promising materials for information technology and data storage applications. The combination of extremely narrow domain wall width and the capability to manipulate polarization by an electric field opens the pathway towards ultrahigh storage densities and small feature sizes. This article provides a summary of the recent progress in applications of piezoresponse force microscopy (PFM) for the imaging, manipulation and spectroscopy of the ferroelectric switching processes. Following an introduction to the principles and instrumental aspects of PFM, local imaging studies of domain dynamics are discussed in detail. The article concludes with a brief review of the latest work on photochemical processes on ferroelectric surfaces, the role of surface adsorbates and imaging and switching in liquids.

Laser cooling of solids

Galina Nemova1 and Raman Kashyap1,2

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2 Department of Electrical Engineering 2, École Polytechnique de Montréal, PO Box 6079, Station-Centre-ville, Montréal, Canada

2010 Rep. Prog. Phys. 73 086501

Laser cooling of solids, sometimes also known as optical refrigeration, is a fast developing area of optical science investigating interaction of light with condensed matter. Apart from being of fundamental scientific interest, this topic addresses a very important practical issue: design and construction of laser-pumped solid-state cryocoolers, which are compact, free from mechanical vibrations, moving parts and fluids, and cause only low electromagnetic interference in the cooled area. At the present time, laser cooling of solids can be largely divided into three main areas: laser cooling of rare-earth doped solids, laser cooling in semiconductors and radiation-balanced lasers. This article reviews and addresses these three areas of fundamental interest.

Modelling of nanoparticles: approaches to morphology and evolution

A S Barnard

CSIRO Materials Science and Engineering, Clayton, VIC, 3168, Australia

2010 Rep. Prog. Phys. 73 086502

As we learn more about the physics, chemistry and engineering of materials at the nanoscale, we find that the development of a complete understanding is not possible using one technique alone. This review focuses on strategies and techniques to model the structure of individual inorganic nanoparticles, and outlines the various methods available to help unlock the secrets of nanomorphology and nanoparticle evolution. To illustrate how these methods are best used, results of studies from many research groups are reviewed, and informal case studies are constructed on carbon, titania and gold nanoparticles.

Polymer–fullerene bulk heterojunction solar cells

Carsten Deibel1 and Vladimir Dyakonov1,2

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2 Energy Technology, Bavarian Centre for Applied Energy Research (ZAE Bayern), 97074 Würzburg, Germany

2010 Rep. Prog. Phys. 73 096401

Organic solar cells have the potential to be low-cost and efficient solar energy converters, with a promising energy balance. They are made from carbon-based semiconductors, which exhibit favourable light absorption and charge generation properties, and can be manufactured by low temperature processes such as printing from solvent-based inks, which are compatible with flexible plastic substrates or even paper. This article presents an overview of the physical function of organic solar cells, their state-of-the-art performance and limitations, as well as novel concepts to achieve a better material stability and higher power conversion efficiencies. Processing and cost are also briefly reviewed in view of the market potential.

Controlling nanowire structures through real time growth studies

Frances M Ross

IBM T J Watson Research Center, Yorktown Heights, NY, USA

2010 Rep. Prog. Phys. 73 114501

In situ electron microscopy can be used to visualize the physical processes that control the growth of Si and Ge nanowires through the vapour–liquid–solid mechanism. Images and movies are recorded in a transmission electron microscope that has capabilities for depositing catalysts onto a sample and for introducing chemical vapour deposition precursor gases while the sample remains under observation. This review discusses the growth mechanism of semiconductor nanowires and surveys how in situ electron microscopy can probe the fundamentals of crystal growth, providing an opportunity to fabricate precisely controlled structures for novel applications.
The treatment of electronic excitations in atomistic models of radiation damage in metals

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² Department of Materials, Imperial College, London SW7 2AZ, UK

2010 Rep. Prog. Phys. 73 116501

Atomistic simulations are a primary means of understanding the damage done to metallic materials by high energy particulate radiation. In many situations the electrons in a target material are known to exert a strong influence on the rate and type of damage. The dynamic exchange of energy between electrons and ions can act to damp the ionic motion, to inhibit the production of defects or to quench-in damage, depending on the situation. Finding ways to incorporate these electronic defects into atomistic simulations of radiation damage is a topic of current major interest, driven by materials science challenges in diverse areas such as energy production and device manufacture. In this review, we discuss the range of approaches that have been used to tackle these challenges. We compare augmented classical models of various kinds and consider recent work applying semi-classical techniques to allow the explicit incorporation of quantum mechanical electrons within atomistic simulations of radiation damage. We also outline the body of theoretical work on stopping power and electron–phonon coupling used to inform efforts to incorporate electronic defects in atomistic simulations and to evaluate their performance.

Fundamental studies of superconductors using scanning magnetic imaging

J R Kirtley
Center for Probing the Nanoscale, Stanford University, Stanford, CA, USA

2010 Rep. Prog. Phys. 73 126501

This article provides a review of the application of scanning magnetic imaging to fundamental studies of superconductors, concentrating on three scanning magnetic microscopies: scanning SQUID microscopy, scanning Hall bar microscopy and magnetic force microscopy. Following a brief discussion of the history, sensitivity, spatial resolution, invasiveness and potential future developments of each technique, a survey of selected applications extending across superconductivity is given.

Electrothermal transport coefficients at finite frequencies

B Sriram Shastry
Physics Department, University of California, Santa Cruz, CA 95064, USA

2009 Rep. Prog. Phys. 72 016501

Understanding correlated electron systems—which include high $T_c$ superconductors and other oxides—is a serious theoretical challenge. This article reviews a new formalism for computing thermoelectric coefficients in correlated matter. It draws parallels between the Hall constant and the Seebeck coefficient, which can be used to compute the exact finite frequency transport coefficients and hence to benchmark various approximations. This formalism is applied to the physically important case of Na$_2$CoO$_2$, and interesting predictions for new materials are highlighted.
Electron energy-loss spectroscopy in the TEM

R F Egerton
Physics Department, University of Alberta, T6G 2G7 Canada

2009 Rep. Prog. Phys. 72 016502

This article reviews electron energy-loss spectroscopy using higher-energy electrons (100–300 keV), as used in a transmission electron microscope. The higher-energy electrons can pass completely through specimens up to 1 µm thick to produce a transmitted-electron image of the specimen with a spatial resolution down to atomic dimensions. This enables spectroscopic analysis of extremely small volumes of material. This article reviews the technique and suggests future developments.

Nuclear magnetic resonance in the heavy fermion superconductors

N J Curro
Department of Physics, University of California, One Shields Avenue, Davis, CA 95616-8677, USA

2009 Rep. Prog. Phys. 72 026502

Nuclear magnetic resonance is a vital technique for investigating strongly correlated electron systems, and is particularly important for studying superconductivity. This article reviews the basic features of NMR as a technique for probing the superconducting state. Topics include spin relaxation processes, studies of vortex lattices and phenomena associated with unconventional pairing symmetries. Recent experimental work is reviewed, with a particular emphasis on the heavy fermion superconductors.

Hybrid atomistic simulation methods for materials systems

N Bernstein1, J R Kermode2,3 and G Csányi3
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2 TCM Group, Cavendish Laboratory, JJ Thomson Avenue, Cambridge, CB3 0HE, UK
3 Engineering Laboratory, University of Cambridge, CB2 1PZ, UK

2009 Rep. Prog. Phys. 72 026501

This review focuses on hybrid schemes that combine two atomistic treatments: one explicitly quantum mechanical (QM) and one using interatomic potentials (MM, which stands for ‘molecular mechanics’). A unified terminology is defined into which the various and disparate schemes fit, based on whether the information from the QM and MM calculations is combined at the level of energies or forces. It discusses the pertinent issues for achieving ‘seamless’ coupling, the advantages and disadvantages of the proposed schemes, and summarizes the applications and scientific results that have been obtained to date.

Mottness in high-temperature copper-oxide superconductors

Philip Phillips, Ting-Pong Choy and Robert G Leigh
Department of Physics, University of Illinois 1110 W. Green Street, Urbana, IL 61801, USA

2009 Rep. Prog. Phys. 72 036501

Superconductivity in the copper-oxide ceramics stands as a challenging problem, as its solution is fundamentally rooted in the physics of strong coupling. The standard theory of metals, Fermi liquid theory, hinges on the key assumption that although the electrons interact, the low-energy excitation spectrum stands in a one-to-one correspondence with that of a non-interacting system. This article focuses on the series of experiments on the copper-oxide superconductors which reveal that the number of low-energy addition states per electron per spin exceeds unity, in direct violation of the key Fermi liquid tenet. These experiments point to new degrees of freedom that are not made out of the elemental excitations, and a possible route to superconductivity is explored.
X-ray diffraction of III-nitrides

M A Moram and M E Vickers
Department of Materials Science and Metallurgy, University of Cambridge, Pembroke St., Cambridge, CB2 3QZ, UK

2009 Rep. Prog. Phys. 72 036502

Thin films of III-nitrides are used to make UV, violet, blue and green light emitting diodes and lasers, as well as solar cells, high-electron mobility transistors and other devices. However, the film growth process gives rise to unusually high strain and high defect densities, which can affect device performance. This article reviews the use of x-ray diffraction to characterize films and device structures, allowing improvements in device efficiencies to be made, and also reviews the basic principles of x-ray diffraction of thin films and areas of special current interest.

Fundamental questions relating to ion conduction in disordered solids

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Ion conduction in glasses, polymers, nanocomposites, highly defective crystals and other disordered solids plays an increasingly important role in technology. This article summarizes and discusses a number of basic scientific questions relating to ion conduction in non-crystalline solids. Possible answers to the questions are occasionally suggested, but the main purpose of the paper is to inspire further research in a field that still presents several fundamental challenges.

Advanced quantum dot configurations

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Quantum dots (QDs) are nanometer-sized structures which confine the motion of charge carriers (electrons and holes) in all three spatial directions leading to discrete energy levels. The structure dependence of their emission properties means that QDs can be incorporated in wide ranging semiconductor devices with potential novel functionalities. This article presents an overview of the approaches currently used to fabricate advanced QD configurations by epitaxial growth. Results from photoluminescence spectroscopy are used to access the properties of the buried structures and a promising approach to realize QD crystals with controlled spatial and optical properties is discussed.

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KEY ISSUES REVIEWS:

→ Open the door on current disputes, debates and contrasting perspectives within emerging fields
→ Present personal and potentially controversial viewpoints from eminent thinkers in the field
→ Get to the heart of crucial advances from the forefront of physics as they develop
Fröhlich polaron and bipolaron: recent developments

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Electron–phonon interactions dominate the transport properties of many metals and semiconductors and are relevant in high-temperature superconductors. This article reviews recent developments in the field of continuum and discrete (lattice) Fröhlich (bi)polarons starting with the basics and covering a number of active directions of research. This problem has been a testing ground for analytical, semi-analytical and numerical techniques, such as path integrals strong-coupling perturbation expansion, advanced variational, exact diagonalisation and quantum Monte Carlo techniques.

Suspended single-wall carbon nanotubes: synthesis and optical properties

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A single-wall carbon nanotube (SWNT) is a rolled-up graphene sheet. All the carbon atoms are in the surface layer and interact strongly with substrate atoms or other nanotubes. However, when a SWNT is suspended between mesa structures, these interactions are minimized. This paper first reviews the growth and characterization of suspended SWNTs, the mechanisms of suspended structure formation and control of the structures (individual or bundled). Then it describes photoluminescence and Raman spectroscopy of individual and ensemble SWNTs, which enable us to examine the structure of individual SWNTs. Finally it describes device applications of suspended SWNTs.

Femtosecond superradiant emission in inorganic semiconductors

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Superradiance, the cooperative radiative decay of an initially inverted assembly of quantum oscillators, has been extensively studied both theoretically and experimentally in atomic and molecular systems under external optical pumping. This article provides a review of experimental studies in semiconductor inorganic structures, demonstrating that unique properties of superradiant emission, including its femtosecond pulse duration, record peak power, optical spectrum, spatial and temporal coherency, and macroscopically large fluctuations, are determined by the unusual properties of electrons and holes, namely, the formation of a BCS-like state in a system of collectively paired electrons and holes. The effect of non-equilibrium condensation of electrons and holes in the phase domain at room temperature is experimentally demonstrated and, finally, the critical temperature of condensation in a strongly degenerate system of electrons and holes is theoretically estimated.

Short-range correlations in disordered systems: nonlocal coherent-potential approximation

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Substitutionally disordered systems such as metallic alloys are important technologically. They usually crystallize into a solid solution at a high temperature, and then undergo transitions to ordered or separate phases as the temperature is lowered. This article reviews approaches based on the instability of the high-temperature disordered phase to concentration fluctuations. Once the effective cluster interactions are obtained, the thermodynamic behaviour can be examined as the temperature is lowered. This review aims to clarify the ideas underlying the existing theory in relation to other known methods and to highlight the theoretical issues which need to be addressed.

Quantum Hall ferromagnets

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This article reviews new developments in quantum Hall (QH) systems, which have received renewed interest since the discovery of quantum coherence associated with the spin and layer degrees of freedom. Topics covered include the microscopic theory based on noncommutative geometry, the composite-boson theory to understand the mechanism by which quantum coherence develops spontaneously, the bilayer QH system, where the layer degree of freedom acts as the pseudospin leading to a pseudospin skyrmion, the phase current, which induces an anomalous behaviour of the Hall resistance in a counterflow geometry, and the tunnelling current, which demonstrates Josephson-like phenomena. Experimental evidence for these phenomena is also presented.
The Kondo effect in coupled-quantum dots
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This article reviews Kondo systems in coupled-quantum dots, with an emphasis on the semiconductor quantum-dot system. These systems show a rich variety of behavior, such as distinct quantum phases, non-Fermi liquid behavior, and associated quantum phase transitions and cross-over behaviors. The experimentally observed behavior may provide clues to the relevance of the two-impurity Kondo (2IK) effect and the two-channel Kondo (2CK) effect to the unusual characteristics in strongly correlated systems such as the heavy fermion system.

Muonium as a model for interstitial hydrogen in the semiconducting and semimetallic elements
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Although the interstitial hydrogen atom would seem to be one of the simplest defect centres in any lattice, its solid state chemistry is in fact unknown in many materials, not least amongst the elements. This article charts the contribution made to this subject by studies, not of the hydrogen defect centres themselves, but of their muonium counterparts, and specifically documents the progress of muon spin rotation, resonance and relaxation µSR studies for all the semiconductors and semimetals of the p-block elements, Groups III–VI.

Theory of radio frequency spectroscopy experiments in ultracold Fermi gases and their relation to photoemission in the cuprates
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This article provides an overview of radio frequency (RF) spectroscopy in the atomic Fermi superfluids with the ultimate goal of suggesting new directions in the cold gas research agenda from the condensed matter perspective. The experimental and theoretical literature on cold gases and the photoemission spectroscopy of the cuprates is reviewed, and in addition to a comparison with the cuprates a systematic overview of the theory of RF spectroscopy is presented. For the cold gases, the reader is introduced to such topical issues as the effects of traps, population imbalance, final state interactions and, over the entire range of temperatures, theory and experiment are compared. We show that this broad range of phenomena can be accommodated within the BCS-Leggett description of BCS–BEC crossover. Importantly, this scheme captures some of the central observations in photoemission experiments in the cuprates.
Recent advances in the surface forces apparatus (SFA) technique
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This article reviews recent developments in the surface forces apparatus (SFA) technique which has been used for many years to measure the physical forces between surfaces, such as van der Waals (including Casimir) and electrostatic forces in vapours and liquids, adhesion and capillary forces, forces due to surface and liquid structure (e.g. solvation and hydration forces), polymer, steric and hydrophobic interactions, bio-specific interactions, as well as friction and lubrication forces. It focuses on the SFA 2000, its simplicity of operation and its extension into new areas of measurement of both static and dynamic forces as well as both normal and lateral (shear and friction) forces.

Sound attenuation near the demixing point of binary liquids: interplay of critical dynamics and noncritical kinetics
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During the past decades considerable attention has been directed towards the long-wavelength fluctuations in the local concentration which are associated with the critical demixing of binary fluids at their consolute point. This review article discusses the nature and origin of sound attenuation due to critical fluctuations near the liquid consolute point. Starting from basic principles, the background of critical phenomena is reviewed and the conceptions of theoretical approaches to describe the critical contributions to the propagation of sound are analysed.

Diffuse optics for tissue monitoring and tomography
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This review describes the diffusion model for light transport in tissues and the medical applications of diffuse light. Diffuse optics is particularly useful for measurement of tissue hemodynamics, wherein quantitative assessment of oxy- and deoxy-hemoglobin concentrations and blood flow are desired. The theoretical basis for near-infrared spectroscopy or diffuse optical spectroscopy is developed, and the basic elements of diffuse optical tomography are outlined. There is also a discussion of diffuse correlation spectroscopy, a technique whereby temporal correlation functions of diffusing light are transported through tissue and are used to measure blood flow. Essential instrumentation is described, and representative brain and breast functional imaging and monitoring results illustrate the workings of these new tissue diagnostics.

The biophysics of neuronal growth
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Neuroscience has for many years focused on biochemical, molecular biological and electrophysiological aspects of neuronal physiology and pathology. There is, however, a growing body of evidence indicating the importance of physical stimuli for neuronal growth and development. This review provides a summary of the historical background of neurobiophysics and gives an overview of the current understanding of neuronal growth from a physics perspective. The contribution of biophysics in providing a better understanding of neuronal growth is discussed and it is speculated as to how biophysics may contribute to the successful treatment of lesions to the central nervous system, which had been considered incurable until very recently.

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Physics of bubble oscillations

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Bubbles appear in different disciplines, both in the life and the natural sciences and in the corresponding technologies that have been developed and are still emerging. Focusing on bubbles in liquids, this article provides a comprehensive review of the latest state of knowledge of their dynamics in response to pressure forces. The basic equations for nonlinear bubble oscillation in sound fields are given, together with a survey of typical solutions. Bubble collapse is also treated with a discussion of temperature and pressure effects, and light emission. Bubble–bubble interaction and related phenomena are also surveyed and the article concludes with a comparison of numerical bubble simulations with three-dimensional bubble dynamics obtained by stereoscopic high speed digital videography.

Thermal non-equilibrium transport in colloids

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A temperature gradient acts like an external field on colloidal suspensions and drives the solute particles to the cold or to the warm, depending on interfacial and solvent properties. This article reviews the different transport mechanisms for charged colloids and discusses how a thermal gradient gives rise to companion fields. Particular emphasis is put on the thermal response of the electrolyte solution: positive and negative ions diffuse along the temperature gradient and thus induce a thermoelectric field which in turn acts on the colloidal charges. Regarding polymers in organic solvents, the physical mechanism changes with decreasing molecular weight: high polymers are described in the framework of macroscopic hydrodynamics; for short chains and molecular mixtures of similar size, the Brownian motion of solute and solvent becomes important.

The uses of radiotracers in the life sciences

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Radionuclides at very low concentration are used as tracers for medical imaging (planar imaging, PET and SPECT) and radiotherapy. The tracer must interact reproducibly with the system to be probed and not perturb it, and its concentration must be measurable. Most radiotracers have relatively short half-lives, so there is a low radiation dose associated with each study, serial studies are possible and radioactive waste disposal problems are minimized. This article gives detailed examples of the application of radioactive tracers, illustrating the high sensitivity of the techniques.
Biophysical models of tumour growth

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Tumour growth is a multifactorial process which has stimulated in recent decades the development of numerous models trying to figure out the mechanisms controlling solid tumour morphogenesis. After a presentation of the experimental background, this article outlines a number of representative models describing, at different scales, the growth of avascular and vascularized tumours. Special attention is paid to the formulation of tumour–host tissue interactions that selectively drive changes in tumour size and morphology, and which are notably mediated by the mechanical status and elasticity of the tumour microenvironment. Patient-oriented implications of tumour growth modelling are outlined in the context of brain tumours and, finally, some conceptual views of the adaptive strategies and selective barriers that govern tumour evolution are presented as potential guidelines for future model development.

The hydrodynamics of swimming microorganisms

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2009 Rep. Prog. Phys. 72 096601

Cell motility in viscous fluids is ubiquitous and affects many biological processes, including reproduction, infection, and the marine life ecosystem. This article reviews the biophysical and mechanical principles of locomotion at the small scales relevant to cell swimming—tens of microns and below. An emphasis is placed on the simple physical picture and fundamental flow physics phenomena in this regime. Areas of active research including hydrodynamic interactions, biological locomotion in complex fluids, the design of small-scale artificial swimmers and the optimization of locomotion strategies are also outlined.

Recent progress and novel applications of photonic crystal fibers

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This article provides a detailed review of the recent progress and novel potential applications of photonic crystal fibers. Photonic crystal fibers present a wavelength-scale periodic microstructure running along their length. Their core and two-dimensional photonic crystal might be based on varied geometries and materials, enabling light guidance due to different propagation mechanisms at an extremely large wavelength range, extending to terahertz regions. As a result, these fibers have revolutionized optical fiber technology by means of creating new degrees of freedom in fiber design, fabrication and applicability.

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Phonon-mediated entanglement for trapped ion quantum computing

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Trapped ions are a near ideal system for studying quantum information processing due to the high degree of control over the ion’s external confinement and internal degrees of freedom. This review demonstrates the key steps necessary for trapped ion quantum computing and focuses on phonon-mediated entangling gates. It highlights several key algorithms implemented over the last decade with these gates and gives a detailed description of Grover’s quantum database search implemented with two trapped ion qubits.

Quantum gases and optical speckle: a new tool to simulate disordered quantum systems

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Fifty years ago, it was predicted that the introduction of impurities or defects in a conducting material could induce a sudden transition from conductor to insulator. The suggestion was that electrons that move freely inside the solid do not simply diffuse on the defects as expected for classical particles but can be completely stopped. Instead of a simple decrease of the conductivity, a total cancellation of the conductivity occurs past a certain amount of disorder. The origin of this phase transition is a fundamental quantum phenomenon: interference between the many quantum amplitudes associated with various trajectories of the electron in the disordered material. This original result is essentially based on a mathematical argument, and fifty years after there are still many open questions. This article provides an overview of how ultra-cold atoms, when combined with complex optical potential, can provide powerful tools to answer some of them.

Complex plasmas: a laboratory for strong correlations

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Strong correlations occur in many systems including electrolytic solutions, dense plasmas, ultracold ions and atomic gases in traps, complex (dusty) plasmas, electrons and excitons in quantum dots and the quark–gluon plasma. Because of the dominant role of interactions in such systems, a number of universal properties are observed in all of them. The purpose of this article is to provide an overview of recent experimental and theoretical results in complex plasmas specifically (including liquid-like behavior, crystal formation, structural and dynamic properties) with the expectation that many of these effects will have relevance to other systems where strong correlations play a prominent role.

Imbalanced Feshbach-resonant Fermi gases

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Feshbach resonance tunability has led to laboratory realizations and theoretical proposals for a broad range of quantum many-body phenomena. This article provides an overview of recent developments in species-imbalanced (‘polarized’) Feshbach-resonant Fermi gases. The current status of thermodynamics of these systems in terms of a phase diagram as a function of the Feshbach resonance detuning, polarization and temperature is summarized and instabilities of the s-wave superfluidity across the BEC–BCS crossover to phase separation, FFLO states, polarized molecular superfluidity and the normal state, driven by the species imbalance is reviewed. Finally, a discussion of different models and approximations of this system is provided, together with a comparison of their predictions with current experiments.

Manipulating light with strongly modulated photonic crystals

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Recently, strongly modulated photonic crystals, fabricated by the state-of-the-art semiconductor nanofabrication process, have realized various novel optical properties. This article reviews the way in which they differ from other optical media and clarifies what they can do. In particular, three important issues are considered: light confinement, frequency dispersion and spatial dispersion. The last two sections are devoted to applications of these novel properties in relation to on-chip all-optical processing and novel ways of controlling light.

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Anderson localization in Bose–Einstein condensates
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The understanding of disordered quantum systems is still far from being complete despite many decades of research on a variety of physical systems. This review discusses how ultracold Bose–Einstein condensates in disordered potentials have opened a new window for studying fundamental phenomena related to disorder. A particular focus is placed on recent experimental studies on Anderson localization and on the interplay of disorder and weak interactions. These realize a very promising starting point for a deeper understanding of the complex behaviour of interacting disordered systems.

Ultra-cold polarized Fermi gases
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2010 Rep. Prog. Phys. 73 112401

Recent experiments with ultra-cold atoms have demonstrated the possibility of experimentally realizing fermionic superfluids with imbalanced spin populations. This article provides a discussion of how these developments have shed a new light on a key open problem within condensed matter (the microscopic origin of high critical temperature superconductivity) and raised new questions of their own.

Electron-impact cross sections for deuterated hydrogen and deuterium molecules
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2010 Rep. Prog. Phys. 73 116401

There is an ongoing special interest in the electron-impact cross sections for hydrogen molecules and their isotopomers (HD and D2) because of their presence in wide ranging environments including the tokamak edge plasma, planetary atmospheres and other astrophysical sites. This article provides a survey of the electron scattering cross sections, for both elastic and inelastic processes, at different electron energies for both HD and D2. Elastic momentum transfer cross sections and inelastic cross sections for electron-impact rotational, vibrational and electronic excitation, emission, dissociation, ionization and dissociative electron attachment are all evaluated and summarized.
**Fundamental processes of quantum electrodynamics in laser fields of relativistic power**

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2009 Rep. Prog. Phys. 72 046401

Since the invention of the laser, physicists have been supplied with strong sources of coherent radiation which are now available in the frequency range between the far infrared and, at present, up to the vacuum ultraviolet (VUV) and soft x-ray region. This article reviews the progress made in the investigation of fundamental processes of quantum electrodynamics in laser fields of relativistic power in view of the more recent experimental progress in the generation of laser field intensities.

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**Generalized Kramers–Kronig relations in nonlinear optical- and THz-spectroscopy**

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Kramers–Kronig (K–K) relations are one of the principal tools in optical spectroscopy for the assessment of the optical properties of media from measured spectra. A novel way to utilize generalized K–K relations is related to the measurement and correction of terahertz (THz) spectra in the time-domain reflection spectroscopy. This article reviews the latest advances of K–K relations for use in nonlinear optical and THz spectroscopy.

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**The physics of light transmission through subwavelength apertures and aperture arrays**

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The passage of light through apertures much smaller than the wavelength of the light has proved to be a surprisingly subtle phenomenon. This article reports on progress in our understanding of this phenomenon over the past decade, and describes how modern developments in nanofabrication, coherent light sources and numerical vector field simulations have led to the upending of early predictions from scalar diffraction theory and classical electrodynamics.

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**Laser diffraction microscopy**

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The crystalline state is of fundamental importance to soft matter physics. Regular arrangements, ‘crystals’, form spontaneously in suspensions of small nanometer to micrometer size colloidal particles, driven by their Brownian motion and by the interaction between the particles. These crystals are extremely soft and can be disrupted easily, yet they exhibit similarities to their atomic counterpart that are of fundamental interest. The technique of laser diffraction microscopy, in analogy to transmission electron microscopy as used for imaging atomic crystals, explores optical diffraction contrast to image these crystals and crystal defects. This review discusses in particular the application of optical diffraction contrast imaging to elucidate colloidal crystal nucleation and growth, and defect propagation.

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**The formation and interactions of cold and ultracold molecules: new challenges for interdisciplinary physics**

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This article reviews extensively the experimental methods to produce, detect and characterize cold and ultracold molecules including association of ultracold atoms, deceleration by external fields and kinematic cooling. It also discusses confinement of molecules in different kinds of traps and reviews the basic theoretical issues related to the knowledge of the molecular structure, the atom–molecule and molecule–molecule mutual interactions, and to their possible manipulation and control with external fields. A short discussion on the broad area of applications completes the review.

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**Nearly perfect fluidity: from cold atomic gases to hot quark gluon plasmas**

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This article reviews theoretical and experimental information on the properties of three main classes of quantum fluids—strongly coupled Bose fluids (in particular liquid helium), strongly correlated ultracold Fermi gases and the quark gluon plasma. The main theoretical approaches to transport properties of these fluids—kinetic theory, numerical simulations based on linear response theory and holographic dualities—are discussed, and the experimental situation is summarized with regard to the observation of hydrodynamic behavior in ultracold Fermi gases and the quark gluon plasma.
The physics of dipolar bosonic quantum gases

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This article reviews the recent theoretical and experimental advances in the study of ultracold gases made of bosonic particles interacting via the long-range, anisotropic dipole–dipole interaction, in addition to the short-range and isotropic contact interaction usually at work in ultracold gases. The specific properties emerging from the dipolar interaction are emphasized, from the mean-field regime valid for dilute Bose–Einstein condensates, to the strongly correlated regimes reached for dipolar bosons in optical lattices.

Astrophysics and cosmology

Angular momentum and the formation of stars and black holes

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In the formation of compact objects like stars and black holes, nearly all of the initial angular momentum of the diffuse material from which they form must be removed or redistributed. This article reviews the mechanisms involved for (1) low-mass stars, most of which probably form in binary or multiple systems, (2) massive stars, which typically form in clusters, and (3) supermassive black holes that form in galactic nuclei. In all cases, gravitational interactions with other stars in a forming system probably play an important role in redistributing angular momentum. If this is true, the formation of stars and black holes must be a more complex, dynamic and chaotic process than in standard models.

The physical properties of extra-solar planets

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Since the discovery of a Jupiter orbiting the nearby Sun-like star 51 Pegasi in 1995, significant progress in the science of extrasolar planets has been achieved. This article reviews our current knowledge of the physical properties of exoplanets, internal structure and composition, atmospheric signatures, including expected biosignatures for exo-Earth planets, evolution, and the impact of tidal interaction and stellar irradiation on these properties for short-period planets. A discussion of our present understanding of planet formation is provided together with a critical examination of the different suggested formation mechanisms.

The icy Jovian satellites after the Galileo mission

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The icy satellites of Jupiter have diverse characteristics. Their initial compositions were determined by conditions in the circum-Jovian nebula, and they evolved under the complex interplay of orbital and geophysical processes. This article reviews theories of their formation, studies of their plausible orbital evolution, measurements of geophysical properties, observations of the geological structure of their surfaces, and theoretical modeling of the processes that connect these. The three large icy satellites probably contain significant liquid water. Each of the four moons is fascinating in its own right, and the ensemble provides a powerful set of constraints on the processes that led to their formation and evolution.

Thermodynamical aspects of gravity: new insights

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The fact that one can associate thermodynamic properties with horizons brings together principles of quantum theory, gravitation and thermodynamics and possibly offers a window to the nature of quantum geometry. This review discusses certain aspects of this topic, concentrating on new insights gained from some recent work. After a brief introduction of the overall perspective, the pedagogical background on the geometrical features of bifurcation horizons, the path integral derivation of horizon temperature, black hole evaporation, the structure of Lanczos–Lovelock models, and the concept of Noether charge and its relation to horizon entropy is provided. Several conceptual issues introduced by the existence of temperature and entropy of the horizons are discussed, together with the connection between horizon thermodynamics and gravitational dynamics. The article finishes by providing a thermodynamic interpretation of the field equations of gravity in any diffeomorphism invariant theory and by obtaining the field equations of gravity from an entropy maximization principle.
This article reviews both the theoretical and experimental efforts in searching for the role of spin/polarization in gravitation. Torsion, Poincaré gauge theories, teleparallel theories, metric-affine connection theories and pseudoscalar (axion) theories are discussed, as well as laboratory searches for electron and nucleus spin-couplings and the role played by angular momentum and rotation. The article also covers astrophysical and cosmological searches for photon polarization coupling and surveys the evidence for the weak equivalence principle II before discussing the strategies for performing experiments aimed at probing the microscopic origins of gravity.

Thick brane solutions

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This article provides a comprehensive review on thick brane solutions and related topics. Such models have attracted much attention from many aspects since the birth of the brane world scenario. In many works it has been usually assumed that a brane is an infinitely thin object, however in more general situations one can no longer assume this. Many multidimensional field theories coupled to gravitation have exact solutions of gravitating topological defects, which can represent our brane world. The inclusion of brane thickness can realize a variety of possible brane world models and this article provides an overview of the approaches to obtain cosmological equations in the thick brane world. Solutions with spatially extended branes (S-branes) and those with an extra time-like direction are also discussed.

The dark matter of gravitational lensing

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Evidence from many sources now implies that five sixths of the material content of the universe is in the form of dark matter—separate from and beyond the ordinary ‘baryonic’ particles in the Standard Model of particle physics. This article reviews progress in understanding dark matter by astrophysics, and in particular via the effect of gravitational lensing. The curvatures of space-time near any gravitating mass (including dark matter) deflects passing rays of light—observably shifting, distorting and magnifying the images of background galaxies. Measurements of such effects currently provide constraints on the mean density of dark matter and its density relative to baryonic matter, the size and mass of individual dark matter particles, and its cross section under various fundamental forces.

The magnetic fields of forming solar-like stars

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Magnetic fields play a crucial role at all stages of the formation of low mass stars and planetary systems. However, it is only in the past few years that the current generation of optical spectropolarimeters has allowed the magnetic fields of forming solar-like stars to be probed in unprecedented detail. In order to do justice to the recent extensive observational programs, new theoretical models are being developed that incorporate magnetic fields with an observed degree of complexity. This article draws together disparate results from the classical electromagnetism, molecular physics/chemistry and geophysics literature, and demonstrates how they can be adapted to construct models of the large scale magnetospheres of stars and planets. The incorporation of multipolar magnetic fields into new theoretical models towards driving future progress in the field through the elucidation of several observational conundrums is also examined.

2011 – Celebrating 100 years of superconductivity

This year Reports on Progress in Physics will be publishing a very special collection of review articles surveying the field of ‘Iron-Based Superconductors’, edited by George Crabtree, Laura H Greene and Peter Johnson.

iopscience.org/ropp
Warm inflation and its microphysical basis

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Warm inflation is the only alternative dynamical realization of inflation to the standard scenario. This article describes the warm inflation scenario along with its results, predictions and comparison with the standard cold inflation scenario and discusses the basics of thermal field theory required in the study of warm inflation. It gives specific results of dissipation coefficients for a variety of quantum field theory interaction structures relevant to warm inflation, in a form that can readily be used by model builders and presents different particle physics models realizing warm inflation along with their observational predictions.

LIGO: the Laser Interferometer Gravitational-Wave Observatory

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The goal of the Laser Interferometric Gravitational-Wave Observatory (LIGO) is to detect and study gravitational waves of astrophysical origin. Direct detection of gravitational waves holds the promise of testing general relativity in the strong-field regime, of providing a new probe of exotic objects such as black holes and neutron stars and of uncovering unanticipated new astrophysics. LIGO operates three multi-kilometer interferometers which are the result of decades of worldwide technology development, design, construction and commissioning. This article provides an overview of the latest status of the LIGO detectors, explaining how they operate, how they have achieved their high sensitivity and how their data can be used to learn about a variety of astrophysical phenomena.

Approaches to understanding cosmic acceleration

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The natural expectation is that an expanding universe, evolving under the rules of general relativity and populated by standard matter sources, will undergo deceleration—the expansion rate should slow down as cosmic time unfolds. Over the last decade however a mounting body of observational evidence has shown that the rate of expansion is actually speeding up—that is, we observe cosmic acceleration. Following a brief discussion of the evidence so far, this article reviews the theoretical approaches to explaining the observed acceleration of the universe.
How far are we from the quantum theory of gravity?

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This article provides a pedagogical explanation of what it is about quantization that makes general relativity go from being a nearly perfect classical theory to a very problematic quantum one. In doing so, the work addresses why some quantization of gravity is unavoidable, why quantum field theories have divergences, why the divergences of quantum general relativity are worse than those of the other forces, what physicists think this means and what they might do with a consistent theory of quantum gravity if they had one. Quantum gravitational data that have recently become available from cosmology are also discussed in relation to these issues.

Nuclear and particle physics

Spin-polarized high-energy scattering of charged leptons on nucleons

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Most of our present knowledge of the structure of the proton is based on experimental measurements interpreted within the rich framework of quantum chromodynamics. An area presently attracting intense interest, both experimental and theoretical, is the relationship between the spin of the proton and the spins and orbital angular momenta of its constituents. While remarkable progress has been made, especially in the last decade, the discovery and investigation of new concepts has revealed that much more remains to be learned. This progress is reviewed in this article and an outlook for the future is offered.

The R-matrix theory

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The R-matrix theory is a powerful tool of quantum physics and at present its main aim is to describe scattering states resulting from the interaction of particles or systems of particles, which can be nucleons, nuclei, electrons, atoms and molecules. Over the years, two variants have been developed: (i) the ‘calculable’ R-matrix method and (ii) the ‘phenomenological’ R-matrix method. This article provides an overview of the different facets of the R-matrix method, presented pedagogically in a general framework. Through simple examples from both nuclear and atomic physics the two variants of R-matrix theory are explained and illustrated, and more recent (and ambitious) applications of the theory in nuclear physics are also presented.

The evaluation of $V_{ud}$ and its impact on the unitarity of the Cabibbo–Kobayashi–Maskawa quark-mixing matrix

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Although the 3 × 3 quark-mixing matrix, now known as the Cabibbo–Kobayashi–Maskawa (CKM) matrix, was not formulated until 1973, the first publication that could be said to have started physicists on the path that ultimately led to the determination of $V_{us}$, its top-left element, dates back some twenty years earlier. This article reviews the determination of this CKM matrix element on the basis of data from superallowed beta decay in nuclei, neutron decay, beta decay of odd-mass mirror nuclei and pion beta decay. Data leading to the determination of the $V_{us}$ and $V_{ub}$ matrix elements are also summarized, and the constraints that their values place on selected extensions to the Standard Model are discussed.

Fermi Gamma-ray Space Telescope: high-energy results from the first year

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High-energy gamma-ray radiation provides an important astrophysical probe of physical processes in extreme environments and of new physics, e.g. particle acceleration to ultra-relativistic energies in the vicinity of black holes, neutron stars and supernovae remnants, and possible signatures of dark matter decay or annihilation. This article provides a summary of the published results from observations made with the Large Area Telescope on the Fermi Gamma-ray Space Telescope during the first year of science operations that began in August 2008.
Pilot-wave theory and quantum fields

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Pilot-wave theories provide possible solutions to the measurement problem. In such theories, quantum systems are not only described by the state vector, but also by some additional variables such as particle positions, field configurations and strings. This review presents an overview of pilot-wave theories in which the additional variables are field configurations. Various bosonic quantum field theories including the Schrödinger field, the free electromagnetic field, scalar quantum electrodynamics and the Abelian Higgs model are all discussed.

Time projection chambers

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The time projection chamber (TPC) was originally proposed to enable full reconstruction of events of up to 20 particles at an electron–positron collider and to provide three-dimensional information for tracking and momentum measurement, together with particle identification by multiple ionization sampling. Applications in other fields have ranged from studies of rare events of simple structure to heavy ion collisions. This article provides an overview of the basic physics, performance and limitations of drift chambers in general, before discussing the specific characteristics of TPCs and their practical realization and performance. The development of TPCs over the last 30 years is covered and as well as the outlook for applications in the future.

Review of high energy diffraction in real and virtual photon–proton scattering at HERA

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Diffraction phenomena in particle physics have been well known since the 1960s. In hadron–hadron scattering these processes are phenomenologically described by the exchange of a virtual colourless and flavourless neutral object carrying no quantum numbers, called the Pomeron. The electron–proton collider HERA at DESY opened the door for the study of diffraction in real and virtual photon–proton scattering at centre-of-mass energies up to 250 GeV. This article reviews the results on diffraction in high energy photon–proton and deep-inelastic electron–proton scattering obtained up to 2008 by the experiments H1 and ZEUS at HERA which were in operation between 1992 and 2007.
Physics at a future Neutrino Factory and super-beam facility

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This article presents the conclusions of the Physics Working Group of the International Scoping Study of a future Neutrino Factory and super-beam facility. It proposes an extensive experimental programme to understand the properties of the neutrino and discusses the role of high-precision measurements of neutrino oscillations. It compares the performance of second generation super-beam experiments, beta-beam facilities and the Neutrino Factory. High-precision studies of the properties of the muon are complementary to the study of neutrino oscillations. The Neutrino Factory has the potential to provide extremely intense muon beams and the physics potential of such beams is discussed.

Earth science

Solar radiation transport in the cloudy atmosphere: a 3D perspective on observations and climate impacts

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The interplay of sunlight with clouds presents major challenges for science because of the spatial complexity of clouds and the dominance of multiple scattering of light. This article reviews 3D atmospheric radiative transfer. It considers how to assess and mitigate the damage (bias) caused by 3D effects in the operational 1D radiative transfer models and whether we can exploit 3D radiative transfer phenomena to innovate observation methods and technologies. The smallest scale resolved computationally or observationally is a key quantity that separates the 3D radiative transfer solutions into two classes: stochastic and deterministic. Both approaches draw on classic and modern statistical, mathematical and computational physics.

Thermodynamics of the Earth

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Applications of elementary thermodynamic principles to the dynamics of the Earth lead to robust, quantitative conclusions about the tectonic effects that arise from convection. The grand pattern of motion conveys deep heat to the surface, generating mechanical energy with a thermodynamic efficiency corresponding to that of a Carnot engine operating over the adiabatic temperature gradient between the heat source and sink. Complications that arise from mineral phase transitions can be used to illuminate details of the motion. There are two superimposed patterns of convection, plate subduction and deep mantle plumes, driven by sources of buoyancy, negative and positive, respectively, at the top and bottom of the mantle. Uncertainty persists over the core energy balance because thermal conduction is a drain on core energy that has been a subject of diverse estimates, with attendant debate over the need for radiogenic heat in the core. This article provides an overview of the geophysical approach to thermal physics, especially thermal expansion and the Grüneisen parameter, and the unique insights it can provide.

Abrupt global events in the Earth’s history: a physics perspective

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The timeline of the Earth’s history reveals quasi-periodicity of the geological record over the last 542 million years, on timescales close, in order of magnitude, to 1 million years. This Key Issues Review discusses the origin of this quasi-periodicity and the nature of the global events that define the boundaries of the geological timescale. In doing so, a single mechanism is proposed for three such events: mass extinctions, geomagnetic polarity reversals and sea-level fluctuations.

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You can read the ROPP Highlights of 2010 for free until 31 December 2011. These articles represent the breadth and excellence of the work published in the journal last year, and were selected by the Editorial Board for their outstanding reviews of key fields of current interest.

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Nucleation in the atmosphere

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Small particles play major roles in modulating radiative and hydrological fluxes in the atmosphere and therefore impact both climate and weather. This article provides a comprehensive overview of the process responsible for creating most atmospheric particles—nucleation. After summarizing the relevant characteristics of the troposphere, an outline of the literature on theoretical approaches to the study of particle nucleation is presented. A particular examination of the two most important instances of atmospheric nucleation is also provided: (i) the nucleation of small aqueous solution droplets from the gas phase and (ii) the nucleation of ice particles from the liquid.

General physics

The birth of the blues: how physics underlies music

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Art and science have intimate connections, although these are often underappreciated. Western music provides compelling examples. The sensation of harmony and related melodic development are rooted in physical principles that can be understood with simple mathematics. The focus of this review is not the better known acoustics of instruments, but the structure of music itself. The physical basis of the evolution of Western music in the last half millennium is discussed, culminating with the development of the ‘blues’ and this article refers to a number of works which expand the connections, and introduces material specific to the development of this genre. Brief reference is also made to the value of music as a tool for teaching physics, mathematics and engineering to non-scientists.

Precision mass measurements

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Precision mass measurements today are required in various fields with balances being used in trade, in the fields of chemistry, health, environment, and in science and development. This article describes mass as a physical quantity, and discusses the principles and methods of its measurement culminating in a review of experiments and recent discussions for a future new definition of the kilogram, the SI unit of mass.
Celebrating 100 years of superconductivity

This year marks the 100th anniversary since superconductivity was discovered in Leiden, the Netherlands, by Heike Kamerlingh Onnes and his co-workers on 8 April 1911. Yielding no less than seven Nobel prizes, the study of superconductors remains more active than ever in terms of forming a fundamental understanding of their underlying mechanism, and in seeking new and novel applications that already extend to digital electronics, sensors, medicine and metrology.

In recognition of this centennial year we are pleased to present a collection of superconductivity-themed review articles published in Reports on Progress in Physics over the last 10 years. Reflecting the wide-reaching impact of superconductors across many areas of physics, each article will be free to read until the end of 2011.

Tim Smith, Senior Publisher

iopscience.org/ropp

Image: Superconducting ceramic Y-Ba-Cu-O at 123 Kelvin, at NRIM lab, Tsukuba Science City, Japan. Courtesy: Takeshi Takahara/Science Photo Library.
We would like to thank all of our authors, referees, boards members and supporters across the world for their vital contribution to the work and progress of *Reports on Progress in Physics*.