REVIEWS of MODERN PHYSICS

Volume 81 **Number 2** **April–June 2009**

445 **High-order harmonics from laser-irradiated plasma surfaces**

U. Teubner
P. Gibbon

The generation of high order harmonics of the laser frequency during high intensity laser-plasma interactions is reviewed. Nonlinear processes, including relativistic effects, govern the method. The harmonics could have high enough frequencies and sufficient coherence to rival x-ray and free electron lasers for ultrafast physical, chemical, and biological imaging. The coherent sum of many harmonics allows the generation of attosecond pulse (10–15 s) for studies of ultrafast chemistry and physics. The state of understanding of this field is discussed and prospects for future advances are presented.

481 ***Colloquium*: Electron-lattice interaction and its impact on high T_c superconductivity**

V. Z. Kresin
S. A. Wolf

Superconductivity originates with electrons that form bound Cooper pairs in a lattice and serve as the charge carriers. This Colloquium discusses the electron-lattice interaction responsible for the attractive force that underlies the electron pairing in novel superconducting systems, especially in the high T_c cuprates. Both the theoretical framework for explaining superconductivity and the experimental evidence for proposed mechanisms are described.

503 **Heat transfer and large scale dynamics in turbulent Rayleigh-Bénard convection**

Guenter Ahlers
Siegfried Grossmann
Detlef Lohse

Generally considered an annoyance on airplane flights, convective turbulence is a ubiquitous and important phenomenon, controlling weather patterns, transport in stellar interiors, and Earth's magnetic field. Moreover, from the perspective of basic physics, Rayleigh-Bénard convection is the paradigm for emergent behavior—the presence of a rich phenomenology at long length scales which bears little, if any, semblance to the microscopic or atomistic description of the same system. In this review, the authors guide the reader through one aspect of convection, namely, heat transfer and flow at large length scales.

539 **Random matrices and chaos in nuclear physics: Nuclear structure**

H. A. Weidenmüller
G. E. Mitchell

Predicting the long-term behavior of any chaotic system is impossible, simply because it is impossible to know the initial conditions with sufficient precision. Manifestations of classical chaos in quantum systems are dealt within a subfield known as quantum chaos. Its origins are rooted in nuclear physics theory—specifically in the random-matrix theory that was developed in the 1950s and 1960s, initially by Nobel Prize winner Eugene Wigner, to explain statistical properties of the compound nucleus in the regime of neutron resonances. Today, random matrix theory is the basic tool of the interdisciplinary field of quantum chaos, and the atomic nucleus is still a prime laboratory of chaotic phenomena. This article reviews the applicability of random-matrix theory to nuclear spectra. It is concluded that chaos is a generic property of nuclear spectra, except for the low-energy region.

591 **Statistical physics of social dynamics**

Claudio Castellano
Santo Fortunato
Vittorio Loreto

How can a group of simple atoms or molecules apparently respond and react in a collective fashion? The study of statistical physics has provided a framework to understand this sort of simplicity which arises in many-particle systems. Social organizations, formed out of conspiring and cognizant actors, are the new challenge to the statistical mechanical approach. This review provides a broad overview of the current thinking in the dynamics of opinion, crowds, language, and other cultural structures.

647 **Rotating trapped Bose-Einstein condensates**

Alexander L. Fetter

The appearance of quantized vortices provides immediate and dramatic evidence of superfluidity in a quantum gas. This article focuses on the physics of quantized vortices in dilute trapped quantum gases. In a slowly rotating condensate single vortices or small numbers of vortices are shown to occur, and as the rotation rate increases the vortices form a dense triangular array. As the rotation rate is further increased the collective behavior of these vortices becomes significant. Ultimately, the rotating Bose gas is predicted to make a quantum phase transition to one of several highly correlated ground states, analogous to those familiar from the fractional quantum Hall effect for electrons. The article focuses on models and predictions with experimental basis or confirmation.

693 **Hamiltonian theory of guiding-center motion**

John R. Cary
Alain J. Brizard

Guiding-center motion theory provides a reduced set of dynamical equations for the movement of charged particles in electromagnetic fields that vary slowly in space or time. This article reviews various Hamiltonian theories of guiding-center motion, both canonical and noncanonical. Those theories are guaranteed to show energy conservation for time-independent fields.

739 **Wetting and spreading**

Daniel Bonn
Jens Eggers
Joseph Indekeu
Jacques Meunier
Etienne Rolley

Wetting is a pervasive phenomenon which is the key to capillary flow in plants, the secret ingredient of ice skating, and necessary for the proper coating of optical and electronic devices. However, the basic understanding of wetting is far from simple and there are still many open questions and puzzles. In this review, the authors lead the reader through the current knowledge and static and dynamic wetting, spreading on random substrates, and highlight the burning issues in the field.

807 **Multipolar interactions in *f*-electron systems: The paradigm of actinide dioxides**

Paolo Santini
Stefano Carretta
Giuseppe Amoretti
Roberto Caciuffo
Nicola Magnani
Gerard H. Lander

Actinide dioxides with localized f electrons provide physical systems where the delicate balance of the various multipolar interactions can be modeled with relatively simple Hamiltonians and thoroughly studied. This review provides a comprehensive overview of the theoretical and experimental tools used to characterize and understand the physics of actinide dioxides and their role as archetypes of systems dominated by multipolar interactions.

865 **Quantum entanglement**

Ryszard Horodecki
Paweł Horodecki
Michał Horodecki
Karol Horodecki

From the point of view of quantum information science, entanglement is a resource that can be used to perform tasks that are impossible in a classical world. In a certain sense, the more entanglement we have, the better we can perform those tasks. Thus, one of the main goals in this field has been to identify under which conditions two or more systems are entangled, and how entangled they are. This paper reviews the main criteria to detect entanglement as well as entanglement measures and also discusses the role of entanglement in quantum communication and cryptography.

943 ***Colloquium*: Modeling the unconventional superconducting properties of expanded A_3C_{60} fullerides**

Massimo Capone
Michele Fabrizio
Claudio Castellani
Erio Tosatti

Fullerides, in which atoms or molecules are interspersed within a lattice of fullerene molecules, display a variety of electrical properties, from superconductivity to Mott insulator. The electron pairing responsible for superconductivity changes with expanding distance between fullerenes, and can be altered either by pressure or by choice of cation. This Colloquium describes a Hubbard-type model, where electrons hop between molecular sites, each endowed with intramolecular interactions including Jahn-Teller phonons and Coulomb exchange. Electronic correlations are evaluated from dynamic mean-field theory, to explain these properties, drawing on numerical simulation but successfully fitting a variety of experimental observations and making precise predictions.

Forthcoming articles