

REVIEWS of MODERN PHYSICS

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011001 *Colloquium: Nanoplasmas generated by intense radiation*

Physical phenomena at the nanoscale can be considerably different from the behavior in the macroscopic world. This rule is also true for plasmas at the nanoscale. This Colloquium discusses nanoplasmas from the experimental and theoretical point of view and shows that nanoplasmas can also have applications in certain technological areas.

Kostya (Ken) Ostrikov
Farhat Beg
Andrew Ng

011002 *Colloquium: Water's controversial glass transitions*

Besides being fundamental for life on Earth, water is one of the most complex materials in nature. Due to the unusual properties of the hydrogen bond, water displays numerous crystalline as well as amorphous states and the glass and phase transitions among them have led to much controversial discussion. This Colloquium reviews water's amazing properties and different approaches to understand them.

Katrin Amann-Winkel
Roland Böhmer
Franz Fujara
Catalin Gainaru
Burkhard Geil
Thomas Loerting

015001 *Lattice tests of beyond standard model dynamics*

Originally developed for quantum chromodynamics at strong coupling, lattice approximations provide an essential tool applicable to any strongly coupled gauge theory. The resolution of the lightweight Higgs puzzle may require new strongly coupled gauge theories at shorter distances. This review introduces the modern lattice tool kit as a combination of analytical and numerical techniques. Numerous applications to new physics with strong coupling gauge theories are presented, and results analyzed.

Thomas DeGrand

015002 *Jerusalem lectures on black holes and quantum information*

The quantum mechanics of black holes, and particularly the information paradox, have been a crucial arena for testing theories of quantum gravity. This review covers the quantum physics of black holes, anti-de Sitter/conformal field theory duality and holography, and the recent firewall paradox, with a focus on ideas from quantum information theory.

D. Harlow

015003 *Experimental tests of particle flow calorimetry*

Methods of measuring the energies of jets have relied on detection of photons, charged hadrons, and neutral hadrons in a sampling calorimeter. However, the response for each particle is different, leading to poor jet energy resolution. Improved energy resolution for future studies of Higgs bosons and new particles decaying to jets requires improved energy resolution. The particle flow algorithm recognizes that charged particle momenta are better measured than their energies, so considerable improvement in energy resolution can be made using track momenta and substituting the energy deposited in the calorimeter. This article describes beam tests of the particle flow algorithm and the confrontation of data and simulations.

Felix Sefkow
Andy White
Kiyotomo Kawagoe
Roman Pöschl
José Repond

015004 Big bang nucleosynthesis: Present status

How do we understand the production of the lightest nuclides from H to Li during the first seconds of cosmic time? This article reviews recent developments based on new precision cosmic microwave background measurements from the *Planck* satellite and observational abundance data. Utilizing updated input on nuclear reactions and the neutron lifetime as well as limits on the baryon density of the Universe obtained from *Planck* data leads to a number of neutrino flavors.

Richard H. Cyburt
Brian D. Fields
Keith A. Olive
Tsung-Han Yeh

015005 Delayed-choice gedanken experiments and their realizations

Wave-particle duality lies at the root of quantum mechanics and is central in the description of interferences observed with elementary objects. In a delayed-choice experiment, the decision to observe the particle or wave character of a quantum system is delayed with respect to the time at which the system enters the interferometer. This paper reviews the history of the delayed-choice idea, introduced as a challenge to a realistic explanation of the wave-particle duality. It also describes recent experimental realizations of this idea and discusses intriguing extensions, such as the duality between separability and entanglement in multiple quantum systems.

Xiao-song Ma
Johannes Kofler
Anton Zeilinger

015006 The physics of x-ray free-electron lasers

The advent of x-ray free-electron lasers has made possible the study of matter at the characteristic space and time scales of atomic and molecular phenomena using intense coherent x-ray pulses. This article describes the physical principles and theoretical models governing the interaction of charged particles, electromagnetic waves, and external magnetic fields that comprise the x-ray free-electron lasers. It also includes a discussion of existing facilities and avenues for increasing the peak power and improving the control of spectral and coherence properties to allow the exploration of an even larger range of phenomena.

C. Pellegrini
A. Marinelli
S. Reiche

015007 Linac Coherent Light Source: The first five years

In the five years since achieving first light at the Linac Coherent Light Source, transformative studies have been conducted in a new regime with femtosecond pulses of short-wavelength, high-intensity x rays. This article summarizes these results in atomic, molecular, and optical physics; condensed matter physics; matter in extreme density, temperature, and pressure conditions; chemistry and soft matter; and biological structure and dynamics. In each of these areas, perspectives for future research are discussed.

Christoph Bostedt
Sébastien Boutet
David M. Fritz
Zhirong Huang
Hae Ja Lee
Henrik T. Lemke
Aymeric Robert
William F. Schlotter
Joshua J. Turner
Garth J. Williams

015008 Physics of Alfvén waves and energetic particles in burning plasmas

In magnetic fusion reactors relying on the burning of deuterium and tritium, sufficient confinement of the alpha particles produced in the nuclear reactions is crucial to sustaining the burning plasma. In this article the interactions of these energetic particles with linear and nonlinear Alfvén waves generated in the magnetized plasma are reviewed.

Liu Chen
Fulvio Zonca