REVIEWS of MODERN PHYSICS

Volume 81 **Number 4** **October–December 2009**

1353 **Complex plasmas: An interdisciplinary research field** — Gregor E. Morfill, Alexei V. Ivlev

Dusty complex plasmas are composed of a weakly ionized gas and charged microparticles or dust. Such plasmas constitute a model system giving us an opportunity to go beyond the limits of continuous media and study atomistic processes occurring in classical liquids or solids, in regimes ranging from the onset of cooperative phenomena to large strongly coupled systems. The generic properties of complex plasmas and their connections with classical condensed matter are described.

1405 **The physics of the intergalactic medium** — Avery A. Meiksin

Intergalactic space is filled with neutral and ionized gas which constitutes the so-called intergalactic medium (IGM). The properties of the IGM can be studied experimentally through the absorption features the gas produces in the spectra of quasistellar objects. The features reveal a highly fluctuating medium well reproduced by gravity-hydrodynamics simulations in standard cosmological structure formation scenarios. The IGM can probe primordial density fluctuations on scales unavailable to other methods. It is the principal source of baryons for galaxy formation, while detected metal systems within the IGM indicate early enrichment by evolved stars. This article reviews the current understanding of the structure and physical properties of the IGM and its relation to galaxies and their formation.

1471 ***Colloquium*: Phase transitions in polymers and liquids in electric fields** — Yoav Tsori

Electric fields deform the interface between two liquids which may lead to interfacial instabilities, orientation, and phase transitions in simple liquids or heterogeneous polymers. This Colloquium describes experimental studies and theoretical models of various polymeric systems of interest.

1495 **Spin mapping at the nanoscale and atomic scale** — Roland Wiesendanger

Modern spin-sensitive microscopy techniques have made possible the direct observation of spin structures at an atomic scale. This review gives an overview of these techniques and their exciting applications, which include the discovery of novel types of magnetic order at the nanoscale.

1551 **Superconducting phases of *f*-electron compounds** — Christian Pfleiderer

Intermetallic *f*-electron compounds challenge a number of long-held beliefs about the origin of superconductivity, e.g., that magnetism is detrimental to superconductivity. They also provide some of the most convincing evidence yet for unconventional pairing in superconductors. This paper provides a review of the experimental evidence for the interplay between, and the coexistence of, superconductivity with both ferromagnetism and antiferromagnetism in these materials, as well as other electronic degrees of freedom.

1625 **X-ray Thomson scattering in high energy density plasmas** — Siegfried H. Glenzer, Ronald Redmer

X-ray Thomson scattering has been developed to study high energy density plasmas. This technique employs powerful x-ray sources and allows the characterization of solid density plasmas and compressed matter. Besides extracting standard plasma parameters, x-ray Thomson scattering allows critical experimental tests of many-particle theory.

1665 **Nonequilibrium fluctuations, fluctuation theorems, and counting statistics in quantum systems** — Massimiliano Esposito, Upendra Harbola, Shaul Mukamel

Quantum systems not in thermodynamic equilibrium are difficult to describe theoretically, but certain simple statements can still be shown to hold. The best known example is the fluctuation-dissipation theorem, which relates the response of quantum systems close to equilibrium to equilibrium fluctuations. This paper reviews the important topic of universal properties of fluctuations in quantum systems far from equilibrium, which are known as fluctuation theorems.

1703 ***Colloquium*: Statistical mechanics of money, wealth, and income** — Victor M. Yakovenko, J. Barkley Rosser, Jr.

"Econophysics"—a fast growing subfield of physics in which physicists and economists interact with each other—comprises mainly the application of statistical models to examine the distribution of money, wealth, and income amongst economic agents. This Colloquium written jointly by a physicist and an economist deals with these topics and introduces concepts, e.g., by analogy with the Boltzmann-Gibbs distribution of energy in physics, which imply an exponential probability distribution of money for certain class of models with interacting economic agents. Furthermore, conservation laws—and their exceptions—all find applications.

1727 ***Colloquium*: The Einstein-Podolsky-Rosen paradox: From concepts to applications** — M. D. Reid, P. D. Drummond, W. P. Bowen, E. G. Cavalcanti, P. K. Lam, H. A. Bachor, U. L. Andersen, G. Leuchs

The Einstein-Podolsky-Rosen paradox—the seemingly absurd but true consequence of quantum mechanical correlations between degrees of freedom—quantifies as various inequalities based on the Heisenberg uncertainty relations. This Colloquium describes experimental and theoretical advances related to measuring and interpreting these inequalities, as well as wide ranging applications up to the engineering of quantum key distributions, quantum teleportation, and entanglement swapping.

1753 ***Colloquium*: Star-branched polyelectrolytes: The physics of their conformations and interactions**

Arben Jusufi
Christos N. Likos

Star electrolytes are macromolecules of charged polymer chains anchored to a single fixed center, with novel properties intermediate to linear polymers and spherical soft colloids that make them useful for many practical applications. This Colloquium uses simple principles to deduce physical properties, such as size and shape, free energy, and intermolecular forces, illustrated with simulations and experiments.

1773 **Modern theory of nuclear forces**

E. Epelbaum
H.-W. Hammer
Ulf-G. Meißner

The nuclear forces acting between protons and neutrons, that are responsible for the nuclear binding, are residual color forces, much like the van der Waals forces between neutral molecules. The effective field theory allows for a systematic and model-independent derivation of those forces in harmony with the symmetries of quantum chromodynamics (QCD). This review addresses the key concepts, in particular, the spontaneously and explicitly broken chiral symmetry of QCD, and discusses applications to light and heavy nuclei at various resolution scales.

1827 **The Casimir force between real materials: Experiment and theory**

G. L. Klimchitskaya
U. Mohideen
V. M. Mostepanenko

The Casimir effect, a force between objects in vacuum due to vacuum fluctuations, was predicted in 1948, but has only recently become accessible to precision measurements. This paper reviews the current experimental and theoretical status of studies of the Casimir force, and the closely related van der Waals force, which have implications that range from the theory of fundamental interactions beyond the standard model to biophysics and nanomaterials.

1887 **New physics at a Super Flavor Factory**

Thomas E. Browder
Tim Gershon
Dan Pirjol
Amarjit Soni
Jure Zupan

High luminosity e^+e^- storage rings have been proposed as crucial tools for studies of heavy flavor processes that will be important to the understanding of phenomena which might be discovered at the LHC. These new machines will provide samples of charm and beauty mesons as well as tau leptons that exceed current data by two orders of magnitude or more and thus allow searches for processes that are not included in the current standard model of electroweak interactions. This review focuses on the experimental signatures and expected precision as well on the theoretical predictions for processes that are forbidden in the standard model.

1943 **Publisher's Note: The physics of the intergalactic medium [Rev. Mod. Phys. 81, 1405 (2009)]**

Avery A. Meiksin

Forthcoming articles