REVIEWS of MODERN PHYSICS

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799 **Announcement: New Prices and Payment Policy for Color Figures in the Print Journal**

801 ***Colloquium*: The spin-incoherent Luttinger liquid** — Gregory A. Fiete

Low temperatures bring out striking properties of quantum matter. For fermions, prohibited by the Pauli exclusion principle from sharing quantum states, the properties of cold matter depend strongly on the spatial dimensions. Most notably when the particles are confined to one dimension (a wire) a situation known as a Luttinger liquid is realized. As with all condensed matter, the effect of temperature is quantified by comparing the thermal energy kT with the characteristic energies of (collective) excitations. Because electrons interact both through weak spin-dependent magnetic interactions and stronger charge-dependent Coulomb interactions, there exists a regime in which the thermal energy exceeds the characteristic spin-excitation energy yet is much less than the Coulomb-interaction energy. In one dimension this is the regime of the spin-incoherent Luttinger liquid. This Colloquium present some underlying mathematical underpinnings for describing such systems, and describes some experimental results indicating its realization in quantum wires.

821 ***Colloquium*: Soap bubble clusters** — Frank Morgan

Clusters of bubbles occur in households not only as soapy froth but in foams, cushions, and bread. Such structures appear also in more technical applications, metallurgy, magnetic domains, and liquid crystals. It is known that a single round bubble and a conjoined bubble pair have the least possible total surface area. But despite centuries of interest by mathematicians, much remains unknown for more complicated clusters, even those formed as two-dimensional films or confined within a box. This Colloquium reviews some of the known, the unproven, and the unknown properties of bubbles.

829 **Spatiotemporal order out of noise** — Francesc Sagués, José M. Sancho, Jordi García-Ojalvo

While noise in natural systems typically leads to disorder, in the presence of strong nonlinearities it is possible for more regular behavior to emerge. Particularly interesting examples of this behavior are found in spatially extended systems, described mathematically by stochastic partial differential equations. This review presents an overview of systems displaying this phenomenon and the mathematical and computational challenges of their description, with examples drawn from the fields ranging from fluid dynamics to biology.

883 **Simple viscous flows: From boundary layers to the renormalization group**

John Veysey II
Nigel Goldenfeld

The Stokes drag formula for a sphere is an essential ingredient in the understanding of Brownian motion, low Reynold's number propulsion, and even the Millikan oil drop experiment. However, the systematic treatment of the viscous flow around the sphere has proved subtle and spawned the mathematical development of singular perturbation theory. In this review, it is shown that the renormalization group, familiar in the theory of critical phenomena and quantum field theory, can be applied to this problem with stunning success. The authors thoroughly review the history of the problem and connect the more traditional approaches based on matched asymptotic expansions to the renormalization group methods.

929 ***Colloquium*: Illuminating the Kapitza-Dirac effect with electron matter optics**

H. Batelaan

The Kapitza-Dirac (KD) effect is the diffraction of an electron beam by a standing light wave. The interpretation of the effect is considered here from both wave and particle pictures. The two-color KD effect, i.e., electron diffraction from counterpropagating laser beams of different frequencies, presents conceptual challenges for the wave picture as there is seemingly no standing light wave grating from which to diffract. Nevertheless, as analyzed in this Colloquium, diffraction is expected and may be understood in either the particle or wave pictures.

943 **Structure and interactions of biological helices**

Alexei A. Kornyshev
Dominic J. Lee
Sergey Leikin
Aaron Wynveen

Many of the essential molecules of life, from proteins to DNA, are helical. Their mutual interactions, and the properties of their aggregates and mesophases, must be understood in light of their helical structure. This review covers recent advances in establishing this link, with a particular focus on the role of electrostatic interactions and elasticity manifested in a wide range of phenomena, including biomolecular aggregation and structural transitions in molecules and assemblies.

997 ***Colloquium*: Random matrices and chaos in nuclear spectra**

T. Papenbrock
H. A. Weidenmüller

Quantum systems are called chaotic if the statistical properties of their eigenvalue spectrum are in accordance with predictions from random-matrix theory (RMT). It is shown in this Colloquium (i) that predictions of RMT often agree well with spectroscopic data in atomic nuclei, and (ii) how this success of RMT—or equivalently the existence of chaos—can be reconciled with the known dynamical features of spherical nuclei which are described by the shell-model plus a residual nucleon-nucleon interaction. The matrix elements of the residual interaction are thereby taken to be random variables which form a so-called two-body random ensemble. Chaos in nuclear structure is then a generic feature of the ensemble with properties which partly differ from those of standard RMT.

1015 **Fermi-liquid instabilities at magnetic quantum phase transitions**

Hilbert v. Löhneysen
Achim Rosch
Matthias Vojta
Peter Wölfle

Fermi-liquid theory, which describes in particular the state of electrons at low temperatures, is one of the central pillars of modern condensed-matter physics. Instabilities of the Fermi-liquid state are therefore of fundamental interest, in addition to leading to very remarkable observable properties. In this article the authors discuss one way for the Fermi-liquid state to break down, namely, the system undergoing a quantum phase transition, and difficulties in understanding the latter within the framework of simple theories.

1077 **NMR survey of reflected Brownian motion**

Denis S. Grebenkov

Nuclear magnetic resonance techniques can be used to probe molecular dynamics in restricted geometries, as found in a wide range of contexts, from biophysical to industrial. A common feature in all of these processes is the interaction of a diffusing quantity with a confining interface, leading to reflected Brownian motion. This review focuses on the mathematical interpretation of this stochastic process and its diverse applications.

Forthcoming Articles