REVIEWS of MODERN PHYSICS

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731 **Hadron structure at low Q^2**

Dieter Drechsel
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Hadrons have a size of about 1 fm and are strongly interacting many-body systems of quarks and gluons. Although the latter cannot be resolved in scattering experiments at relatively low momentum transfer Q in the GeV region, their presence becomes manifestly evident in bound many-body systems like pions, nucleons, and their resonances. This review describes the interaction of electrons and photons with hadrons, presents results on the most significant experimental observables, and compares them with results from phenomenological and theoretical approaches to quantum chromodynamics in the nonperturbative regime.

787 **The Unruh effect and its applications**

Luís C. B. Crispino
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George E. A. Matsas

In 1976 Unruh argued that, in the framework of general relativity and quantum mechanics, uniformly accelerated observers in a zero-temperature Minkowski spacetime observe a thermal bath of particles. This demonstrates that the concept of a "particle" is observer dependent. The authors of this review give a careful explanation of the Unruh effect and its applications to spacetimes with horizons.

839 **Transport phenomena in nanofluidics**

Reto B. Schoch
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Philippe Renaud

As the length scales of channels shrink to the submicron scale, surface effects become ever more important. In particular, Gauss's law of electrostatics plays a pivotal role on these scales along with the ions in the solution being pumped through these nanochannels. In this review, the authors lead the reader through the complex hydrodynamics, thermodynamics, and, especially, electrostatics in these highly confined spaces. The connection and relation to ion channels in membranes is highlighted as is the promise for "lab-on-a-chip" applications.

885 **Many-body physics with ultracold gases**

Immanuel Bloch
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Wilhelm Zwerger

Ultracold gases have had a surprising impact on condensed matter physics: they allow for an experimental realization of simple models for many-body physics, such as the Hubbard model. This review explains how the flexibility of trapped atomic gases can be used to observe important phenomena, such as the superfluid to Mott-insulator and Kosterlitz-Thouless transition, the exactly integrable Lieb-Liniger gas, and the BCS-BEC crossover by means of optical lattices and Feshbach resonances.

965 **Waiting for precise measurements of $K^+ \to \pi^+ \nu\bar{\nu}$ and $K_L \to \pi^0 \nu\bar{\nu}$**

Andrzej J. Buras
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The rare decays $K^+ \to \pi^+ \nu\bar{\nu}$ and $K_L \to \pi^0 \nu\bar{\nu}$, with branching ratios of order $\sim 10^{-10}$ and $\sim 10^{-11}$, respectively, provide a sensitive test of the mechanism for quark mixing and CP violation in the standard model, because the theoretical rates can be accurately predicted. This article gives an introduction to rare K decays in general, and then discusses in detail the theoretical predictions and uncertainties for these two decay modes. The predictions are discussed for the standard model, and for several popular beyond-the-standard-model scenarios.

1009 **Finite-size scaling of ^{4}He at the superfluid transition**

Francis M. Gasparini
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Kevin P. Mooney
Manuel Diaz-Avila

Confined ^{4}He in the critical region near the superfluid transition exhibits behaviors that can often be described in terms of correlation-length scaling. This experimental review describes data for specific heat, superfluid density, and thermal conductivity, for both bulk and confined helium. It discusses the successes and failures of correlation-length scaling with respect to the crossover dimensions of 2, 1, and 0, and also with respect to universality.

1061 ***Colloquium*: Quantum annealing and analog quantum computation**

Arnab Das
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Optimization of parameters in complex systems, based on suitable cost or energy criteria, poses severe challenges for computation. This Colloquium describes techniques, similar to the natural annealing of spin glasses, that can facilitate solutions by supplementing simulation of thermal cooling with quantum tunneling effects.

1083 **Non-Abelian anyons and topological quantum computation**

Chetan Nayak
Steven H. Simon
Ady Stern
Michael Freedman
Sankar Das Sarma

Fault-tolerant quantum computers that are not affected by errors caused by local perturbations are an intriguing prospect. They may be realizable by exploiting topological states of matter whose excitations are neither bosonic nor fermionic in nature, so-called non-Abelian anyons. This review explains the mathematical and physical bases of topological quantum computation, using the $\nu=5/2$ fractional quantum Hall state as an example.

1161 **Quarkonia and their transitions**

Estia Eichten
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Hanna Mahlke
Jonathan L. Rosner

Quarkonium spectroscopy has celebrated a great resurgence in the past few years. Transitions between quarkonium states (bound states of $Q\bar{Q}$, with the heavy quark $Q=b$ or c) shed light on aspects of quantum chromodynamics, the theory of string interactions, in both the perturbative and nonperturbative regimes. New information on such states and their transitions and theoretical implications are discussed.

1195 **Publisher's Note: Finite-size scaling of ^{4}He at the superfluid transition [Rev. Mod. Phys. 80, 1009 (2008)]**

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