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251 ***Colloquium*: Metallic behavior and related phenomena in two dimensions**

Elihu Abrahams
Sergey V. Kravchenko
Myriam P. Sarachik

Experimental evidence is presented of metallic behavior in two-dimensional electron or hole systems that hitherto were expected to be insulators. Decreases of resistivity with decreasing temperature have been found above a critical carrier density and below a certain temperature. The metallic behavior obeys scaling laws and is quenched by a parallel magnetic field. No theory capable of describing the observed phenomena exists.

267 ***W* boson physics at hadron colliders**

Randy M. Thurman-Keup
Ashutosh V. Kotwal
Monica Tecchio
Aesook Byon-Wagner

The *W* boson is an important ingredient of the standard model of electroweak interactions. Since the *W* boson was discovered in 1983 at the CERN $Sp\bar{p}S$ collider, its properties have been precisely measured at hadron colliders and have provided means to test the standard model. This article presents a comprehensive review of *W* boson physics at the Fermilab Tevatron collider and discusses future prospects at the upgraded Tevatron and at the CERN LHC.

307 **Bose-Einstein condensation in the alkali gases: some fundamental concepts**

Anthony J. Leggett

This tutorial on the theory of Bose-Einstein condensation complements the review by Dalfovo *et al.* in Volume 71. The present article emphasizes particularly the derivation of the fundamental equations of the theory, phenomena such as the Josephson effect and the metastable currents that arise in nontrivial topologies, and the role of the hyperfine degree of freedom in experimentally realized condensates.

357 **Quantum-state engineering with Josephson-junction devices**

Yuriy Makhlin
Gerd Schön
Alexander Shnirman

Low-capacity Josephson junctions promise a new quantum technology, which allows the coherent manipulation of these systems on the single-quantum level. This is of particular relevance in view of the present interest in realizing quantum information processors. This article reviews from a theoretical point of view the properties of charge and phase (flux) based Josephson-junction devices and discusses in depth issues related to decoherence.

401 ***Colloquium*: Acoustical analogs of condensed-matter problems** — Julian D. Maynard

A challenging problem of quantum mechanics, the propagation of electron wave functions in nonperiodic scattering media, may get help from acoustics. In this Colloquium the author reviews simple macroscopic acoustic-wave experiments which serve as analogs of quantum wave phenomena that are otherwise inaccessible to detailed study. The experiments provide insight into such diverse phenomena as Anderson localization, electron persistent currents, and quasicrystalline symmetry in two dimensions.

419 **M(atrix) theory: matrix quantum mechanics as a fundamental theory** — Washington Taylor

M theory is an 11-dimensional quantum theory of gravity that is believed to underlie all superstring theories. It is the only candidate at present for a theory that reconciles gravity and quantum field theory. Yet while there has been much progress in formulating such a theory, we still know little beyond the lowest orders of its perturbation expansions. The matrix model of M theory is a possible nonperturbative formulation that might describe general relativity in conventional quantum mechanics.

463 **Spontaneous symmetry breaking in rotating nuclei** — Stefan Frauendorf

The concepts of spontaneous symmetry breaking are applied to the rotating field of nuclei. The appearance of rotational bands is analyzed and new phenomena appear. One of these is magnetic rotation, which can be viewed as the quantized rotation of the anisotropic current distribution in a near-spherical nucleus. Other topics like band termination, reflection-asymmetric nuclei, nonspatial symmetries, methods beyond the mean field, and analogies in finite many-fermion systems outside nuclear physics are also discussed.

515 **Phonons and related crystal properties form density-functional perturbation theory** — Stefano Baroni, Stefano de Gironcoli, Andrea Dal Corso, Paolo Giannozzi

This article reviews the basic theory and examples of applications in crystals, with emphasis on phonon dispersion curves, but also touching other topics such as dielectric response and the calculation of elastic constants.

563 **Forthcoming articles**