REVIEWS of MODERN PHYSICS

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Author guidelines

1 **Critical phenomena in microgravity: Past, present, and future**

M. Barmatz
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J. A. Lipa
R. V. Duncan

Microgravity experiments aim to precisely determine the detailed behavior of fluids near second-order phase transitions where the asymptotic region is sensitive to the effect of gravity. This review provides a summary of space experiments that have been conducted to date, ground preparations for future measurements, and the theoretical context for their interpretation.

53 ***Colloquium*: Coherently controlled adiabatic passage**

Petr Král
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Moshe Shapiro

Properly crafted laser pulses can produce a wide variety of intentional changes to bound quantum states whose behavior is little disrupted by dissipation. These coherent changes can vary from partial to complete transfer of population from an initial state to a predetermined superposition of final degenerate or nondegenerate states. This Colloquium describes the theory underlying a class of techniques for designing such laser pulses by combining concepts of coherent control and adiabatic passage techniques.

79 **Atomic data for x-ray astrophysics**

T. R. Kallman
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The field of x-ray astrophysics has evolved rapidly in recent years. This has been driven by advances both in observational data of high statistical quality and spectral resolution from x-ray astronomy satellites and in the understanding of the astrophysical implications of x-ray spectra associated with planets, comets, and other primarily neutral or solid objects. This review covers extensively as well atomic data from cosmic sources driven by electron ionization and photoionization as their applications to x-ray astronomy.

135 **Linear optical quantum computing with photonic qubits**

Pieter Kok
W. J. Munro
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Jonathan P. Dowling
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With the discovery that efficient scalable quantum computing is possible in principle, linear optics with photon counting has become a prominent candidate for practical quantum computing. This article reviews the original theory and its improvements, and gives examples of experimental two-qubit gates. It also discusses the use of realistic components, the errors they induce in the computation, and how these errors can be corrected.

175 **Inelastic light scattering from correlated electrons**

Thomas P. Devereaux
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Inelastic light scattering has become an important tool for understanding strongly correlated electron systems in general, and high-temperature superconductors in particular. This review focuses on Raman scattering, and its capability to complement other techniques to probe complex systems including $A15$ superconductors, magnetic insulators, and compounds with competing orders, in addition to the cuprates. Emphasis is put on a pedagogical introduction to Raman scattering, and on common features of various strongly correlated electron systems.

235 **Magnetic microtraps for ultracold atoms**

József Fortágh
Claus Zimmermann

Microtraps offer a number of important advantages over conventional magnetic traps for confining degenerate atomic quantum gases. The tight confinement causes a higher vibrational splitting between modes and the miniature design makes it practical to integrate additional tools into the structure. As a result, microtraps are attractive for studying one- and three-dimensional quantum gases, disordered systems, quantum information processing with neutral atoms, integrated atom optics, matter wave interferometry, precision force sensing, and studies of the interaction between atoms and surfaces. This article describes the principles of microtrap design and the experimental considerations of microtrap construction.

291 **Coupled-cluster theory in quantum chemistry**

Rodney J. Bartlett
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The coupled-cluster theory treats the many-electron Schrödinger equation in a way that provides higher accuracy for a given computational cost than other *ab initio* theories. This article derives the equations and reviews its current status for calculating various molecular properties. These include potential energy surfaces and their critical points, ionization potentials, electron affinities, excitation energies, and perturbation effects.

353 **Scanning tunneling spectroscopy of high-temperature superconductors**

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Martin Kugler
Ivan Maggio-Aprile
Christophe Berthod
Christoph Renner

Tunneling spectroscopy has long been recognized as playing a central role in providing experimental verification of the microscopic theory of classical superconductors. When the related techniques of scanning tunneling microscopy and spectroscopy are applied to the more complex high- T_c layered materials, unusual and intriguing details about superconducting properties (enhanced anisotropic gaps, asymmetric density of states, pseudogaps, and anomalous electronic vortex structures) emerge. These details are captured in this comprehensive review, which begins with a presentation of the fundamentals of tunneling and then proceeds with a wide-ranging overview of experimental data and theoretical interpretation.

Forthcoming articles