Reviews of Modern Physics

Volume 71 **Number 1** **January 1999**

Article and Colloquium guidelines

1 **Experiments and theory in cold and ultracold collisions** — John Weiner, Vanderlei S. Bagnato, Sergio Zilio, Paul S. Julienne

Technological advances have permitted experiments to explore atomic collisions at temperatures that are orders of magnitude below that of liquid helium. This review presents the theoretical and experimental physics of such collisions in the range from millidegrees Kelvin to nanodegrees Kelvin, which includes the phenomena of Doppler cooling, optical molasses, magnetic trapping, and Bose-Einstein condensation. At the upper end of this temperature range, laser-light interactions with atoms are an integral part of the cooling process and are a means of controlling atomic collisions; at the lower end, atom recoil effects from light scattering must be avoided and so one must study ground-state atoms in the dark.

87 **Trapped nonneutral plasmas, liquids, and crystals (the thermal equilibrium states)** — Daniel H. E. Dubin, T. M. O'Neil

Pure electron and pure ion plasmas can be confined for days in thermal equilibrium states. When these plasmas are cooled to the cryogenic temperature range, liquid and crystal-like states are realized. This article reviews the theoretical understanding of these nonneutral plasma states.

173 **Photodissociation regions in the interstellar medium of galaxies** — D. J. Hollenbach, A. G. G. M. Tielens

Photodissociation regions are regions of neutral gas in the interstellar medium of a galaxy in which far-ultraviolet radiation (6 eV$<h\nu<$13.6 eV), which is produced primarily by massive young stars, dominates the heating and/or significant aspects of the chemistry. In many spiral galaxies, photodissociation regions include most of the gas in the galaxy, and they emit most of the nonstellar infrared radiation. This comprehensive review summarizes the current state of our observational knowledge and theoretical understanding of these regions.

231 **The adiabatic molecule–metal surface interaction: Theoretical approaches** — G. P. Brivio, M. I. Trioni

The authors review the various theoretical methods that have been applied to the adsorption of molecules on surfaces. The density-functional theory has been widely applied recently to realistic chemisorption systems with considerable success. However, older methods that are less demanding from a computational point of view are still useful. These can be treated by the embedded Green's-function technique.

267 **Multiresolution analysis of electronic structure: semicardinal and wavelet bases** — T. A. Arias

Wavelet theory is a recent development that provides a rigorous basis for multiresolution analysis of functions, with varying degrees of resolution at different points. Interest in this field has mushroomed, with many recent texts and monographs on theory and applications ranging from signal processing to differential equations. This review provides a description of wavelets in a physicist's language for application to continuum problems in the physical sciences, in particular, problems related to the theory of electronic structure. The article reviews several recent developments important for physical calculations including exact recovery from limited sampling and fast algorithms and transforms for physical operators in wavelet and wavelet-like bases.

313 **Multiple scattering of classical waves: microscopy, mesoscopy, and diffusion** — M. C. W. van Rossum, Th. M. Nieuwenhuizen

Transport of waves through opaque media is of importance both in everyday life and in many branches of physics. Examples are radiative transport in stellar atmospheres, white paint, or human tissue, but also diffusion and localization of electrons in disordered solids. Historically, the theories of scattering in these two contexts developed independently of each other; however, the two areas have much in common. This paper gives a unified account of the scattering of electromagnetic waves and matter waves in weakly random environments. Special attention is paid to weak interference effects.

373 **Forty years of antiprotons** — J. Eades, F. J. Hartmann

Ever since its discovery in 1955 the antiproton has been of interest as a high-precision probe of *CPT* invariance and of the gravitational weak-equivalence principle, as well as an object of study in its own right. The measurement of antiproton properties depends in large part on bringing these particles to rest and confining them in electromagnetic traps or in their microscopic counterparts, exotic atoms. The authors review the technical advances in confinement and the body of experimental results over the last four decades. Antiprotons and antihydrogen atoms should play a still more important role in testing *CPT* symmetry and the weak equivalence principle as experiments at new facilities come into line.

RMP Colloquia:

421 **Gravitational microlensing—A report on the MACHO project** — Will Sutherland

One approach to searching for dark matter in the universe is to observe the gravitational deflection (''microlensing'') of light from background stars passing near dark-matter objects. The MACHO team has obtained data for 14 such events and argue that their data are consistent with some dark-matter objects, having masses of the order of a solar mass. This report describes both the measurements and the analyses of the data obtained.

435 **Built upon sand: Theoretical ideas inspired by granular flows** — Leo P. Kadanoff

This article addresses the question of whether granular materials can be described by hydrodynamic equations applicable to ordinary fluids. Experimental evidence indicates they cannot be so described. Statistical dynamics models of simple inelastic collisions among granular particles also confirms that granular motion is different from that of more familiar materials.

445 **Parity violation in the compound nucleus** — G. E. Mitchell, J. D. Bowman, H. A. Weidenmüller

The study of parity violation in nuclei, until recently confined to transitions between well-resolved, low-lying levels, has been revolutionized by two developments. It was predicted that the magnitude of parity-violating effects is enhanced by factors of $\sim 10^5$ in slow neutron scattering from nuclei compared to what is found at low energy. And the ability of theory to treat such collisions using statistical methods obviates the need for nuclear many-body theory to make precise statements about the wave functions of individual nuclear states. The paper describes this recent progress.

459 **Forthcoming articles**