Reviews of Modern Physics

Volume 72 Number 3 July 2000

621 **Theoretical approaches to x-ray absorption fine structure** J. J. Rehr, R. C. Albers

X-ray absorption fine structure provides unique information on the atomic-scale structure of materials. Recent developments have led to a quantitative theory of XAFS, within a multiple-scattering approach, which is described in this review. The review emphasizes the theory of the extended x-ray absorption fine structure well above the threshold and treats to a lesser extent the more complex near-edge structure. The material covered includes formal considerations, derived from a many-electron formulation, as well as practical computational methods, based on independent-electron models.

655 **Molecular dynamics for fermions** Hans Feldmeier, Jürgen Schnack

The past decade has seen increasing interest in the dynamics of many-fermion systems in which correlations and fluctuations are important. One possible approach to the treatment of these systems is based on a quantal concept of molecular dynamics in which the particles of the system are represented by a many-body quantum state. This state is parametrized in terms of a few single-particle degrees of freedom which assume their intuitive meaning in the classical limit, such as position and momentum. The constituents interact through potentials. The authors review different molecular-dynamics models with applications in atomic and nuclear physics.

689 **Observations and implications of the ultrahigh-energy cosmic rays** M. Nagano, A. A. Watson

The existence of cosmic rays with energies in excess of 10^{20} eV seems to be established now, even though the cosmic microwave background should cut off the spectrum above 6×10^{19} eV. The authors review the present status of ultrahigh-energy cosmic ray observations and survey the next generation of experiments to address the question of their origin.

733 **The discovery of the heaviest elements** S. Hofmann, G. Münzenberg

The nuclear shell model predicts that the next doubly magic nucleus beyond ^{208}Pb with proton number $Z=82$ and neutron number $N=126$ would require half again as many protons and neutrons. The present article describes the meticulous experimental searches at

various heavy-ion laboratories of the world to produce superheavy elements in fusion reactions between heavy nuclei. Elements with $Z=107$ to 112 have been synthesized within the last two decades at Darmstadt, and very recently $Z=114$ at Dubna. Most surprising, however, has been the reported discovery of a superheavy element with $Z=118$ in 1999 at Berkeley. These results are discussed in the context of present-day nuclear models.

769 **μSR studies of the vortex state in type-II superconductors** — Jeff E. Sonier, Jess H. Brewer, Robert F. Kiefl

Muon spin rotation (μSR) has proven to be a useful bulk probe of magnetic vortices in superconductors due to the large magnetic moment of the muon, the applicability of the technique to small single crystals, and the flexibility of sample environment. As discussed in this review, experiments can now extract several properties of interest related to the vortex structure, including the magnetic penetration depth and the superconducting coherence length.

813 **Electrophoresis of DNA and other polyelectrolytes: Physical mechanisms** — Jean-Louis Viovy

Electrophoresis, the separation of molecules by electric fields, is an important tool in molecular biology. The physical basis of the molecules' motion involves a variety of mechanisms which are the subject of this review. Improvements in electrophoresis technique can be expected from a better physical understanding of these mechanisms.

RMP COLLOQUIUM

873 **Universality of ac conduction in disordered solids** — Jeppe C. Dyre, Thomas B. Schrøder

The ac conductivity of disordered media shows a universal behavior among very different complex materials. This behavior is analyzed here using a macroscopic and a microscopic model. The two models differ in the scale on which disorder is assumed, but for both models percolation is responsible for the predicted ac universality.

893 **Forthcoming articles**