

REVIEWS of MODERN PHYSICS

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010001 Editorial: From the APS Editor in Chief

Pierre Meystre

011001 *Colloquium: Persistent spin textures in semiconductor nanostructures*

John Schliemann

Spintronics continues to be a field of fast evolution where new concepts and devices are continuously being developed. One of the limiting factors in spintronics is the decoherence time in the materials used. This Colloquium reviews the current situation in the understanding of decoherence in some important semiconductors which are being considered in applications.

011002 *Colloquium: Status of α -particle condensate structure of the Hoyle state*

Akihiro Tohsaki
Hisashi Horiuchi
Peter Schuck
Gerd Röpke

In 1954, Fred Hoyle made a prediction regarding the existence of a resonant state of carbon-12 that would be associated with a triple α process which would be fundamental in nucleosynthesis in stars and would explain the amount of carbon-12 in the Universe. This prediction was spectacularly confirmed by experiments. Nevertheless, the precise properties of the Hoyle state are still the subject of investigation. This Colloquium describes the current theoretical and experimental investigation of this important prediction.

011003 *Colloquium: An algebraic model of localized surface plasmons and their interactions*

T. J. Davis
D. E. Gómez

Localized surface plasmons are collective modes of the conduction electrons excited by light in metal nanoparticles. Although plasmons have been known for some time, their use for controlling light at the nanometer scale only became possible with developments in near-field optics. To model interactions between such collective modes is a complex problem that requires heavy computation. In this Colloquium an algebraic model for plasmons is discussed that elucidates the physics of these collective modes and their interactions.

011004 *Colloquium: Atomic quantum gases in periodically driven optical lattices*

André Eckardt

Dynamics of quantum many-body systems is one of the most complex problems in physics since it involves the time evolution of a large number of particles that interact with each other under the influence of external forces. With ultracold atoms in optical atomic lattices it can be done in a controlled environment by applying a periodic force. This Colloquium covers the experimental and theoretical developments in this exciting field of physics.

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| 015001 | Dynamics of non-Markovian open quantum systems | Inés de Vega
Daniel Alonso |
| | <p>This review gives a summary of the many techniques that are used in the analysis of open quantum systems. Emphasis is on those cases where it is unsuitable to use a memoryless or Markovian point of view, generally because there is no large separation of time scales between system and environment dynamics. The approaches reviewed include master equations, Heisenberg equations of motion, chain mapping representations, and various stochastic methods such as path integral Monte Carlo and stochastic equations. Guidance is given on how to evaluate the suitability of each of these methods for application in different physical problems.</p> | |
| 015002 | Entropic uncertainty relations and their applications | Patrick J. Coles
Mario Berta
Marco Tomamichel
Stephanie Wehner |
| | <p>The Heisenberg uncertainty principle has a more precise formulation in terms of inequalities involving quantum entropies. Currently known entropic uncertainty relations are presented; they capture and extend Heisenberg's idea of the unpredictability of the outcomes of incompatible measurements. Distinct results are obtained for finite- and infinite-dimensional Hilbert spaces. Applications are surveyed, including the formulation of entanglement witnesses, current ideas about wave-particle duality, and the analysis of quantum cryptography.</p> | |
| 015003 | Electron-phonon interactions from first principles | Feliciano Giustino |
| | <p>The electron-phonon interaction in solids is important for many interesting properties of solids, among them the critical temperature of phonon-mediated superconductors, the effective electron mass in metals and semiconductors, and the carrier dynamics in semiconductors. Modern density-functional techniques have made it possible to perform <i>ab initio</i> calculations of the electron-phonon interaction. This review explains these techniques and discusses their applications.</p> | |
| 015004 | Quantum random number generators | Miguel Herrero-Collantes
Juan Carlos Garcia-Escartin |
| | <p>In mathematics and computer science, random numbers have the role of a resource for assisting proofs, making cryptography secure, and enabling computational protocols. This role motivates efforts to produce random numbers as a physical process. Potential physical sources abound, but arguably the most fundamental are those based on elementary quantum mechanical processes. This review discusses the current status of devices that generate quantum random numbers.</p> | |
| 015005 | Light fields in complex media: Mesoscopic scattering meets wave control | Stefan Rotter
Sylvain Gigan |
| | <p>Wave front shaping, the ability to manipulate light fields both spatially and temporally, in complex media is an emerging field with many applications. This review summarizes how insight from mesoscopic scattering theory have direct relevance for optical wave control experiments and vice versa. The results are expected to have an impact on a number of fields ranging from biomedical imaging to nanophotonics, quantum information, and communication technology.</p> | |

015006 Stimulated Raman adiabatic passage in physics, chemistry, and beyond

By use of a pulse sequence, the technique of stimulated Raman adiabatic passage transfers population without loss between quantum states via unstable intermediate states. This article reviews many applications of stimulated Raman adiabatic passage to control quantum states in physics and chemistry, from precision spectroscopy over molecular reactions to quantum information processing.

Nikolay V. Vitanov
Andon A. Rangelov
Bruce W. Shore
Klaas Bergmann

015007 Equations of state for supernovae and compact stars

What are the thermodynamic properties of matter at extreme densities, even exceeding nuclear matter density severely? How can we describe the composition of matter for such conditions, the resulting pressure, and the maximum mass of cold neutron stars? How is this affected by finite temperatures, as they occur in core-collapse supernovae and in compact star mergers? This review addresses these points within the framework of constraints from experiments as well as astronomical observations.

M. Oertel
M. Hempel
T. Klähn
S. Typel