Reviews of Modern Physics

Volume 85 **Number 4** **October–December 2013**

1383 ***Colloquium*: Laser probing of neutron-rich nuclei in light atoms**

Z.-T. Lu
P. Mueller
G. W. Drake
W. Nörtershäuser
Steven C. Pieper
Z.-C. Yan

Marginally bound quantum systems are studied in different domains of physics, including nuclear, molecular, and atomic physics. In this context, short-lived isotopes of helium are one of the most spectacular examples of neutron halos, in which outermost neutrons move at a large distance from the alpha-particle core. This Colloquium describes how laser trapping and cooling of short-lived, rare helium atoms and the measurement of isotope shifts can be used to determine with high precision charge radii of light halo nuclei (including also lithium and beryllium). The results are test benches for modern advanced nuclear structure models of loosely bound systems.

1401 ***Colloquium*: Multimessenger astronomy with gravitational waves and high-energy neutrinos**

Shin'ichiro Ando
Bruny Baret
Imre Bartos
Boutayeb Bouhou
Eric Chassande-Mottin
Alessandra Corsi
Irene Di Palma
Alexander Dietz
Corinne Donzaud
David Eichler
Chad Finley
Dafne Guetta
Francis Halzen
Gareth Jones
Shivaraj Kandhasamy
Kei Kotake
Antoine Kouchner
Vuk Mandic
Szabolcs Márka
Zsuzsa Márka
Luciano Moscoso
Maria Alessandra Papa
Tsvi Piran
Thierry Pradier
Gustavo E. Romero
Patrick Sutton
Eric Thrane
Véronique Van Elewyck
Eli Waxman

Cosmological and astrophysical information can be transported mostly undistorted through space via gravitational waves and high-energy neutrinos. This Colloquium discusses the prospects for their detection and how coincidence measurements can enhance our understanding of the cosmos.

1421 **Single-electron current sources: Toward a refined definition of the ampere**

Jukka P. Pekola
Olli-Pentti Saira
Ville F. Maisi
Antti Kemppinen
Mikko Möttönen
Yuri A. Pashkin
Dmitri V. Averin

The objective of developing techniques to identify, control, and collect single electrons within a defined time interval has implications for redefining the ampere in terms of fundamental constants. This review discusses the physics governing the manipulation of single electrons and then presents and compares a variety of achieved and proposed implementations, including quantum dot pumps and hybrid turnstiles, to achieve this objective. This topical subject is important to the metrological community but at the same time addresses related work on Cooper pair and coherent spin transport with context for advances in fundamental and applied measurements that require precise control.

1473 ***Colloquium*: Artificial spin ice: Designing and imaging magnetic frustration**

Cristiano Nisoli
Roderich Moessner
Peter Schiffer

Frustration, the competition between strong interactions, can lead to highly unconventional physical properties. The frustrated artificial spin ice materials not only allow for such emergence to be custom tailored but also to be visualized at the constituent level. This Colloquium collates ideas of the interdisciplinary field of the artificial frustration, taken from classical correlated spin models, disordered systems, information theory, granular media, and micromagnetics; it also provides vistas on its future developments.

1491 **Life at the interface of particle physics and string theory**

A. N. Schellekens

String theory apparently involves an enormous ''landscape'' of possible vacua involving different parameters and physics, with no known selection principle to determine a unique one. Moreover, eternal inflation suggests that the various vacua may be sampled in different regions of an enormous ''multiverse,'' of which our observable Universe is but a small part. This suggests the possibility that some or all of the observed properties of nature may be environmentally selected rather than unique.

1541 ***Colloquium*: Beta-delayed fission of atomic nuclei**

Andrei N. Andreyev
Mark Huyse
Piet Van Duppen

Nuclear fission splits a heavy actinide nucleus such as uranium or plutonium into two lighter nuclei, called fission fragments. Mass distributions of fission fragments in actinide nuclei are typically strongly asymmetric. Recent studies of low-energy beta-delayed fission of very neutron-deficient nuclei in the lead region established a new region of asymmetric fission. The data and their interpretation demonstrate the extent to which, more than 75 years after the discovery of nuclear fission, we are still learning about this nuclear decay of fundamental importance to society.

1561 ***Colloquium*: Annual modulation of dark matter**

Katherine Freese
Mariangela Lisanti
Christopher Savage

Several experiments have reported evidence for an annual modulation of the count rate in experiments designed to search for dark matter, in tension with other experiments which have observed no definitive effect. This Colloquium surveys the theoretical issues needed to describe and interpret a possible annual modulation, including the particle and astrophysics models and their uncertainties, as well as the experimental situation and future prospects for resolving the discrepancies.

1583 **Defect identification in semiconductors with positron annihilation: Experiment and theory**

Filip Tuomisto
Ilja Makkonen

Defects in semiconductors are of great practical and fundamental importance. This review describes how to use positron annihilation spectroscopy to identify and characterize defects in many different classes of crystalline semiconductors. A discussion of possible extensions of this method to amorphous systems, and to interfaces and surfaces, is also given.

1633 **Fermi gases in one dimension: From Bethe ansatz to experiments**

Xi-Wen Guan
Murray T. Batchelor
Chaohong Lee

Cold atomic gases can be made effectively unidimensional using tight magnetic or laser traps that freeze the particle motion along two directions of space. One obtains to good approximation the practical implementation of an exactly solvable model of a 1D quantum fluid with contact interaction. This article discusses the theoretical analysis of these 1D gases based on the Bethe ansatz. It describes several types of many-body phenomena that appear in these fluids, such as universal thermodynamics, quantum criticality, and large-spin magnetism. It also reviews the recent experimental progresses in the realization and characterization of quasi-1D atomic gases.

1693 **Quantum-Bayesian coherence**

Christopher A. Fuchs
Rüdiger Schack

This review explores some of the consequences and features of the quantum-Bayesian approach to quantum theory. This approach contends that the difficulties in the foundations of quantum theory arise from the difficulties in understanding the nature of probabilities. ''Dutch-book'' wager games are explored to illustrate the Bayesian view on probabilities and to give a different underpinning for the Born rule for measurement probabilities. A new view on the state-space structure of quantum mechanics arises from these considerations.