

# REVIEWS of MODERN PHYSICS

Volume 88

Number 3

July–September 2016

**030501**     **Nobel Lecture: Discovery of atmospheric neutrino oscillations**     Takaaki Kajita

**030502**     **Nobel Lecture: The Sudbury Neutrino Observatory: Observation of flavor change for solar neutrinos**     Arthur B. McDonald

The 2015 Nobel Prize for Physics was shared by Takaaki Kajita and Arthur B. McDonald. These papers are the text of the address given in conjunction with the award.

**035001**     **Fermion path integrals and topological phases**     Edward Witten

Symmetry-protected phases of matter have been at the forefront of condensed matter physics in recent years. Bosonic symmetry-protected phases have been interpreted in terms of anomalies and group cohomology. The present article aims to develop an analogous description of fermionic symmetry-protected phases, such as the topological insulators that have been seen experimentally in 2 or 3 space dimensions. The relevant mathematical concepts include the Atiyah-Singer index theorem and the Atiyah-Patodi-Singer eta invariant.

**035002**     **Nonlinear waves in  $\mathcal{PT}$ -symmetric systems**     Vladimir V. Konotop  
Jianke Yang  
Dmitry A. Zezyulin

The concept of parity-time symmetric systems is rooted in non-Hermitian quantum mechanics where complex potentials obeying this symmetry could exhibit real spectra. The concept has applications in many fields of physics, e.g., in optics, metamaterials, acoustics, Bose-Einstein condensation, electronic circuitry, etc. The inclusion of nonlinearity has led to a number of new phenomena for which no counterparts exist in traditional dissipative systems. Several examples of nonlinear parity-time symmetric systems in different physical disciplines are presented and their implications discussed.

**035003**     **Statistical mechanics of ecological systems: Neutral theory and beyond**     Sandro Azaele  
Samir Suweis  
Jacopo Grilli  
Igor Volkov  
Jayanth R. Banavar  
Amos Maritan

It is of societal importance to advance the understanding of emerging patterns of biodiversity from biological and ecological systems. The neutral theory offers a statistical-mechanical framework that relates key biological properties at the individual scale with macroecological properties at the community scale. This article surveys the quantitative aspects of neutral theory and its extensions for physicists who are interested in what important problems remain unresolved for studying ecological systems.

**035004      Strangeness in nuclear physics**

Everyday matter is made of the lightest up and down quarks. The strange quark is the third lightest of all quarks. Strangeness, a property of particles associated with the number of strange quarks, preceded the theory and discovery of the quark by about two decades. Recent experimental and theoretical developments in the field of strangeness in nuclei are reviewed. Topics include the production of strange particles, properties of hypernuclei, and strange dense matter.

A. Gal  
E. V. Hungerford  
D. J. Millener

**035005      Classification of topological quantum matter with symmetries**

In recent years an increasing amount of attention has been devoted to quantum materials with topological characteristics that are robust against disorder and other perturbations. In this context it was discovered that topological materials can be classified with respect to their dimension and symmetry properties. This review provides an overview of the classification schemes of both fully gapped and gapless topological materials and gives a pedagogical introduction into the field of topological band theory.

Ching-Kai Chiu  
Jeffrey C. Y. Teo  
Andreas P. Schnyder  
Shinsei Ryu

**035006      Control principles of complex systems**

Complex networks range from subcellular biological networks to the Internet. Our ability to control these systems deeply challenges our understanding. Control also may well be a guiding principle in their design. This article reviews the emerging science of the control of complex networks.

Yang-Yu Liu  
Albert-László Barabási

**035007      Sap flow and sugar transport in plants**

Green plants harvest the energy of the Sun in the leaves by converting light energy into chemical energy in the bonds of sugar molecules, using water from the soil and carbon dioxide from the air. This review provides an overview of the vascular anatomy of plants and the physical models that describe the long-distance transport of water and minerals from root to leaf, and, in particular, of sugars from the leaves to the entire body of the plant sustaining growth and communication throughout even the tallest tree.

K. H. Jensen  
K. Berg-Sørensen  
H. Bruus  
N. M. Holbrook  
J. Liesche  
A. Schulz  
M. A. Zwieniecki  
T. Bohr

**035008      Leptonic and semileptonic decays of  $B$  mesons**

In the standard model of particle physics, the strong and weak interaction eigenstates of the three generations of quarks differ and are related by the unitary Cabibbo-Kobayashi-Maskawa matrix. This article reviews measurements of the decays of the mesons containing a bottom quark into final states with leptons. These measurements provide determinations of the matrix elements and other observables and offer constraints on the standard model as well as pointers to possible new physics.

Jochen Dingfelder  
Thomas Mannel

**035009 CODATA recommended values of the fundamental physical constants: 2014**

Peter J. Mohr  
David B. Newell  
Barry N. Taylor

This review article contains the 2014 self-consistent set of values of the constants and conversion factors of physics and chemistry recommended by the Committee on Data for Science and Technology (CODATA). The CODATA values are based on a least-squares adjustment that takes into account all data available up to the end of 2014. Details of the data selection and methodology are described.

**039901 Publisher's Note: Metallic quantum ferromagnets  
[Rev. Mod. Phys. 88, 25006 (2016)]**

M. Brando  
D. Belitz  
F.M. Grosche  
T.R. Kirkpatrick

**039902 Erratum: Hidden variables and the two theorems of John Bell  
[Rev. Mod. Phys. 65, 803 (1993)]**

N. David Mermin

**039903 Erratum: Modeling semiflexible polymer networks  
[Rev. Mod. Phys. 86, 995 (2014)]**

C. P. Broedersz  
F. C. MacKintosh

**039904 Erratum: Ultrafast optical manipulation of magnetic order  
[Rev. Mod. Phys. 82, 2731 (2010)]**

Andrei Kirilyuk  
Alexey V. Kimel  
Theo Rasing

**039905 Publisher's Note: Google matrix analysis of directed networks  
[Rev. Mod. Phys. 87, 1261 (2015)]**

Leonardo Ermann  
Klaus M. Frahm  
Dima L. Shepelyansky