

# REVIEWS of MODERN PHYSICS

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**021001**     *Colloquium: Measuring the neutron star equation of state using x-ray timing*

How are two essential quantities of neutron stars (the mass and radius), which provide constraints for the equation of state in their interiors where supranuclear densities are experienced, precisely determined? This Colloquium discusses major techniques for how this information can be inferred from x-ray observations of neutron stars that accrete matter from a binary companion, or of isolated neutron stars that experience seismic vibrations, taking into account rotation, relativistic effects, and magnetic fields.

Anna L. Watts  
Nils Andersson  
Deepto Chakrabarty  
Marco Feroci  
Kai Hebeler  
Gianluca Israel  
Frederick K. Lamb  
M. Coleman Miller  
Sharon Morsink  
Feryal Özel  
Alessandro Patruno  
Juri Poutanen  
Dimitrios Psaltis  
Achim Schwenk  
Andrew W. Steiner  
Luigi Stella  
Laura Tolos  
Michiel van der Klis

**021002**     *Colloquium: Non-Markovian dynamics in open quantum systems*

An ongoing theme in quantum physics is the interaction of small quantum systems with an environment. If that environment has many degrees of freedom and is weakly coupled, it can often be reasonable to treat its decohering effect on the small system using a “memoryless,” or Markovian description. This Colloquium shows that for many phenomena a more refined, non-Markovian treatment is necessary. The suite of developing theoretical tools is reviewed, with which recent progress on this problem has been based.

Heinz-Peter Breuer  
Elsi-Mari Laine  
Jyrki Piilo  
Bassano Vacchini

**021003**     *Colloquium: Search for a drifting proton-electron mass ratio from H<sub>2</sub>*

Looking back into 10–12 billion years of cosmic history this Colloquium paper summarizes what is presently known about the proton-to-electron mass ratio and its variation with time. The hydrogen spectra of quasars and how they reveal fundamental information on some of the most important constants in physics and cosmology are reviewed.

W. Ubachs  
J. Bagdonaite  
E. J. Salumbides  
M. T. Murphy  
L. Kaper

**021004**     *Colloquium: Topological band theory*

First-principles band theory, properly augmented by topological considerations, has provided a remarkably successful framework for predicting new classes of topological materials. This Colloquium discusses the underpinnings of the topological band theory and its materials applications.

A. Bansil  
Hsin Lin  
Tanmoy Das

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| <b>025001</b> | <b>Phase diagram of QCD in a magnetic field</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Jens O. Andersen<br>William R. Naylor<br>Anders Tranberg                                                                            |
|               | <p>This review addresses the current theoretical understanding of hadronic matter at large magnetic fields. Applications include heavy-ion collisions, neutron stars, and the early Universe. Models used describe the thermodynamic properties and phases of quantum chromodynamics as functions of temperature and magnetic field strength. These models are examined and directions for future research are pointed out.</p>                                                                                                                                                                                                                                                        |                                                                                                                                     |
| <b>025002</b> | <b>The physics of epigenetics</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Ruggero Cortini<br>Maria Barbi<br>Bertrand R. Caré<br>Christophe Lavelle<br>Annick Lesne<br>Julien Mozziconacci<br>Jean-Marc Victor |
|               | <p>Epigenetics is essential in understanding the development, from a common undifferentiated cell, of different cell types that share the same hereditary materials in their genome. A meaningful decoration of chemical marks on chromosomes selects the genes to be expressed by directing the differential folding of the genome in the cell nucleus. This article surveys plausible physical mechanisms involved in setting up epigenetic marks and their role in genome folding and expression.</p>                                                                                                                                                                               |                                                                                                                                     |
| <b>025003</b> | <b>Coulomb drag</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | B. N. Narozhny<br>A. Levchenko                                                                                                      |
|               | <p>Coulomb drag, a term coined in analogy to phonon drag, refers to the effect of mutual friction between nonequilibrium conduction electrons belonging to two electrically isolated but closely spaced conductors. Coulomb drag experiments provide unique insight into microscopic properties of interacting many-body systems and are important in systems of small size or of reduced dimensionality. This review provides an overview of the effect in semiconductor heterostructures, double-layers devices, and nanostructures.</p>                                                                                                                                             |                                                                                                                                     |
| <b>025004</b> | <b>Scaled plane-wave Born cross sections for atoms and molecules</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | H. Tanaka<br>M. J. Brunger<br>L. Campbell<br>H. Kato<br>M. Hoshino<br>A. R. P. Rau                                                  |
|               | <p>Electron-atom and electron-molecule collisional cross sections are needed in the modeling and understanding of phenomena ranging from planetary atmosphere science to industrial applications of plasmas. This article reviews the Born approximation and phenomenological scaling approaches that provide accurate excitation cross sections over a range of electron impact energies. The methods are illustrated for a variety of atomic and molecular systems.</p>                                                                                                                                                                                                              |                                                                                                                                     |
| <b>025005</b> | <b>Physical properties of low-dimensional <math>sp^2</math>-based carbon nanostructures</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | V. Meunier<br>A. G. Souza Filho<br>E. B. Barros<br>M. S. Dresselhaus                                                                |
|               | <p>This review focuses on the fundamental physical properties of low-dimensional carbon nanostructures (graphene, graphene nanoribbons, and carbon nanotubes), with an emphasis on understanding and utilizing the unique physical properties that make this class of materials ideal building blocks for future nanoscience and nanotechnology development. In-depth discussions of the structural, electronic, vibrational, and transport properties of these carbon nanostructures from both theoretical and experimental standpoints provide a coherent and foundational overview for researchers interested in broader areas of carbon science and related noncarbon systems.</p> |                                                                                                                                     |

**025006      Metallic quantum ferromagnets**

A full understanding of long-range ferromagnetic order in metallic systems reflects a variety of phenomena which are best understood in the context of quantum phase transitions (QPTs). This review presents experimental data on ferromagnetic QPTs in metals, confronting results with currently available theory. The coverage of clean materials, materials with varying degrees of disorder, and materials with phase diagrams is exhaustive, revealing a trend where the QPTs of clean systems driven by a control parameter are first order compared to more disordered systems where the QPTs are second order.

M. Brando  
D. Belitz  
F. M. Grosche  
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