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1383 **A common thread: The pairing interaction for unconventional superconductors** — D. J. Scalapino

Unconventional superconductivity has been found in different classes of materials, including cuprates, Fe-based compounds, and heavy-fermion systems. This review provides phenomenological and theoretical arguments that in all of these classes the pairing is mediated by spin fluctuations.

1419 **Maximally localized Wannier functions: Theory and applications** — Nicola Marzari, Arash A. Mostofi, Jonathan R. Yates, Ivo Souza, David Vanderbilt

The dichotomy between extended, or Bloch, states, and localized, or Wannier, states in solid-state physics has been known for 75 years. However, the notion of a unique, or maximally localized, Wannier function is of much more recent origin. This review explains this concept, shows how to explicitly construct maximally localized Wannier functions, and explains why they are useful for describing systems from solids to optical lattices and cold atoms.

1477 **Tests of the standard electroweak model at the energy frontier** — John D. Hobbs, Mark S. Neubauer, Scott Willenbrock

Experiments at the Fermilab Tevatron pp\overline collider have greatly enhanced our understanding of the electroweak sector of the standard model and explored signatures for spontaneous symmetry breaking at the highest energies in the past decades prior to the ones now available at the LHC. Properties and couplings of the gauge bosons (including diboson production) and the top quark and searches for the Higgs boson are the focus of this review. Many of the experimental methods have become the basis of new measurements at the LHC where the energy scale is being extended to the multi-TeV range.

1527 **CODATA recommended values of the fundamental physical constants: 2010** — Peter J. Mohr, Barry N. Taylor, David B. Newell

This review of the fundamental physical constants and conversion factors of physics and chemistry provides recommended values and their associated uncertainties. The set of values replaces the previous CODATA set of 2006. Since then new data became available which have led to important adjustments of former values. Furthermore, for future evaluations of the fundamental constants the authors emphasize by way of several examples the desirability of having from experiments not only multiple results with competitive uncertainties for a given quantity but also having one or more results obtained with a different method.

1607 **The properties of hydrogen and helium under extreme conditions**

Jeffrey M. McMahon
Miguel A. Morales
Carlo Pierleoni
David M. Ceperley

Hydrogen and helium, the most abundant elements in the Universe, show extraordinary properties under extreme conditions. Both elements form a large fraction of the mass of the planets Jupiter and Saturn in our Solar System as well as of a sizable number of exoplanets. This article summarizes recent advances made primarily in computational methods toward modeling dense objects resulting in a reliable equation of state, i.e., the pressure as function of temperature, density, and composition of the objects, and the understanding of the respective phase diagrams.

1655 **The classical-quantum boundary for correlations: Discord and related measures**

Kavan Modi
Aharon Brodutch
Hugo Cable
Tomasz Paterek
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Separated quantum mechanical systems can be correlated in ways that are not possible in classical physics. Schroedinger coined the word entanglement to describe those correlations that are possible whenever the wave function of a multipart system cannot be written as a product of its parts. We now have a much more nuanced description of quantum correlations. Many phenomena can exhibit nonclassical behavior. Quantum discord seems to play a role, similar to entanglement, in quantum systems that are highly mixed. Research on discord has now spread to many different branches of physics. This paper reviews the role of correlations in defining the classical-quantum boundary, and provides a survey of results on discord, and related measures of quantum correlations other than entanglement.

1709 **Nonequilibrium phenomena in high Landau levels**

I. A. Dmitriev
A. D. Mirlin
D. G. Polyakov
M. A. Zudov

The physics of two-dimensional electron systems placed in moderately strong perpendicular magnetic fields continues to be an active area of interest with developments going well beyond the widely recognized quantum Hall effect. The availability of high-purity (high-mobility) semiconductor heterostructures in conjunction with techniques to drive electrons out of equilibrium leads to signature magnetoresistance oscillations related to the underlying Landau level quantization. This review describes within a unified theoretical context the experimental manifestations of these phenomena, which include microwave-induced resistance oscillations, radiation-induced zero-resistance states, and Hall field- and phonon-induced resistance oscillations.

1765 ***Colloquium*: Multiparticle quantum superpositions and the quantum-to-classical transition**

Francesco De Martini
Fabio Sciarrino

Decoherence is the process in which a quantum degree of freedom, electron, phonon, or photon, becomes ''classical'' and thermalizes when in contact with the environment. This process can become uncontrollable when the number of degrees of freedom involved is large. This occurs because they interact among themselves and the environment, speeding up the loss of quantum effects. However, in certain cases, as discussed in this Colloquium, decoherence can be somewhat suppressed and quantum phenomena be observed in a reasonable time scale even for a large number of photons. The consequences of these findings for our understanding of the quantum world are tantalizing.

1791 ***Colloquium*: Modeling the dynamics of multicellular systems: Application to tissue engineering**

Ioan Kosztin
Gordana Vunjak-Novakovic
Gabor Forgacs

Biological materials, such as tissues, are complex multiscale structures composed of many heterogeneous and active components. Because of these properties their understanding represents a major challenge. In this Colloquium it is shown how an effective approach to predicting biomechanical processes shape these systems, leading to useful applications in tissue engineering.

1807 **Steady-state tokamak research: Core physics**

M. Kikuchi
M. Azumi

Developing a steady-state fusion reactor from the leading fusion plasma confinement device, the tokamak, is critical for fusion success. This article reviews the major scientific aspects of the tokamak, including equilibrium, magnetohydrodynamic activity, and transport. It also discusses the efforts made toward a steady-state operation of a tokomak, including a physical process called bootstrap current.