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471 **Models of wave-function collapse, underlying theories, and experimental tests**

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It remains possible that quantum theory breaks down at the macroscopic scale. That is, the absence of superposition of large objects, rather than a feature of quantum decoherence and quantum measurement, could be the result of modified dynamical laws. This article reviews the mechanisms proposed for continuous spontaneous collapse and discusses the status of and prospects for experiments, in optomechanics and matter interferometry, for confirming or ruling out these mechanisms.

529 ***Colloquium*: Modeling friction: From nanoscale to mesoscale**

Andrea Vanossi
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Michael Urbakh
Stefano Zapperi
Erio Tosatti

Friction is a fundamental phenomenon that affects many different areas of human life and technology. In this Colloquium the microscopic origins of friction are reviewed in light of recent developments that are beginning to unveil the processes at the interface of two sliding materials. Large-scale simulations and theoretical modeling help reveal the complex nature of this basic phenomenon which is still the subject of much controversy.

553 **Cold atoms in cavity-generated dynamical optical potentials**

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Tilman Esslinger

When an atomic particle is placed inside a high-finesse electromagnetic cavity and is coupled to its radiation field, a rich nonlinear dynamics arises. This review describes recent advances in this research field, from both the theoretical and experimental points of view. At the single atom level, it presents novel cooling schemes that are applicable to any polarizable particle. It also addresses the situation where many atoms are simultaneously present in the cavity, in which case spectacular collective phenomena can occur, from superradiant light scattering to the formation of supersolids.

603 ***Colloquium*: Homochirality: Symmetry breaking in systems driven far from equilibrium**

Yukio Saito
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In 1848, Louis Pasteur discovered that certain molecules can rotate the polarization of light either clockwise or anticlockwise, defining their chirality. Some biological molecules, such as amino acids and sugars, are homochiral, that is, they rotate their polarization in only one direction. Although this observation seems to be directly related with the existence of life on Earth, it is still poorly understood partially because of its complexity and emergent nature. Recent experiments, discussed in this Colloquium, have provided new evidence for the nonlinear, nonequilibrium, nature of this important phenomenon.

623 **Hybrid quantum circuits: Superconducting circuits interacting with other quantum systems**

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Sahel Ashhab
J. Q. You
Franco Nori

Superconducting quantum bits, and the microwave photonic structures that control, couple, and measure them, have exhibited markedly improved functionality for future quantum information processing in recent years. These superconducting systems can now be joined with other structures and devices from atomic physics, quantum optics, and nanoscience to create new quantum phenomena and possible new platforms for quantum technologies. This article surveys current progress in the implementation of these hybrid quantum structures and circuits.

655 **The spin structure of the nucleon**

Christine A. Aidala
Steven D. Bass
Delia Hasch
Gerhard K. Mallot

Throughout much of the twentieth century, the nucleon spin has been—just as the spin of the electron—viewed as an intrinsic property. There are, however, very complex interactions that lead to the spin of 1/2 of the nucleon. Extensive experiments have established that most of the proton's spin cannot be attributed to the sum of the spins of its three quarks and that contributions from the orbital motion of quarks and/or gluons play an important role. This review is devoted to the proton spin puzzle. The current experimental and theoretical developments are reviewed, and open questions and challenges for future investigations are discussed.

693 **Theory and application of explicitly correlated Gaussians**

Jim Mitroy
Sergiy Bubin
Wataru Horiuchi
Yasuyuki Suzuki
Ludwik Adamowicz
Wojciech Cencek
Krzysztof Szalewicz
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Among the theoretical approaches that are available to study quantum few-body systems, the variational method with correlated Gaussian functions is one of the most powerful. This article reviews the foundations of the method, discusses its strengths and its limitations, and illustrates with numerous examples ranging from hadrons and light nuclei to atoms, molecules, and quantum dots.

751 **Ion acceleration by superintense laser-plasma interaction**

Andrea Macchi
Marco Borghesi
Matteo Passoni

Laser-plasma acceleration of ions has been making steady progress, with the ability now to generate ultrashort, multi-MeV ion bunches in extremely short distances. This article reviews the physics behind the ion acceleration and discusses the directions that this research field is taking.

795 ***Colloquium*: New physics search with flavor in the LHC era**

Tobias Hurth
Farvah Mahmoudi

This Colloquium is a status report on quark flavor physics in view of the latest data from the B factories and the CERN LHC and the implication of these data on the issue of supersymmetry.

809 **Pregalactic metal enrichment: The chemical signatures of the first stars**

Torgny Karlsson
Volker Bromm
Joss Bland-Hawthorn

Light observed from high redshifts indicates the formation of the very first stars. How did they form and how are they related to the formation of galaxies? What stellar mass distribution resulted from the cooling, fragmentation, and collapse of pristine matter, containing only a big bang abundance composition? Which abundance pattern did these first stars emit? These open questions related to the transition from initial cosmological conditions to star or galaxy formation and the properties of the first stars are discussed.

849 ***Colloquium*: The unexpected properties of alkali metal iron selenide superconductors**

Elbio Dagotto

Iron-based superconductors are an amazing class of layered materials where superconductivity and magnetism coexist, cooperate, and, sometimes, compete with each other. The complexity of these materials comes from the strong orbital nature of its electrons. In this Colloquium the latest developments and controversies regarding these materials are discussed with an eye on the future developments in this exciting field.

869 **Leaking chaotic systems**

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Jefferson S. Portela
Tamás Tél

When a hole or a leak is introduced in an otherwise closed chaotic system, persistent dynamics is converted into transient chaos. Theories based on the persistent dynamics of closed systems are often applied to leaking systems, but they fail to describe realistic configurations which typically have finite-size leaks. A transient chaos based theory is developed and shown to be applicable to problems in planetary science, hydrodynamical flow and environmental sciences, room acoustics, and magnetic confinement in plasmas up to quantum and wave chaotic systems with leaks.

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

N. David Mermin