Reviews of Modern Physics

Volume 90 **Number 4** **October–December 2018**

040501 **Nobel Lecture: LIGO and the discovery of gravitational waves I** — Rainer Weiss

The 2017 Nobel Prize for Physics was shared by Rainer Weiss, Barry C. Barish, and Kip S. Thorne. These papers are the text of the address given in conjunction with the award.

040502 **Nobel Lecture: LIGO and gravitational waves II** — Barry C. Barish

The 2017 Nobel Prize for Physics was shared by Rainer Weiss, Barry C. Barish, and Kip S. Thorne. These papers are the text of the address given in conjunction with the award.

040503 **Nobel Lecture: LIGO and gravitational waves III** — Kip S. Thorne

The 2017 Nobel Prize for Physics was shared by Rainer Weiss, Barry C. Barish, and Kip S. Thorne. These papers are the text of the address given in conjunction with the award.

041001 ***Colloquium*: Nonequilibrium effects in superconductors with a spin-splitting field** — F. Sebastian Bergeret, Mikhail Silaev, Pauli Virtanen, Tero T. Heikkilä

Superconductivity and magnetism both reflect the strong interactions between electrons in a material. When these two effects either compete or collaborate with each other, a variety of new phenomena occur that can be exploited for use in devices. In this Colloquium the authors discuss the experimental and theoretical aspects of how the transport of spin and charge is affected in actual devices through this competition.

041002 ***Colloquium*: Phononic thermal properties of two-dimensional materials** — Xiaokun Gu, Yujie Wei, Xiaobo Yin, Baowen Li, Ronggui Yang

The thermal conductivity of 3D samples is usually intensive. However, this holds only when phonon transport is diffusive and the sample is sufficiently large. In this Colloquium, a framework is presented that shows how phonon scattering in 2D materials influences thermal transport properties that depend on geometry, substrate and interlayer coupling, and imperfections. These considerations suggest ways of enabling new thermoelectric materials, thermal conductors or insulators, and perhaps even phononic computing devices.

045001 **Collective behavior of colloids due to critical Casimir interactions**

Anna Maciołek
Siegfried Dietrich

Colloidal particles suspended in a solvent experience solvent-mediated interactions due to the adsorption on the colloidal surface. The range of this interaction is set by the bulk correlation length of the solvent, which diverges with universal scaling properties at the critical point of the solvent. The sensitivity of these solvent-mediated interactions, critical Casimir forces, to the thermodynamic state of the solvent presents opportunities to realize the reversible self-assembly of colloids. This review discusses the experimental observations of reversible aggregation and phase transitions due to solvent-mediated interactions, as well as the various theoretical descriptions of this phenomenon.

045002 **History of dark matter**

Gianfranco Bertone
Dan Hooper

The standard model of modern cosmology is unthinkable without dark matter, although direct detections are still missing. A broad perspective of how dark matter was postulated and became accepted is presented, from prehistory, over observations of galaxy clusters, galaxy rotation curves, the search for baryonic dark matter, possible alternative explanations via modified gravity, up to the hunt for dark matter particles. The interplay is described between observational discoveries and theoretical arguments which led finally to the adoption of this paradigm.

045003 **APS Medal for Exceptional Achievement in Research: Invited article on entanglement properties of quantum field theory**

Edward Witten

The 2016 APS Medal for Excellence in Physics was given to Edward Witten. This contribution was invited in conjunction with this award. These original notes contain concise explanations of some key results in the axiomatic and algebraic approaches to quantum field theory, which are relevant to quantum entanglement. They serve to put the connection between quantum field theory and quantum information theory on a precise and rigorous footing.

045004 **Physics of liquid crystals of bent-shaped molecules**

Antal Jákli
Oleg D. Lavrentovich
Jonathan V. Selinger

Bent-shaped molecules form a large variety of liquid crystal phases, such as nematic and smectic phases with polar and even chiral order, and also the recently discovered twist-bend nematic phase with a heliconical modulation of the nematic director. A small kink in the molecular shape can lead to new properties and liquid crystal phases. This paper discusses the theory of liquid crystals of banana-shaped molecules and the underlying physics, and it reviews experimental research of both rigid and flexible bent-core molecules.

045005 **Highly charged ions: Optical clocks and applications in fundamental physics**

M. G. Kozlov
M. S. Safronova
J. R. Crespo López-Urrutia
P. O. Schmidt

Electronic states of highly charged ions show magnified fine-structure, Lamb shift, and hyperfine effects making them sensitive probes of bound-state quantum electrodynamics and nuclear physics. Being also impervious to external perturbations renders them ideal candidates for precision spectroscopy and accurate clocks that could test physics beyond the standard model. This review discusses how a variety of ion species and transitions may optimally be used to target such new applications and presents routes to handle them in the laboratory.

045006 **Deformation and flow of amorphous solids: Insights from elastoplastic models**

Alexandre Nicolas
Ezequiel E. Ferrero
Kirsten Martens
Jean-Louis Barrat

As with liquids, amorphous solids are disordered but nonetheless preserve their shapes under small stress and flow only when pushed hard enough. Common examples include emulsions, foams, and colloidal, metallic, and polymer glasses, and even mayonnaise, toothpaste, shaving foam, and heaps of rice. This paper presents a review of elastoplastic models to describe the deformation and flow of these materials, the physical insight provided by these models on strain localization, creep, and steady-state rheology, and addresses the fundamental questions of criticality at the yielding point and the statistics of avalanches.