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031001 ***Colloquium*: Geometric phases of light: Insights from fiber bundle theory**

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This Colloquium reviews the role of geometric phases in optics from the perspective of fiber bundle theory. The transformation of the polarization of light by discrete optical components illustrates many elements of the theoretical formalism, and an outlook is presented for the study and application of geometric phases in higher dimensions through analyses of higher order Gaussian modes and general vectorial fields.

031002 ***Colloquium*: Multiscale modeling of brain network organization**

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The brain is a formidably complex system made of neurons and neuronal ensembles that segregate and integrate information across organized layers at multiple spatial and temporal scales. A physicist's perspective is provided on modeling the brain as interconnected and multilayered networks that grow into complex organizations for processing information dynamically. The analytical tools for multilayer networks root deeply in statistical physics that render interpretable features connecting network patterns as biomarkers to a mental state or brain diseases.

031003 ***Colloquium*: Machine learning in nuclear physics**

Amber Boehnlein
Markus Diefenthaler
Nobuo Sato
Malachi Schram
Veronique Ziegler
Cristiano Fanelli
Morten Hjorth-Jensen
Tanja Horn
Michelle P. Kuchera
Dean Lee
Witold Nazarewicz
Peter Ostroumov
Kostas Orginos
Alan Poon
Xin-Nian Wang
Alexander Scheinker
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Nuclear physics deals with complex systems, large datasets, and complicated correlations between parameters, which makes the field suitable for the application of machine learning techniques. Machine learning can help classify and analyze data, find hidden correlations, and assist in the design of new experiments and detectors. This Colloquium explains how this will lead to advances in nuclear theory, experimental methods and data acquisition, and accelerator technology.

035001 **Micius quantum experiments in space**

Chao-Yang Lu
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Cheng-Zhi Peng
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The Micius satellite, launched from China in August 2016, is the first and only satellite dedicated entirely to quantum experiments. The ultralow loss transmission of photons on most of the path between ground and space enables quantum communication capabilities that are still far from being realized. This review details the commissioning of Micius as a full quantum communications system, and describes the achievement of global-scale quantum key distribution, entanglement distribution, and other fundamental studies, with this unique space-based system.

035002 **Optical diagnostics of laser-produced plasmas**

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F. N. Beg

Laser-produced plasmas (LPP) are important for fundamental research, industrial, and medical applications. Typical laser intensities used for producing these plasmas are low to moderate, and the plasma conditions change with both space and time, can be spatially inhomogeneous, and have various degrees of ionization states for the ionized material. Measuring these properties is key for understanding, tailoring, and optimizing the plasma conditions. This review provides an overview of optical diagnostic tools employed for the characterization of the LPPs and emphasizes techniques, associated assumptions, and challenges.

035003 **Interplay between optical vortices and condensed matter**

Guillermo F. Quinteiro
Rosen
Pablo I. Tamborenea
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The interaction between light and matter is a subject of ongoing fundamental interest at the intersection of optics and condensed-matter physics. This review discusses how the structuring of light into optical vortices leads to distinctive optical selection rules and coupling to sample geometry, requiring reformulation of the standard theory for interaction of plane-wave light with matter. The interactions of optical vortices with semiconductor nanostructures, quantum rings, and 2D materials are presented. The results suggest further avenues for fundamental investigation as well as current and prospective applications in quantum control, communications, and sensing.

035004 **Sachdev-Ye-Kitaev models and beyond: Window into non-Fermi liquids**

Debanjan Chowdhury
Antoine Georges
Olivier Parcollet
Subir Sachdev

The Sachdev-Ye-Kitaev (SYK) model is a solvable model of a many-body quantum system that has stimulated interest in both condensed matter physics and quantum gravity. This review focuses on the insights provided by the SYK model, which has no quasiparticle excitations, into the physics of Planckian non-Fermi-liquid metals. This is discussed for a range of strongly correlated models and in relation to experiments on strongly correlated materials. Also included is a discussion of recent developments regarding the connections between the SYK model and the quantum theory of black holes.

035005 **Statics and dynamics of skyrmions interacting with disorder and nanostructures**

C. Reichhardt
C. J. O. Reichhardt
M. V. Milošević

The study of skyrmions has grown as they have been realized in topologically stable spin-textured magnetic excitations. This overview treats magnetic skyrmions and skyrmion assemblies using a particle-based approach to describe a system in which the energy scales of the skyrmion-skyrmion interactions, sample disorder, temperature, and drive magnitude compete. Pinning and dynamic effects of skyrmions interacting with disordered or ordered substrates are of technological importance for skyrmion applications. Analogs to vortices in type-II superconductors, charge density waves, and colloidal particles are presented.

039901 **Erratum: *Colloquium*: Statistical mechanics and thermodynamics at strong coupling: Quantum and classical [Rev. Mod. Phys. 92, 041002 (2020)]**

Peter Talkner
Peter Hänggi