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010501 **Nobel Lecture: Physical modeling of Earth's climate** — Syukuro Manabe

The 2021 Nobel Prize for Physics was shared by Syukuro Manabe, Klaus Hasselmann, and Giorgio Parisi. This paper is the text of the address given in conjunction with the award.

011001 ***Colloquium*: Hydrodynamics and holography of charge density wave phases** — Matteo Baggioli, Blaise Goutéraux

Hydrodynamics is an old example of an effective description of complex matter, which describes the system's behavior at large length and timescales and lumps microscopic details into transport coefficients. A combination of hydrodynamics and the gauge-gravity duality, which was first explored in the context of string theory, has proven promising for a description of strongly correlated electron fluids. This Colloquium explains how to apply these techniques to strongly correlated materials where the electron fluid crystallizes, and in particular to the strange metal phase of high-temperature superconductors.

011002 ***Colloquium*: Quantum anomalous Hall effect** — Cui-Zu Chang, Chao-Xing Liu, Allan H. MacDonald

The quantum Hall effect, discovered by von Klitzing more than 40 years ago, requires strong magnetic fields for its realization. More recently it was found that the effect can also be realized in zero magnetic field as a result of spontaneous time-reversal symmetry breaking. This Colloquium discusses the physics underlying this quantum anomalous Hall effect, the materials it is observed in, and potential applications.

011003 ***Colloquium*: Incompatible measurements in quantum information science** — Otfried Gühne, Erkka Haapasalo, Tristan Kraft, Juha-Pekka Pellonpää, Roope Uola

It is common to say that a quantum measurement is described by a Hermitian operator; e.g., we do a "position" measurement or a "momentum" measurement. The modern perspective is that this is too narrow a view of what a measurement can be, with more concepts needed, like partial measurement, weak measurement, and a quantum instrument. This Colloquium provides a larger perspective, and shows how measurement incompatibility and related uncertainty relations are extended to more general settings. One such insight is that measurements that disturb each other are in fact a valuable resource in a variety of quantum information protocols.

011006 ***Colloquium*: Advances in automation of quantum dot devices control** — Justyna P. Zwolak, Jacob M. Taylor

A promising platform for quantum computing consists of arrays of quantum dots. However, operating these devices presents a challenging control problem, since the location of the dots and the charges they contain must be reliably and reproducibly matched with the gate voltages. This Colloquium explains how automated control protocols that make use of machine learning techniques can succeed in systems where heuristic control is not feasible.

015001 **Synchrotron radiation techniques and their application to actinide materials**

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The actinides comprise a 15-member group of metallic radioactive elements occupying the bottom row of the periodic table. Electron localization accompanied by the formation of large magnetic moments due to the strong Coulomb repulsion is balanced by hybridization with neighboring-atom electronic states. This hybridization promotes an opposite tendency toward itinerancy and the emergence of complex behavior. This review shows how x-ray synchrotron radiation techniques provide a variety of powerful tools to unravel the complexity of actinide materials. Experimental techniques, theoretical background, and applications to actinide materials are covered in detail.

015002 **Waveguide quantum electrodynamics: Collective radiance and photon-photon correlations**

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Quantum emitters coupled to waveguides experience long-range interactions mediated by photons. This leads to superradiant and subradiant states, photon bound states, and various mechanisms for the preparation of entangled states of the emitters. This article reviews experiments on a wide range of systems and their description by theoretical methods and insights from different fields of physics.

015003 **Measuring interfacial Dzyaloshinskii-Moriya interaction in ultrathin magnetic films**

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G. Soares
G. Durin
F. Garcia-Sanchez
L. Chen
C. H. Back
C. H. Marrows
S. Tacchi
G. Carlotti

In magnetically ordered systems the Heisenberg exchange interaction between neighboring spins favors collinear alignment such as that seen in ferromagnets and antiferromagnets. The inclusion of antisymmetric exchange, also known as the Dzyaloshinskii-Moriya interaction (DMI), promotes an orthogonal arrangement between spins and is the subject of this review. The DMI interaction is responsible for chiral magnetism, spin-textured skyrmions, and magnetoelectric effects in multiferroic materials. The review, organized by measurement method, is focused on experiments that determine the DMI associated with thin film interfaces occurring in a variety of samples.

015004 **Helfrich-Hurault elastic instabilities driven by geometrical frustration**

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Guillaume Durey
Randall D. Kamien
Teresa Lopez-Leon
Maxim O. Lavrentovich
Lisa Tran

The Helfrich-Hurault instability is a well-known mechanism behind the undulations that occur as a result of strain upon liquid crystal systems with periodic ground states. In this review, the Helfrich-Hurault elastic instability is examined with a focus on layered liquid crystals that are geometrically frustrated. The frustration is relieved by undulations in the layered structure to maintain the preferred layer spacing. Examples of cholesteric and smectic liquid crystals confined between two spherical fluid interfaces are described and the effects of topological constraints, anchoring conditions, and curvature on the instability are examined. Lastly, the Helfrich-Hurault instability is surveyed as a pattern formation mechanism across a range of materials, both biological and synthetic.