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021001 ***Colloquium*: Room temperature superconductivity: The roles of theory and materials design** — Warren E. Pickett

Superconductivity, discovered in 1911 and first theoretically understood in 1957, remains a fascinating phenomenon for reasons both fundamental and applied. Reliably calculating the critical temperature of a given material, and even more so predicting it, turned out to be a considerable challenge. This Colloquium explains how theoretical developments have led to increasingly reliable predictions that have culminated in the discovery of the hydride materials that display superconductivity under high pressure at temperatures just shy of room temperature.

021002 ***Colloquium*: Positronium physics and biomedical applications** — Steven D. Bass, Sebastiano Mariazzi, Pawel Moskal, Ewa Stępień

Positronium, a bound system consisting of an electron and a positron, provides a platform for studying a wide variety of physical effects, ranging from tests of the equivalence principle to diagnostic applications in medicine. This Colloquium gives an overview of the current state of positronium physics, with an equal emphasis on fundamental and applied physics.

025001 **Topological phases in polar oxide nanostructures** — Javier Junquera, Yousra Nahas, Sergei Prokhorenko, Laurent Bellaiche, Jorge Íñiguez, Darrell G. Schlom, Long-Qing Chen, Sayeef Salahuddin, David A. Muller, Lane W. Martin, R. Ramesh

Topology provides a framework for an understanding of emergent phenomena in various fields such as the appearance of new results in the field of ferroelectrics. A historical introduction and a primer on the concepts of topology are followed by a discussion of experimental and theoretical methods that elucidate the exotic textures that appear in polar oxide nanostructures and superlattices. The complex interplay of several fundamental processes occurring on different energy scales leads to ground states that compete with one another and have large and/or novel responses with respect to external stimuli.

025002 **Toward the discovery of matter creation with neutrinoless $\beta\beta$ decay** — Matteo Agostini, Giovanni Benato, Jason A. Detwiler, Javier Menéndez, Francesco Vissani

Observation of neutrino oscillations implies that neutrinos have mass, but one does not know whether they are described by Dirac or Majorana mass terms. The discovery of a Majorana mass would provide a test of the global symmetries of the standard model, and would have implications for the origin of the number of baryons in the Universe. To achieve this one can search for neutrinoless double-beta decay, a rare nuclear decay where two new electrons are created with no antimatter. The next generation of experiments will explore large Majorana neutrino mass values, also testing alternative theoretical models. In this review, devoted to neutrinoless double-beta decay, the particle and nuclear physics aspects involved in predicting the decay rate and the experimental search methods are discussed.

025003 **Semiconductor spin qubits**

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Spin qubits, employing the fundamental quantum property of intrinsic angular momentum of individual electrons and nuclei, continue to develop and evolve. Lithographically patterned semiconductor chips play host to spin-qubit systems in which long coherence times, high-fidelity quantum gates, and single-shot quantum measurement are now routine. This review summarizes progress in four current qubit types: single spin qubits, donor spin qubits, singlet triplet spin qubits, and exchange-only spin qubits. All have been boosted by advances in mesoscopic physics. On the other hand, all systems still need to address challenges to further progress, such as the mitigation of noise and the establishment of long-distance quantum entanglement.

025004 **Culinary fluid mechanics and other currents in food science**

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This review describes recent scientific advances in the context of the culinary arts. It is written as a menu, starting with the physics of drinks, followed by the main course, and ending with complex desserts. Recent discoveries are reviewed, particularly in fluid mechanics and soft matter physics, and their relevance to food science is highlighted. Many phenomena like the Cheerios effect, coffee-ring effect, Brazil nut effect, Leidenfrost effect, and Marangoni effect are described and illustrated by epicurean examples.

025005 **Physics principles of inertial confinement fusion and U.S. program overview**

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The quest for controlled fusion has been ongoing since the middle of the last century. Recently, however, there have been great strides in inertial confinement fusion, a method based on creating high energy densities through implosions. This review covers the three major approaches being pursued in the U.S., discussing key concepts, principles, and technical challenges.