Reviews of Modern Physics

Volume 92 **Number 1** **January–March 2020**

011001 ***Colloquium*: Multiconfigurational time-dependent Hartree approaches for indistinguishable particles**

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The problem of many interacting particles in classical mechanics is notoriously difficult. In quantum mechanics, indistinguishability makes the theoretical description of many-particle systems even more challenging. In this Colloquium a theory and associated practical numerical approaches to treat the time-dependent Schrödinger equation for identical interacting particles from first principles and their use in atomic and molecular systems are discussed.

011002 ***Colloquium*: Heavy-electron quantum criticality and single-particle spectroscopy**

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Quantum critical behavior occurs at low temperatures where quantum fluctuations become more important than thermal fluctuations. Of particular current interest is unconventional quantum criticality, which lacks a classical thermal counterpart. Angle-resolved photoemission and scanning tunneling microscopy are experimental techniques that measure single-particle excitations, and have recently been used to probe strongly correlated metals near quantum critical points. Here, how the single-particle properties reflect the unconventional quantum criticality is discussed, and the prospect for further measurements to unearth new physical behavior.

011003 ***Colloquium*: Neutrino detectors as tools for nuclear security**

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Patrick Huber
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In 1930, Wolfgang Pauli proposed that conservation of energy and momentum in beta decay required the existence of a new particle: the neutrino. Since then experimental methods have matured to the point that neutrino detection now has an important practical application, namely, enhancing nuclear security. In this Colloquium the challenges and advances in the field of neutrino detection and their use in national security are discussed.

015001 **Quantum steering**

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In his 1936 paper, "Probability relations between separated systems," Schrödinger analyzed the quantum steering effect, showing that measurements on one part of an entangled quantum system can result in the state of the other part being "steered" to any state vector consistent with the original joint state. This result, which was meant to sharpen and make more precise the argument of Einstein, Podolsky, and Rosen, lay invisible in plain sight for more than 70 years. This review discusses the many extensions and generalizations to steering that have been uncovered since the "rediscovery" of Schrödinger's work.

015002 **Evolution of shell structure in exotic nuclei**

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The next generation of rare-isotope beam facilities will enable access to key regions of the nuclear chart, where the measured properties of short-lived isotopes will challenge our current theoretical picture and help develop a comprehensive model of the atomic nucleus. This article reviews the mechanisms driving the evolution of shell structure in exotic nuclei that impact nuclear physics and nuclear astrophysics research.

015003 **Quantum computational chemistry**

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With small quantum computers becoming a reality, first applications are eagerly sought. Quantum chemistry presents a spectrum of computational problems, from relatively easy to classically intractable. Algorithms for the easiest of these have been run on the first quantum computers. But an urgent question is, how well will these algorithms scale to go beyond what is possible classically? This review presents strategies employed to construct quantum algorithms for quantum chemistry, with the goal that quantum computers will eventually answer presently inaccessible questions, for example, in transition metal catalysis or important biochemical reactions.

015004 **Sensitivity optimization for NV-diamond magnetometry**

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Nitrogen-vacancy (NV) centers in diamond carry spin degrees of freedom that enable their use for sensing of weak magnetic fields with high spatial resolution and under ambient conditions. This article reviews measurement technologies and identifies the physical mechanisms that limit the sensitivity with a focus on NV ensembles. Present-day NV sensors are far from theoretical limits imposed by quantum mechanics, and strategies are suggested for improvement of methods and materials.