Reviews of Modern Physics

Volume 96 **Number 3** **July–September 2024**

030501 **Nobel Lecture: Genesis and applications of attosecond pulse trains** — Pierre Agostini

The 2023 Nobel Prize for Physics was shared by Pierre Agostini, Ferenc Krausz, and Anne L'Huillier. These papers are the text of the address given in conjunction with the award.

030502 **Nobel Lecture: Sub-atomic motions** — Ferenc Krausz

030503 **Nobel Lecture: The route to attosecond pulses** — Anne L'Huillier

031001 ***Colloquium*: Quantum batteries** — Francesco Campaioli, Stefano Gherardini, James Q. Quach, Marco Polini, Gian Marcello Andolina

Storage of energy in quantum devices is of practical relevance for applications in quantum technologies. The topic attracts attention also of a more foundational character due to the possibility that the charging power and work extraction can benefit from quantum coherence and collective effects. This Colloquium reviews theoretical concepts and experimental implementations of energy storage in quantum batteries drawing on work in quantum thermodynamics and quantum information science.

031002 ***Colloquium:* Eigenvector continuation and projection-based emulators** — Thomas Duguet, Andreas Ekström, Richard J. Furnstahl, Sebastian König, Dean Lee

The numerical treatment of quantum systems often requires large amounts of computing power and time. As a result, performing calculations repeatedly for different values of the input parameters is often not feasible. One remedy is using eigenvectors describing the system that are analytic functions that vary smoothly for real values of the input parameters. This allows one to replace computationally expensive calculations with emulators that project onto a reduced-basis set. This Colloquium explores a particular class of reduced-basis methods known as eigenvector continuation and its applications, with emphasis on nuclear physics.

031003 ***Colloquium*: Inclusions, boundaries, and disorder in scalar active matter** — Omer Granek, Yariv Kafri, Mehran Kardar, Sunghan Ro, Julien Tailleur, Alexandre Solon

Active systems defy the laws of equilibrium statistical mechanics, often enjoying long range order in situations where dead matter cannot, as required by rigorous results. These strong, long-range correlations result in a preternatural sensitivity to sample boundaries and boundary conditions. This Colloquium demonstrates this phenomena by focusing on a simple model of dry scalar active matter that demonstrates the salient effects without the additional complexity of hydrodynamics.

035001 **Ultimate Rayleigh-Bénard turbulence**

Detlef Lohse
Olga Shishkina

Rayleigh-Bénard convection is the flow in a closed box heated from below and cooled from above. The ultimate regime of Rayleigh-Bénard turbulence occurs when the dimensionless temperature difference between the bottom and top plates is large. This review gives a comprehensive overview of the theoretical approaches to the ultimate regime and of the experimental and numerical results on the transition to this regime. These are reconciled by realizing that the transition is of non-normal–nonlinear nature, as typical for the laminar to turbulent transition in shear flow. The review also suggests experimental and numerical approaches to further understand the transition to the ultimate regime.

035002 **FLASH: New intersection of physics, chemistry, biology, and cancer medicine**

Marie-Catherine Vozenin
Billy W. Loo
Sami Tantawi
Peter G. Maxim
Douglas R. Spitz
Claude Bailat
Charles L. Limoli

Treating cancer with ionizing radiation has been pursued for nearly a century. A key challenge has been finding the right balance between providing enough dose to kill the cancer cells while minimizing the damage to normal ones. The discovery of the so-called FLASH effect, where short radiation bursts allow for higher lethal doses to be delivered to cancer cells while sparing healthy tissue, opens up the therapeutic window and ushers in a new era for radiation therapy. In this review multidisciplinary aspects are discussed of dose delivery, the chemistry and biology behind the effect, and readiness for clinical deployment.