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041001 ***Colloquium*: Miniature insect flight** — Mao Sun

The flight of the bumblebee has long been a source of fascination, in part because the lift requirements cannot be explained by conventional steady fluid dynamics, and unsteady aerodynamic mechanisms must be invoked. In addition, viscous effects are important for the majority of flying insects, which are an order of magnitude smaller than bumblebees. This leads to different wingbeat patterns and aerodynamic mechanisms. In this Colloquium, recent advances in the study of the mechanics of flight in these miniature insects are reviewed.

041002 ***Colloquium*: Gravitational form factors of the proton** — V. D. Burkert, L. Elouadrhiri, F. X. Girod, C. Lorcé, P. Schweitzer, P. E. Shanahan

The gravitational form factors encode fundamental particle properties including mass, spin, and D-term. Their physical interpretation promises, for composed particles, insights on spatial distributions of energy, angular momentum, and internal forces. This Colloquium reviews the theoretical and recent experimental advances in this field with a focus on the quark-gluon structure of the proton in QCD.

045001 **Respiratory aerosols and droplets in the transmission of infectious diseases** — Mira L. Pöhlker, Christopher Pöhlker, Ovid O. Krüger, Jan-David Förster, Thomas Berkemeier, Wolfgang Elbert, Janine Fröhlich-Nowoisky, Ulrich Pöschl, Gholamhossein Bagheri, Eberhard Bodenschatz, J. Alex Huffman, Simone Scheithauer, Eugene Mikhailov

The pandemic of coronavirus disease 2019 has led to a renewed focus on the physicochemical properties of the droplets and aerosol particles that are exhaled during breathing, speaking, singing, coughing, and sneezing. In this article, the properties of respiratory particles, including their number concentrations and size distributions, as well as their formation mechanisms at different sites in the respiratory system, are reviewed. The data in the literature are synthesized via a parametrization of the particle size distribution data using log-normal modes related to the different origin sites.

045002 **Atmospheric nanoparticle growth** — Dominik Stolzenburg, Runlong Cai, Sara M. Blichner, Jenni Kontkanen, Putian Zhou, Risto Makkonen, Veli-Matti Kerminen, Markku Kulmala, Ilona Riipinen, Juha Kangasluoma

Atmospheric nanoparticles can serve as nuclei for cloud droplets, thereby inducing significant but uncertain effects on the radiative forcing of the climate system. This article focuses on the physicochemical processes that govern the growth of these particles from formation of molecular clusters until the particles reach sizes where they can act as cloud condensation nuclei. The review describes the latest developments in measurement and modeling of these processes and connects these domains to the large-scale simulations such as Earth system models. The authors recommend closer coordination among laboratory studies, atmospheric measurements, and large-scale modeling to understand the importance of nanoparticles in the climate system.

045003 **Light in correlated disordered media**

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The study of optics in correlated disordered media combines wave physics, complex media, and nanophotonics. Investigations have shown how subwavelength structural correlations control light scattering, transport, and localization. This article reviews the formalism behind light scattering in disordered media, experimental techniques, and achievements in studying light interaction with correlated disorder. It explores phenomena like optical transparency, superdiffusive transport, and photonic gaps, offering new perspectives for applications. The research covers systems from photonic liquids to hyperuniform disordered photonic materials, and addresses mesoscopic phenomena and disorder engineering for light-energy management.

045004 **Kinematic variables and feature engineering for particle phenomenology**

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Kinematic variables are important tools for analyzing collider experiments. This article reviews a variety of such tools, which were designed primarily for the experiments at the Large Hadron Collider, but which have potential uses in other experiments. The article also discusses the interconnection and mutual complementarity of kinematic variables and modern machine-learning techniques.

045005 **Quantum error mitigation**

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Simon C. Benjamin
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William J. Huggins
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In most of physics it is normal to obtain information by analysis of noisy data. The paradigm of quantum computing has been a simplified version of this—one measurement of a two-level system gives one bit of reliable information about the result of a computation. But real-world quantum computers do not work this way: the noisiness of quantum evolution also requires good strategies for extracting information. This review covers many error-mitigation strategies used in present-day quantum processors. These strategies make it much more feasible to obtain useful results before fault tolerance is achieved.

045006 **Quantum repeaters: From quantum networks to the quantum internet**

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David Elkouss
Paul Hilaire
Liang Jiang
Hoi-Kwong Lo
Ilan Tzitrin

Quantum technology is now at a point where practical work can begin on creating the quantum internet. However, numerous challenges must be overcome before this vision becomes a reality. A global-scale quantum internet requires the development of the quantum repeater, a device that stores and manipulates qubits while interacting with or emitting entangled photons. This review examines different approaches to quantum repeaters and networks, covering their conceptual frameworks, architectures, and current progress in experimental implementation.

045007 **Proton imaging of high-energy-density laboratory plasmas**

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Probing of electromagnetic fields in high-energy-density experiments is key to understanding questions in fusion processes such as how the fields are compressed, diffuse through the plasma, and can seed instabilities. Many kinetic processes studied, including collisionless shocks, filamentary instabilities, jets, magnetic reconnection, and turbulence, all depend on the field structure. In this review, an overview of experimental techniques and the underpinning theoretical principles and modeling of proton-based imaging is presented, followed by a review of experiments and an outlook for future frontiers in the technique.