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031001 ***Colloquium*: Criticality and dynamical scaling in living systems** — Miguel A. Muñoz

Close to a transition between different phases a substance can show universal behavior that is independent of the microscopic details and is characterized by power-law correlations and critical exponents. In this Colloquium the concepts of criticality and universality are discussed when applied to biological systems and suggest that in some cases these systems can extract functional advantages close to criticality.

031002 ***Colloquium*: Quantum matter built from nanoscopic lattices of atoms and photons** — D. E. Chang, J. S. Douglas, A. González-Tudela, C.-L. Hung, H. J. Kimble

Quantum optics has advanced tremendously over the past two decades by combining ultracold atoms with diverse optical systems. However, fundamental and technical issues place constraints that limit further advances. This Colloquium examines new paradigms for strong quantum interactions of matter and light by way of atoms and photons in nanoscopic dielectric lattices, including novel quantum phases of atoms, photons, and phonons.

031003 ***Colloquium*: Control of dynamics in brain networks** — Evelyn Tang, Danielle S. Bassett

Biological networks are notoriously complex to understand and hence challenging to control. The brain is possibly the most sophisticated network in nature and only recently have we started to comprehend the mechanics of its operation and control. This Colloquium reviews the latest theoretical and technological developments in this emergent and exciting area of research.

035001 **Single top-quark production at the Tevatron and the LHC** — Andrea Giammanco, Reinhard Schwienhorst

The top quark was discovered and extensively studied in strong interactions that produce top-antitop pairs. The companion process in which a single top quark is produced in electroweak interactions offers many complementary insights into top-quark production and properties that are sensitive to a variety of possible nonstandard model interactions.

035002 **Diagnostics for plasma-based electron accelerators** — M. C. Downer, R. Zgadzaj, A. Debus, U. Schramm, M. C. Kaluza

Plasma-based electron accelerators rely on excitation of light-speed plasma density waves and associated ultrahigh electric fields to accelerate electrons to ultrarelativistic energy. Intrinsic time and length scales of these plasma waves are typically a few tens of femtoseconds and micrometers and result in ultrashort electron bunches with often even smaller temporal and spatial dimensions. In this article the progress and challenges of diagnosing the plasma waves, the excited fields, and ensuing particle bunches are reviewed.

035003 **Delocalized excitons in natural light-harvesting complexes**

Seogjoo J. Jang
Benedetta Mennucci

Photosynthetic bacteria, algae, and plants convert solar energy into biochemical fuel via light-harvesting complexes comprised of proteins and pigments. Pigments absorb photons by exciting electron-hole pairs that move readily to other pigments. How biology utilizes such quantum processes at room temperature to achieve efficiency of energy transfer is of interest to physicists. This article reviews computational and spectroscopic advances in understanding the energy conversion and energy transport of such a magnificent nanorectenna.

035004 **Microscopic clustering in light nuclei**

Martin Freer
Hisashi Horiuchi
Yoshiko Kanada-En'yo
Dean Lee
Ulf-G. Meißner

In most nuclei, protons and neutrons are smoothly distributed throughout the nuclear volume. Exceptions to this rule are molecularlike states, especially in light nuclei, where light nuclear clusters such as alpha particles are present. The most prominent example is the 7.65 MeV Hoyle state in carbon-12 that plays an essential role in the production of carbon in stars in the triple-alpha process. This work reviews progress and prospects in the studies of nuclear clustering, including molecular states in alpha-conjugate and neutron-rich systems.

035005 **Quantum metrology with nonclassical states of atomic ensembles**

Luca Pezzè
Augusto Smerzi
Markus K. Oberthaler
Roman Schmied
Philipp Treutlein

Entanglement is the basis of quantum technologies aimed at revolutionizing measurements, computing, and communications. This article reviews methods to improve measurement precision and sensitivity by harnessing entangled states of many atomic probe particles. The achievements of different experimental entanglement schemes are presented with theoretical analyses of their fundamental and practical limits, discussing prospects for applications in clocks, frequency standards, and measurements of forces and fields.

035006 **Quantum-enhanced measurements without entanglement**

Daniel Braun
Gerardo Adesso
Fabio Benatti
Roberto Floreanini
Ugo Marzolino
Morgan W. Mitchell
Stefano Pirandola

Entangled quantum states can enhance measurement precision. But quantum mechanics harbors other possibilities for enhancing precision, including some that have nothing to do with entanglement. This review surveys various strategies with unentangled probes by which measurements have been improved. Among the approaches considered are those that rely on particle statistics and correlations in highly mixed states. Often nonentangled states are more robust, and these approaches are feasible in current experiments: here the current states of research are shown in cold atoms, nonlinear optics, and nanomechanical oscillators.

035007 **Entanglement entropy: Holography and renormalization group**

Tatsuma Nishioka

In this review the entanglement and Rényi entropies in quantum field theory are described from different points of view, including the perturbative approach as well as holographic dualities. The applications of these results to constraining renormalization group flows are presented effectively and illustrated with a variety of examples.