Reviews of Modern Physics

Volume 92 **Number 3** **July–September 2020**

030501 **Nobel Lecture: How physical cosmology grew** — P. J. E. Peebles

030502 **Nobel Lecture: Plurality of worlds in the cosmos: A dream of antiquity, a modern reality of astrophysics** — Michel Mayor

030503 **Nobel Lecture: 51 Pegasi b and the exoplanet revolution** — Didier Queloz

The 2019 Nobel Prize for Physics was shared by James Peebles, Michel Mayor, and Didier Queloz. These papers are the text of the address given in conjunction with the award.

031001 ***Colloquium*: Linear in temperature resistivity and associated mysteries including high temperature superconductivity** — Chandra M. Varma

Even after much research and heated debate, high temperature superconductivity remains one of the most challenging and controversial problems in condensed matter. Apart from that at a phenomenological level some accepted and successful paradigms for the behavior of electrons fail, even the model relevant for the observed properties has been under debate, as well as methods to solve any model satisfactorily. In this Colloquium a perspective is provided into issues involved and results of a systematic solution on a model are reviewed and compared with experiments on an anomalous metallic state which is the basis for the emerging superconducting state.

035001 **Advances and challenges in single-molecule electron transport** — Ferdinand Evers, Richard Korytár, Sumit Tewari, Jan M. van Ruitenbeek

Single-molecule junctions spanning nanosized gaps between metallic contacts represent an opportunity to study electron transport on atomic length scales through specific molecular species. This review provides a critical account of key results on molecules located in break junctions or manipulated into position with scanning probe techniques. Detailed conductance measurements show a qualitative picture of the physical mechanisms for transport with the recognition that studies of benchmark systems with use of atomic scale parameters for simulation inputs will provide better quantitative agreement of theory with experiment.

035002 **The physics of climate variability and climate change** — Michael Ghil, Valerio Lucarini

This article presents a comprehensive survey of the fundamentals of climate dynamics. Recent developments in dynamical systems theory, as well as in random processes and statistical mechanics, have created a common framework for physicists and climate scientists. The key aspects of climate dynamics addressed here are the natural variability of the climate system, the deterministic and random processes that contribute to this variability, its response to perturbations, and the relations between internal and external causes of observed changes in the system. Tools are presented for the study of critical transitions in the climate system, which can help us to understand and possibly predict the potential for catastrophic climate change.

035003 **Thirty years of H_3^+ astronomy**

Steve Miller
Jonathan Tennyson
Thomas R. Geballe
Tom Stallard

H_3^+, the simplest polyatomic molecular ion, has been discovered to play an extensive role in the physics and chemistry of astrophysical environments such as interstellar molecular clouds and the atmosphere of giant planets in our Solar System and beyond. This review presents an account of the progress achieved in this realm after three decades of planetary and interstellar observations, starting from its first, unexpected identification in Jupiter's atmosphere up to the most recent data returned by the ***Juno*** and ***Cassini*** missions, the characterization of gas in the center of our Galaxy, and the latest measurements and calculations of the physical and chemical properties of this fundamental ion.

035004 **Models of polymer solutions in electrified jets and solution blowing**

Marco Lauricella
Sauro Succi
Eyal Zussman
Dario Pisignano
Alexander L. Yarin

Modeling and controlling the flow of complex fluids with nanoscale resolution is an essential component of current and future technologies. In particular, electric fields can be effectively used to steer and manipulate polymeric solutions to create new materials and devices. This review outlines the rich physics of fluid mechanics, electromagnetism, and polymer dynamics that combine to create the theoretical underpinnings of this burgeoning field.

035005 **Modes and states in quantum optics**

C. Fabre
N. Treps

Quantum states of light are at the same time endowed with two superposition principles: the one of the classical Maxwell waves and the one of the quantum states occupying these waves. This article reviews the interplay between these two aspects of quantum optics. A summary of the description of multimode quantum states is presented along with an example of the characterization of correlations and entanglement with applications in metrology and quantum computation.