The quantum Hall effects: overview and recent advances

A. D. Mirlin

Institut für Nanotechnologie, Forschungszentrum Karlsruhe, 76021 Karlsruhe, Germany; Institut für Theorie der Kondensierten Materie, Universität Karlsruhe, 76128 Karlsruhe, Germany

Petersburg Nuclear Physics Institute, 188350 Gatchina, St. Petersburg, Russia

A quarter century after the discovery of the **integer quantum Hall effect (IQHE)** in 1980 and the **fractional quantum Hall effect (FQHE)** in 1982, this field remains among most active research areas of the modern physics. During the past five years or so, the progress in nanofabrication technologies has led to a wave of new discoveries in this area. The aim of this lecture is to give an overview of the field, with the emphasis on recent developments and current research.

I will begin by reminding the basics of the IQHE. Then I will review the recent activity and open problems, including:

— the nature of the IQH transition and corresponding critical properties;
— striped phases in high Landau levels;
— quantum Hall effect in novel materials;
— quantum Hall effect in unconventional symmetry classes.

In the second part of the lecture the FQHE is considered. The main emphasis here is put on the **composite fermion (CF)** physics. A composite fermion is a quasiparticle that may be thought as an electron carrying an even number of flux quanta. The CF theory allows not only to explain the FQHE but also governs a large body of remarkable physics taking place in high-quality 2D electron systems in strong magnetic fields. I will discuss the magnetotransport of CFs near half filling of the lowest Landau level, where the effective magnetic field experienced by a CF is relatively small. A large number of experiments performed in various setups (including lateral superlattices, antidot arrays, and surface acoustic wave coupled to the 2D electron gas) yields a beautiful confirmation of the CF theory. I will also briefly review a number of recently discovered strongly correlated states resulting from the CF interaction, in particular the composite fermion pairing at the Landau level filling factor $\nu = 5/2$, higher generations of composite fermions, and correlated states in bilayer systems.