International Journal of Modern Physics B
Vol. 21, Nos. 8 & 9 (2007) 1131–1132

World Scientific
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The High Magnetic Field Facilities at Nijmegen: Recent Results

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The newly built High Field Magnet Laboratory (HFML) at the Radboud University Nijmegen offers DC magnetic fields up to 33 T to external and internal users.

The general research theme of the HFML consists of the application of high magnetic fields to condensed matter systems in two areas, namely electronic properties of top-down nanostructures and the order in molecular aggregates (bottom-up). The first research line addresses the quantum nature of electrons in high magnetic fields and, in particular, provides access to nanoscale electronic properties (the magnetic length is 4.7 nm at 30 T). The second line uses (dia-)magnetic forces on nanosized organic clusters leading, e.g., to a magnetic alignment of supramolecular structures.

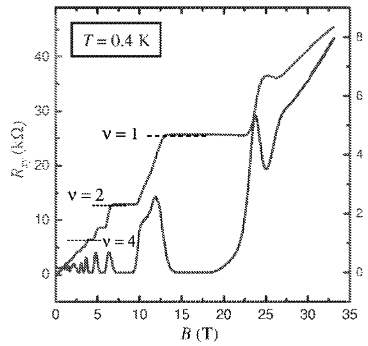
In the field of semiconductor physics we focus on low-dimensional electron systems, studied with transport [1-4], magnetization [4] and optical [5] and far-infrared spectroscopy [6].

A typical example of our research on quantum Hall systems is shown in Fig. 1 where the resistivity ρ_{xx} and the Hall resistivity ρ_{xy} of a bilayer two-dimensional electron system is plotted. These experiments are the first successful complete test of the newly built HFML.

When subjecting bilayer 2DESs to a tilted magnetic field the complex energy level structure of the system leads to crossings and anti-crossing of Landau levels [2]. Additionally, we have accessed their energy level structure directly by means of magnetization experiments where we are able to measure the energetic splitting between the symmetric and antisymmetric state [5].

Fig. 1.

Hall resistance R_{xy} and magneto-resistance R_{xx} in a GaAs/AlGaAs double-quantum well system [2].



Recently, we have contributed to extend quantum Hall physics to the new 2DES realized in grapheme, a single sheet of carbon. In particular, we have measured a novel type of quantum Hall effect associated to massive chiral Dirac fermions in bilayer graphene [2], see Fig. 2, and, we have observed a room-temperature quantum Hall effect in single-layer graphene [3].

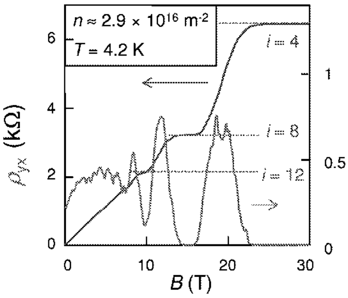


Fig. 2.

Hall resistivity ρ_{xy} and resistivity ρ_{xx} in bilayer graphene at 4.2 K [2].
The Hall resistivity develops plateaus at filling factors i = 4, 8 and 12 corresponding to integer filling of four-fold degenerate Landau levels.

The high magnetic fields at the HFML are also exploited for quantum-dot physics. In this area we succeeded to measure and to interpret the successive charging of InAs quantum dots with *holes* by means of capacitance-voltage spectroscopy [8] (see Fig. 3) to map the hole wavefunctions in InAs quantum dots [9] and to measure the complex magnetic-field dependence of the hole energy levels using photoluminescence spectroscopy [6].

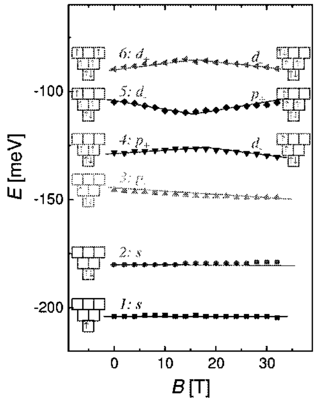


Fig. 3.

Charging energies for InAs quantum dots filled with up to six holes as a function of the magnetic field [6]. The number of holes in the dot and their orbital momentum for zero field is indicated on the left, the high-field orbital momentum for the N-hole ground state is given on the right. The insets show our proposed occupation of the single-particle levels for zero field and high fields.

References

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