Spin splitting of energies in semiconductor heterostructures due to inversion asymmetry — theory and experiment

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Spin splitting of subband energies in semiconductor heterostructures due to inversion asymmetry is reviewed. Both bulk inversion asymmetry (BIA) and structure inversion asymmetry (SIA) are considered. Theoretical and experimental aspects of the subject are presented.

The problem of inversion asymmetry and its effects on spin splitting of energies in two-dimensional systems turned out to be a controversial problem, full of contradictions and misunderstandings. For this reason we begin by the brief history of the subject which started in 1974. Next, the multiband k.p approach to III–V semiconductor heterostructures is introduced which is the basis of the presented theory. This formalism includes both the bulk inversion asymmetry (so called Dresselhaus mechanism) and structure inversion asymmetry (so called Bychkov–Rashba mechanism). It is emphasized that the SIA spin slitting of the conduction subbands is not proportional to the electric field in the same subbands, contrary to claims made in the literature. This feature is illustrated by considering averages electric fields in bound quantum states. Additional properties related to different effective masses in various parts of a heterostructure are discussed. Theoretical results for GaAs/GaAlAs heterostructures are presented and compared to existing experimental data. An influence of an external magnetic field on the spin splitting is presented and illustrated using InAlAs/InGaAs and InSb/InAlSb heterostructures. An influence of an external electric field on the spin splitting is also discussed.

Experimental techniques used to measure the spin splitting are presented: Beatings of the Shubnikov-de Haas oscillations, magnetoconductance in weak localization regime, Raman scattering, spin resonance and cyclotron resonance.

The motivation of this work by spintronic applications ("spin amplifier") is emphasized.

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