The physics of ferromagnetic semiconductors: from symmetry to micromagnetic properties

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The magnitude and spatial distribution of magnetization at the mesoscopic scale (e.i., micromagnetic properties of ferromagnets) are determined by relativistic spin-orbit interaction and crystal symmetry.

In the first part of the lecture I will discuss the role of carrier contribution to the total magnetization in dilute ferromagnetic semiconductors, such as (Ga,Mn)As [1]. In particular, I will compare, within the *k.p* model, the time-honored Landau approach to the modern theory of orbital magnetization developed more recently by Resta and co-workers to account for effects of spin-orbit interaction [2]. The key finding here, allowing to describe experimental data [1,3], is the demonstration that the determination of Landau level energies is not needed within the modern approach. Its implementation requires the proper treatment of contributions arising from remote bands.

In the second part of the talk, in-plane uniaxial anisotropy of (Ga,Mn)As will be discussed. This anisotropy was discovered in 1998 and found to be crucial for functionalities of (Ga,Mn)As [4]. By combining *ab initio* approaches with the Luttinger method of invariance with spin-orbit interaction taken into account we demonstrated that this puzzling anisotropy, whose presence contradicts the results of group theory for zinc-blende crystals, stems from a non-random distribution of Mn over cation sites setting in at the surface during the epitaxial growth [5]. Gaining the insight into the physical origin of the uniaxial anisotropy allows us to propose methods of its control, the important step to explore further novel functionalities in (Ga,Mn)As and related systems. At the same time, our model elucidates the origin of a threefold enhancement of the apparent shape magnetic anisotropy found in thin films of (Ga,Mn)As [6].

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