Domain wall dynamics and magnetic texture behavior in magnetic films with Dzyaloshinskii-Moriya interaction

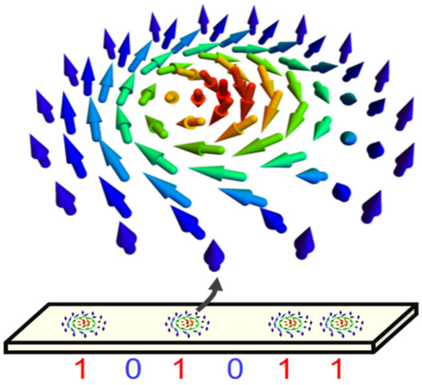

Fig. 1. Chiral magnetic domain structure – skyrmions as a possible candidate for data recording [http://www.nanowerk.com].

With the ever-increasing amounts of digital information being processed, transferred and stored by computers, comes a commensurate demand for increased data storage capacity. For magnetic data storage such as the ubiquitous hard disk drive, this requires not only physically smaller memory elements or bits, but also reduced switching power to avoid heat issues. Thus, in magnetic materials which are used in the newest electronic devices, not only the electron charge is important, but also their spins. Spins and their alignment decide about magnetic properties of the material. An especially fascinating phenomenon in relation to magnetic materials is the chirality. It is characterized by a reflection asymmetry that we are most familiar with in terms of our left hand being the mirror opposite of our right hand. Chirality plays an important role e.g. in physics and e.g. in magnetic materials it can display single-handed, or homochiral spin structures. Such chiral types of magnetization in magnetic material are induced by the Dzyaloshinskii-Moriya interaction (DMI). The DMI in simplicity is a microscopic characteristic of interacting spins that occurs in a system that lacks inversion symmetry and that has a strong spin-orbit coupling. The DMI creates phases which have a winding magnetic configuration – like a skyrmion structure. Observed in magnetic materials, the magnetic structures like magnetic either domain walls or Bloch points, but mainly skyrmions, are the foundation for possible future solid state magnetic information technologies. Because of their possible tiny, nanometer-sized magnetic-spin vortices structure they could potentially be used as extremely dense memory devices, with the either presence or absence of skyrmions being used to denote bits in computer calculations (Fig. 1).

In relation to the described points the main goals of the project will be to obtain a fundamental understanding of the manipulation of micromagnetic structures about static and dynamic properties of out-of-plane anisotropy thin films with Dzyaloshinskii-Moriya interaction. Especially it will be focused on investigating the high-frequency response of partly pinned or free micromagnetic structures to magnetic, electric and thermo-optical (laser pulse with proper pulse energy) stimuli in geometrically confined structures. Planned studies on the tailored structures will be backed by complementary local magnetometry, ferromagnetic resonance, and Brillouin light scattering spectroscopy measurements, from which the indispensable static and dynamic material parameters will be obtained. In collaboration with the first Polish synchrotron radiation facility (SOLARIS) high resolution techniques supporting the research will be available. The obtained data will be the basis for micromagnetic calculations. Combining simulations and time resolved real-time imaging will clarify the underlying physical mechanisms and will provide a fundamental contribution to the realization of envisioned magnetic memory technologies. Particularly the realization of the abovementioned skyrmions in magnetic materials could lead to the advent of a new class of low-power consumption devices dubbed "spintronics", which includes high-density magnetic memory.

The interest on magnetic domain structure like e.g. skyrmions has become a recent trend in experimental and theoretical research activities. Research are mainly focused on understanding the fundamental magnetic properties of this micromagnetic structures in a variety of different material systems as well as advances of the methods for preparation, detection, and their manipulation. So, the proposed studies follow the trend related to magnetic structure development.