UNCONVENTIONAL MAGNONICS: FROM NANO-OPTICS TO SUPERCONDUCTIVITY

O. V. Dobrovolskiy

Physikalisches Institut Goethe University, Frankfurt am Main, Germany
e-mail: Dobrovolskiy@physik.uni-frankfurt.de

In the recent years, magnonics (the study of spin waves — precessional excitations of ordered spins in magnetic materials) has emerged as one of the most rapidly growing research fields in magnetism [1,2]. This is largely because of the recent advances in the understanding of fundamental properties of spin waves in magnetic micro- and nanostructures, rendering magnonics as a potential rival of or complement to semiconductor technology for data communication and processing [3]. At the same time, loss reduction, shortening of the wavelength of spin waves [4], and the associated miniaturization of the implemented magnonic concepts and devices remain major challenges in both experimental research and technological development in magnonics. This is why the development of new approaches and the implementation of ideas originating from other domains of physics is currently at the forefront of the magnonics research.

In my talk, I will primarily address two groups of concepts in magnonics associated with nano-optics and superconductivity.

In spin-wave nano-optics, I will dwell on novel approaches to generate and manipulate spin-wave beams [5,6] in graded-index magnetic media fabricated by focused electron beam-induced deposition (FEBID) [7]. A particular attention will be paid to spin-wave lenses based on the spin-wave phase-tuning using a single nanodefect [8].

At the interface of magnonics and fluxonics research (fluxonics is the study of properties and dynamics of vortices in superconductors [9]), an important conceptual similarity will be exploited: Disturbances in magnetic ordering in magnetic materials propagate in the form of spin waves (magnons) while magnetic fields penetrate superconductors as a lattice of magnetic flux quanta (fluxons). Recently, the interaction of spin waves with a flux lattice in ferromagnet/superconductor Py/Nb bilayers has been evidenced [10]. In particular, it has been demonstrated that, in this system, the magnon frequency spectrum exhibits a Bloch-like band structure with forbidden-frequency gaps which can be tuned by the biasing magnetic field. Furthermore, Doppler shifts have been observed in the frequency spectra of spin waves scattered on a flux lattice moving under the action of a transport current in the superconductor, thereby setting the stage for magnon-fluxonics as a new research domain at the interface between superconductivity and magnetism.

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