3D nanoarchitectures for superconductivity and nanomagnetism

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Patterned superconductors and nanomagnets are traditionally 2D planar structures, but recent work is expanding superconductivity and nanomagnetism into the third dimension. This expansion is triggered by advanced synthesis methods and the discovery of novel geometry- and topology-induced effects. In addition to self-assembled systems, a high level of maturity is now reached in direct-write nanofabrication by focused electron and focused ion beam induced deposition (FEBID and FIBID, respectively) [1], whose potential for various domains of nanomagnetism and superconductivity is outlined in this contribution.

1. 3D ferromagnetic elements allow for breaking the symmetry in the dynamics of superconducting vortices and studying vortex ratchet (rectification) effects. This opens new horizons for magnon fluxonics addressing the interplay between superconductivity and spin-wave physics [2].

2. In contradistinction to planar superconductor structures, the complex 3D geometry determines topologically nontrivial screening currents in superconductors that crucially affects the dynamics of vortices therein. Successful examples of the extension of fluxonic conduits into third dimension will be demonstrated [3,4].

3. Magnonic networks require efficient steering of spin waves which becomes challenging in curved waveguides. A solution is offered by a graded refractive index which smoothly alters the wave trajectory with minimal reflections and can be achieved via a gradual change of e.g. magnetization [5-7] in 3D structures.

4. Despite of exciting theoretical predictions and strong application potential of curvilinear magnetism, the development of fabrication techniques is a essential for this topical area. Fortunately, CAD-assisted direct-write nanofabrication demonstrates potential for bridging this gap, that is expected to open new horizons for curvilinear magnetism and chiral magnonics as will be commented in the talk.

References

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