



## Seminar H2020 MSCA RISE « ULTIMATE-i » :

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### Assembly of super-structures directed by surface and magnetic interactions: from self-assembled magnetic patterned surfaces to tubes

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In this talk, we explore the fascinating world of magnetic nanostructures, specifically the assembly of magnetic nanoparticles guided by surface and magnetic interactions. Our theoretical investigation focuses on two distinct systems: tubular assemblies of magnetic spheres and clusters/lattices of cuboidal particles. The tubular assemblies, constructed through the assembly of dipolar spheres stem from their ground state and implications of the long-range nature of dipolar interaction [1]. Our discussion encompasses the intricate details of magnetic texture transformation revealing a transition from circular to axial magnetization as tube length increases and the emergence of an intermediary helically magnetized state [2]. Besides, we explore the antiferromagnetic phase resulting from a square arrangement of dipolar spheres, unveiling intriguing vortex states.

Shifting focus, we investigate the stabilization of clusters and lattices formed by cuboidal particles, influenced by long-ranged magnetic dipolar and short-ranged surface interactions. Our study encompasses realistic systems with magnetization oriented along distinct crystallographic directions [3]. Our findings showcase the ability of dipolar coupling to stabilize various nanoparticle assemblies, including cubic, planar, and linear arrangements, mirroring experimental observations. Crucially, we highlight how the interplay between attractive surface energy and repulsion dictates the formation of super-cubes or elongated structures such as rods and chains. The stabilization of ferromagnetic planar arrangements further underscores the delicate balance between surface repulsion and magnetic dipolar coupling [4]. With our research, we explore pathways into the design and understanding of novel magnetic super-structures with diverse applications in nanotechnology.

[1] R. Messina et al. "Self-assembly of magnetic balls: From chains to tubes", PRE **89**, 011202, 2014.

[2] I. Stanković et al., "A platform for nanomagnetism—self-assembled ferromagnetic and antiferromagnetic dipolar tubes", Nanoscale **11**, 2521, 2020.

[3] L. Balcells et al., "Spontaneous in-flight assembly of magnetic nanoparticles into macroscopic chains", Nanoscale **11**, 2521, 2020.

[4] I. Stankovic, et al., "Assembly of nanocube super-structures directed by surface and magnetic interactions", Nanoscale **12**, 19390, 2021.