Coexistence of Collinear and Non-collinear Spin Texture in Antiferromagnetic Gyroidal MOFs

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The gyroid structure is a three-dimensional periodic structure with high symmetry and chirality discovered by A. H. Shoen [1] and has attracted much attention in a wide range of fields including chemistry, physics, mathematics, and architecture. We have also provided a rational explanation using line graphs in graph theory for "hidden geometrical frustration" in the gyroidal molecular assembly: when antiferromagnetic spins are present at the midpoints of the vertices of a single gyroid lattice, the resulting spin configuration forms a hyper-kagome lattice known as a spin frustration lattice to have the quantum spin liquid state. [2].

Metal-organic frameworks (MOFs), in which organic ligands interconnect metal centers, are excellently designed systems to show the attractive properties of a gyroid lattice (Fig. 1). The chemical diversity of ligands and the unique topologies of lattices make MOFs highly attractive for research. For instance, our recent findings highlight that the chirality of the single gyroid lattice in the $[Ru(bpy)_3][M_2(ox)_3]$ (M = Zn, Mn, bpy = 2,2'-bipyridyl, ox = oxalate) significantly enhances the solid-state circularly polarized luminescence of $Ru(bpy)_3^{2+}$ luminophores due to the host-guest interactions [1]. Furthermore, we unveiled that the gyroidal MOF with local magnetic anisotropy $[Ru(bpy)_3][Co_2(ox)_3]$ causes exchange frustration resulting in the emergence of various quantum magnetic states [4].

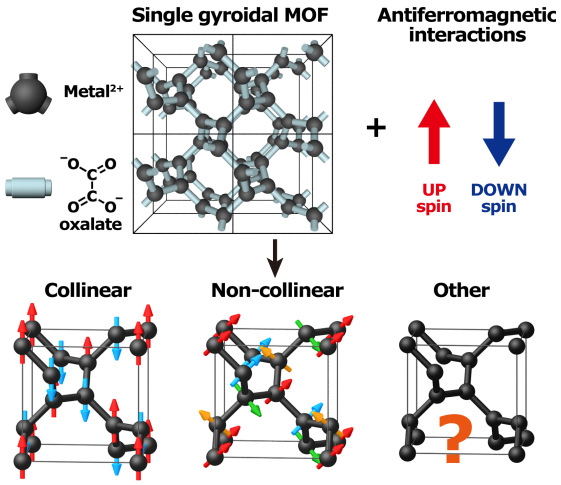

Figure 1 The possible spin texture in antiferromagnetic gyroidal MOFs.

What spin configuration would result if the antiferromagnetic spins were placed at the vertices of a gyroid lattice? This question motivated us to carry out the magnetic structure analysis of the single gyroidal MOF $[Ru(bpy)_3][M_2(ox)_3]$ (M = Mn, Co) using the single-crystal neutron diffraction (Fig. 2). Forbidden reflections derived from magnetic scattering were observed in the antiferromagnetic phase at low temperatures. Detailed analysis of these peaks revealed that the Mn sites split into two sites in the low-temperature phase, forming the coexistence of collinear and non-collinear spin textures.

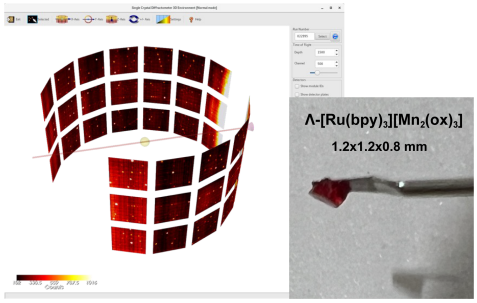

Figure 2 Neutron diffraction images.

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