MS24-03 | High Symmetry Dictates a Vortex Magnetic Structure for the Mysterious Hidden Order in URu_2Si_2

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For more than 30 years, there were tremendous research efforts to understand the mysterious Hidden Order (HO) in the heavy-fermion compound URu_2Si_2 [1].

To solve this enigma, we suppose that there is no spatial symmetry breaking at the HO transition temperature and solely the time-reversal symmetry breaking emerges owing to unusual magnetic ordering [2]. As a result of its high 4*/mmm* symmetry, each uranium atom is a *three-dimensional* magnetic vortex; its intra-atomic magnetization **M**(**r**) is intrinsically noncollinear, so that its dipole, quadrupole, and toroidal magnetic moments vanish, thus making the vortex "hidden". The first nonzero magnetic multipole of the uranium atom is the toroidal quadrupole. In the unit cell, two uranium atoms can have either the same or opposite signs of their vortex magnetization **M**(**r**); this corresponds to either *ferrovortex* or *antiferrovortex* structures with *I*4*/mmm* or P_I4/mmm magnetic space groups, respectively.

Our first-principles calculations (DFT with the spin-orbit interaction) show that the vortex magnetic order of URu_2Si_2 is rather strong [2]: the total absolute magnetization |**M**(**r**)| is about 0.9 Bohr magneton per U atom. The vortex structure provides a very unusual form factor of magnetic neutron scattering, calculated both for *ferrovortex* and *antiferrovortex* structures [2]. We will also discuss other systems with similar unusual vortex order.

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[1] J.A.Mydosh, P.M.Oppeneer, Rev. Mod. Phys. **83**, 1301(2011).
[2] V.E.Dmitrienko, V.A.Chizhikov, Phys. Rev. B**98**, 165118(2018).