Topological magnetic structures in MnGe: Neutron diffraction and symmetry analysis
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From new neutron powder diffraction experiments on the chiral cubic (P213) magnet manganese germanide (MnGe), we analyze all of the possible crystal symmetry-allowed magnetic superstructures that are determined successfully from the data [1]. The incommensurate propagation vectors $k$ of the magnetic structure are found to be aligned with the [100] cubic axes, and correspond to a magnetic periodicity of about 30 Å at 1.8 K. Several maximal crystallographic symmetry magnetic superstructures are found to fit the data equally well and are presented. These include topologically nontrivial magnetic hedgehog and “skyrmion” structures in multi-k cubic or orthorhombic 3+3 (No.198.3.206.1.m10.2, 19.3.95.4.m26.4) and orthorhombic 3+2 (No. 19.2.29.2.m26.3) dimensional magnetic superspace groups (MSSG) respectively, with either potentially responsible for topological Hall effect (THE). The presence of orthorhombic distortions in the space group P212121 (No. 19) caused by the transition to the magnetically ordered state does not favor the cubic magnetic hedgehog structure, and leave both orthorhombic hedgehog and skyrmion models as equal candidates for the magnetic structures. We also report on a new combined mechanocombined and solid-state chemical route to synthesize MnGe at ambient pressures and moderate temperatures, and compare with samples obtained by the traditional high pressure synthesis.

The magnetic structures in MnGe are compared with topological magnetism in the candidate magnetic Weyl semimetal CeAlGe [2], where the topological properties of a phase stable at intermediate magnetic fields parallel to the $c$ axis are suggested by observation of the THE as well. CeAlGe has polar tetragonal I41md crystal symmetry with the magnetic structure based on two propagation vectors along [100] and [010] axes in tetragonal plane with periodicity about 70 Å. The multi-k structure is realised in maximal symmetry 3+2 dimensional tetragonal MSSG (No. 109.2.67.4.m240.2).

Both 3+2 structures in MnGe and CeAlGe host lattices of magnetic particle-like objects called (anti)merons $Q=\pm 1/2$ with half-integer topological numbers. Calculations show that in the external magnetic fields perpendicular to the propagation plane the total charge per magnetic cell abruptly changes from $Q=0$ to skyrmion-like charge $|Q|=1$ in accordance with is the experimental observation of the THE.