SANS study of the critical phenomena in MnSi under applied field

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The chiral spin fluctuations and the spiral structure of the single crystal MnSi has been studied by small angle diffraction with polarized neutrons near T_c = 29 K under applied field and without it. Above T_c and in zero field the diffuse scattering intensity looks like half-moons oriented along the incident neutron polarization. The sum of the intensities for two opposite polarizations form an anisotropic ring with weak spots, which below T_c transform into the Bragg peaks originating from the helical structure. These results are in semi-quantitative agreement with the mean-field calculations based on the Bak-Jensen model that takes into account the hierarchy of the interactions: the exchange interaction, the isotropic Dzyaloshinskii-Moriya (DM) interaction and the weak anisotropic exchange (AE) interaction. The DM interaction is responsible for the scattering intensity concentrated in the half-moons. The AE interaction provides the anisotropy so that the correlation length diverges along [111] only. The corresponding critical exponent is ν=0.62(1). The exponent of the Bragg intensity due to the helical structure at $T<T_c$ is 2β=0.44(1) where β is the exponent of the helix magnetization.

When a magnetic field (H > 20 mT) applied along one of the ⟨111⟩ axes, it produces unidomain sample with the helix wave-vector along the axis chosen. The structural instability of the magnetic system is observed in the field range from 130 to 190 mT in the close vicinity to T_c. Further increase of the field above H = 190 mT restores the original orientation of the helix and leads to the induced ferromagnetic state at H = 350 mT. The observed phenomena are interpreted in terms of the recently developed theory (S.V. Maleyev), which is based on the evaluation of the ground state energy and the spin wave spectrum for this system. The neutron experiments along with the interpretation clarify the nature of the A-phase found in the H-T phase diagram of MnSi by other techniques.