Ferromagnetic properties of single-crystalline U_2NiSi_3

M. Szlawska, D. Kaczorowski, and A. Pikul

W. Trzebiatowski Institute of Low Temperature and Structure Research
Polish Academy of Sciences, 50-950 Wrocław, P. O. Box 1410, Poland

Most of the ternary intermetallic phases U_2TSi_3 (T = *3d*-, *4d*- or *5d*-electron transition metal) crystallize in a hexagonal structure of the AlB_2–type or its disordered derivatives [1, 2]. Recently, they attracted much attention because of their unusual magnetic properties related to atomic disorder or topological frustration in the uranium sublattice [3, 4]. The compound U_2NiSi_3 has previously been studied on polycrystalline samples and characterized as a cluster-glass system with the spin-freezing temperature T_f = 22 K [3, 5]. On the contrary, the neutron diffraction experiment performed on a single crystal has revealed a long-range ferromagnetic ordering below T_C = 30 K with sizeable uranium magnetic moments of 0.6 μ_B oriented perpendicular to the hexagonal *c* axis [6]. This indispensable discrepancy motivated us to undertake a reinvestigation of the bulk properties of U_2NiSi_3 on single-crystalline specimens.

Single crystal of U_2NiSi_3 was grown by the Czochralski pulling method in a tetra–arc furnace under argon atmosphere. The sample was investigated by means of magnetization, electrical resistivity and heat capacity measurements.

The ferromagnetic ordering in single-crystalline U_2NiSi_3 is evident in the magnetic characteristics. The general shape of the $\sigma(T)$ curves, measured in zero-field-cooled (ZFC) and field-cooled (FC) regimes in a magnetic field applied parallel ($\sigma_\parallel$) and perpendicular ($\sigma_\perp$) to the *c* axis, indicates strongly anisotropic ferromagnetism with pronounced domain effect. The Curie temperature, defined as the inflection point on the $\sigma_\perp(T)$ variation, amounts to 26 K. Magnitude of $\sigma_\perp$ is much larger than $\sigma_\parallel$ thus the magnetic moments are confined to the basal hexagonal plane. The ferromagnetic ordering in single-crystalline U_2NiSi_3 manifests only faintly in the heat capacity and electrical transport data. The magnetic phase transition at T_C manifests itself just as a small kink on the $C(T)$ curve. Similarly, the electrical resistivity shows only tiny anomaly at T_C. Worth noting is also that the overall changes in the values of ρ over the entire temperature range are very small. The observed behavior likely results from the presence of atomic disorder in the unit cell of the compound studied.

The new results obtained for the single crystal of U_2NiSi_3 reveal the long-range ferromagnetic ordering that sets in at low temperatures, in agreement with the neutron diffraction data [6]. The Curie temperature of 26 K is however quite different from the value given in Ref. 6. Most likely the investigated system is very sensitive to the level of atom disorder or possible deviations from the ideal stoichiometry. In each particular case T_C may differ considerably, or even ferromagnetism may be replaced by spin-freezing as established for the polycrystalline samples of U_2NiSi_3 studied in Refs. 3 and 5.

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Name of the presenting author (poster session II): Maria Szlawska
e-mail address: m.szlawska@int.pan.wroc.pl
http://www.int.pan.wroc.pl