Critical behavior of 3D Ising-like systems in an external field

M. Kozlovskii

Institute for Condensed Matter Physics of the National Academy of Sciences of Ukraine, 1 Svientsitskii Str., 79011 Lviv, Ukraine, E–mail: mpk@ph.icmp.lviv.ua

The development of the generalized theory which could allow one to get (except the calculation of critical exponents and some other universal characteristics) explicit expressions for physical quantities is the actual problem for description of critical phenomena The scaling theory is the most developed in respect to this problem. It is based on the scheme of effective Kadanoff spin blocks constructing [1]. We consider the system based on the Ising model on the simple cubic lattice with lattice constant c. The initial lattice is splitted into blocks with linear sizes $s \cdot c$, where s is an arbitrary number ($s > 1$) [2]. Then instead of N initial sites with period c we get N_1 sites ($N_1 = Ns^{-d}$) with period $c_1 (c_1 = cs)$ every of which contains s^d spins. Near the phase transition point (PTP) the free energy of effective spins F_s is related to the free energy of initial spins F by the known relation $F(\tau, h) = s^{-d} F_s \left(s^{y_t}\tau, s^{y_h} h\right)$, where $\tau = (T - T_c)/T_c$ is reduced temperature, h is external field, y_τ and y_h are some numbers defined by critical exponents $y_t = 1/\nu, \quad y_h = 1/\mu$. Here ν is the critical exponent of the correlation length at an absence of the external field $\xi_\tau = \xi^{\pm}|\tau|^{-\nu}$, and μ is the critical exponent of the same quantity $\xi_h = \xi^{(c)} h^{-\mu}$ at $T = T_c$. It is known that $\mu = \nu/\beta\delta$, where β and δ are critical exponents (temperature and field ones) of the order parameter. In this communications the method for free energy calculation near the second order phase transition point is suggested. The explicit analytical expression for free energy of the Ising-like system as function of the temperature and external field is found. This expression allows one to calculate magnetization, susceptibility, heat capacity and other thermodynamic characteristics near the phase transition point.

1. Kadanoff L.P., Physics. **2**, 263–273 (1966).
2. Yukhnovskii I.R., Kozlovskii M.P., Pylyuk I.V., Microscopic Theory of Phase Transition in the three dimensional systems (Lviv: Eurosvit, 2001, 592p) (in Russian).