Phase Transitions of Dense Neutron Matter with Generalized Skyrme Interaction to Superfluid States with Triplet Pairing in Strong Magnetic Field

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A generalized non-relativistic Fermi-liquid approach was used to find analytical formulas for temperatures $T_{c,1}(n,H)$ and $T_{c,2}(n,H)$ (which are functions nonlinear of density n and linear of magnetic field H) of phase transitions in spatially uniform dense pure neutron matter from normal to superfluid states with spin-triplet p-wave pairing (similar to anisotropic superfluid phases $^3He-A_1$ and $^3He-A_2$) in steady and homogeneous strong magnetic field (but $|\mu_n|H \ll E_c < \varepsilon_F(n)$, where μ_n is the magnetic dipole moment of a neutron, E_c is the cutoff energy and $\varepsilon_F(n)$ is the Fermi energy in neutron matter). General formulas for $T_{c,1,2}(n,H)$ (valid for arbitrary parametrization of the effective Skyrme interaction in neutron matter) are specified here for generalized BSk18 parametrization of the Skyrme forces [1] (with additional terms dependent on density n) on the interval $0.3\ n_0 < n < n_c(BSk18) \approx 2.7952\ n_0$, where $n_0 = 0.17$ fm^{-3} is nuclear density and at critical density $n_c(BSk18)$ triplet superfluidity disappears, $T_{c,0}(n_c, H=0) = 0$. Expressions for phase transition temperatures $T_{c,0}(n) < 0.09$ MeV (at $E_c = 10$ MeV) and $T_{c,1,2}(n,H)$ are realistic non-monotone functions of density n for BSk18 parametrization of the Skyrme forces (contrary to their monotone increase for all previous BSk parameterizations). Phase transitions to superfluid states of such type might occur in liquid outer core of magnetars (strongly magnetized neutron stars).

[1] N. Chamel, S. Goriely, J.M. Pearson, Phys. Rev. **C 80**, 065804 (2009).