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Theory of Superconductivity, Frühjahrsemester 2023

Blatt 8

Abgabe: 04.05.23, 12:00H (Treppenhaus 4. Stock)
Tutor: Julian Arnold, Zi.: 4.10

(1) **Effects of fluctuations: the Levanyuk-Ginzburg criterion** (10 Punkte)

Ginzburg and Landau assumed that the temperature T is close to T_C, i.e., $|\tau| \ll 1$ where $\tau \equiv (T - T_C)/T_C$, such that the order parameter ψ is small and the free energy density can be expanded in powers of ψ.

However, Ginzburg-Landau theory breaks down if $|\tau|$ is too small because of order parameter fluctuations: the theory becomes inconsistent if the fluctuations are larger than the (mean-field) value of ψ predicted by Ginzburg-Landau theory.

Interestingly, Ginzburg-Landau theory can be used to estimate its own limits!
Levanyuk and (later) Ginzburg derived a limiting value τ_{LG} such that the theory remains valid for $|\tau| > \tau_{LG}$.
The goal of this problem is to understand their argument following the review by
P.C. Hohenberg and A.P. Krekhov, Physics Reports **572**, 1 (2015) (abbreviated as HK).

(a) Read Sections 2.1 and 2.2 of HK (as you will see, their notation is a bit different from the one used in Tinkham) and write down the most important equations for later reference.

(b) Now continue in Section 5.2 of HK that sketches Levanyuk and Ginzburg's argument. Explain the phrase after Eq. (140). Fill in all the details necessary to arrive at Eq. (149).

(c) Estimate the limiting temperature in spatial dimensions 1, 2, and 3.