Capillary Condensation and Critical-Point Shifts in Superconductors

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Within Ginzburg-Landau theory we study effects of confinement, reduced dimensionality and surface curvature on the transition to superconductivity for Type-I and Type-II materials with surface enhancement. The superconducting order parameter is characterized by a negative surface extrapolation length *b*. This leads to an increase of the critical field H_{c3} and to a surface critical temperature in zero field, T_{cs}, which exceeds the bulk T_c. When the sample is {\em mesoscopic} of linear size *L* the surface induces superconductivity in the interior for $T < T_c(L)$, with $T_c(L) > T_{cs}$. In precise analogy with adsorbed fluids, superconductivity in thin films of Type-I materials is akin to *capillary condensation* and competes with the previously predicted interface delocalization or "wetting" transition. The finite-size scaling properties of capillary condensation in superconductors are scrutinized in the limit that the ratio of magnetic penetration depth to superconducting coherence length, $\kappa \equiv \lambda/\xi$ goes to zero, using analytic calculations. While standard finite-size scaling holds for the transition in non-zero magnetic field *H*, an anomalous critical-point shift is found for $H = 0$. The increase of T_c for $H = 0$ is calculated for mesoscopic films, cylindrical wires, and spherical grains of Type-I and Type-II materials. Surface curvature is shown to induce a significant increase of T_c, characterized by a shift $T_c(R) - T_c(\infty)$ inversely proportional to the radius.