Critical Casimir Forces Near Bose-Einstein Condensation of an Imperfect Bose Gas

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We consider the d-dimensional imperfect (mean-field) Bose gas confined in a slit-like geometry and subject to periodic boundary conditions. Within an exact analytical treatment we first extract the bulk critical properties of the system at Bose-Einstein condensation and identify the bulk universality class to be the one of the classical d-dimensional spherical model. Subsequently we consider finite slit width D and analyze the excess surface free energy and the related Casimir force acting between the slit boundaries. Above the bulk condensation temperature ($T > T_c$) the Casimir force decays exponentially as a function of D. For $T = T_c$ and for $T < T_c$ its decay is algebraic. The magnitude of the Casimir forces at T_c and for $T < T_c$ is governed by the universal Casimir amplitudes. We extract the relevant values for different d and compute the scaling functions describing the crossover between the critical and low-temperature asymptotics of the Casimir force. The scaling function is monotonous at any $d \in (2, 4)$ and becomes constant for $d > 4$ and $T \leq T_c$.