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Exact solution of the six-vertex model with DWBC. Critical line between disordered and antiferroelectric phases

We obtain the large N asymptotics of the partition function Z_N of the six-vertex model with domain wall boundary conditions on the critical line between the disordered and antiferroelectric phases. Using the weights $a = 1 - x, b = 1 + x, c = 2, |x| < 1$, we prove that, as $N \rightarrow \infty$, $Z_N = CF^{N^2} N^{1/12} (1 + O(N^{-1}))$, where F is given by an explicit expression in x and the x -dependency in C is determined. Our result gives a complete proof and substantially strengthens the one given in the physics literature by Bogoliubov, Kitaev and Zvonarev. Furthermore, we prove that the free energy exhibits an infinite order phase transition between the disordered and antiferroelectric phases. Our proofs are based on the large N asymptotics for the underlying orthogonal polynomials which involve a non-analytical weight function, the Deift-Zhou nonlinear steepest descent method to the corresponding Riemann-Hilbert problem, and the Toda equation for the tau-function. This is a joint work with Thomas Bothner.