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Absence of Dislocation Quantum Roughening in Solid ^{4}He[1]

DARYA ALEINIKAVA, EUGENE DZEDZITS, ANATOLY KUKLOV, CSI, CUNY, DAVID SCHMELTZER, CCNY, CUNY — Dislocations in quantum crystals are shown to be smooth at zero temperature because of the effective Coulomb-type interaction between kinks induced by exchange of bulk phonons. We provide heuristic Kosterlitz-Thouless and Renormalization Group arguments against quantum roughening and confirm them by Monte Carlo simulations of the effective model of edge dislocation moving in its gliding plane - a quantum string (or classical membrane in $d = 2$) subjected to periodic Peierls potential and Coulomb-type interaction. Simulations of such Sine-Gordon type action have been conducted in the Villain approximation in terms of the J-current formulation. Renormalized stiffness as a function of the long-range interaction strength C and dislocation length L is shown to be described by a master curve $F(C \ln L)$, where $F(x) \to 0$, as $x \to \infty$. We also discuss a mechanism of suppression of superfluidity along the dislocation core by thermal kinks and show that it leads to locking in of the mechanical and superfluid responses at finite temperature, which is consistent with the recent experiment of Day and Beamish (Nature **450**, 853 (2007)).

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