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Superclimb of Dislocations in Solid ^{4}He[1]

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Edge dislocation with superfluid core can perform *superclimb* – non-conservative motion (climb) assisted by superflow along its core. Such dislocation, with Burgers vector along the C-axis, has been found in *ab initio* simulations of *hcp* solid ^{4}He [1]. Uniform network of superclimbing dislocations can induce *isochoric compressibility* $\chi = dN/d\mu$ which is finite (in contrast to ideal solid where it vanishes) and, practically, independent of the network density. Here N is total number of atoms and μ is chemical potential [1]. Such giant response has been observed by Ray and Hallock during superfluid flow events through solid He4 [2]. Study [3] of superclimbing dislocation within the model of Granato-Lücke string, subjected to Peierls potential and to vanishing bias by μ, has found that χ exhibits wide peak in the intermediate range of temperatures (T) - above some T_p determined by Peierls energy and below $T_s \sim 0.5$K above which superfluidity of the core essentially vanishes. Non-Luttinger type behavior characterized by $\chi \sim L^b$ scaling as some power $1 < b \leq 2$ of dislocation length L is observed in the wide peak region. Biasing superclimbing dislocation by finite μ (due to a contact with liquid ^{4}He through vycor electrodes [2],[4]) can induce core roughening caused by thermally assisted tunneling of jog-antijog pairs through the barrier produced by combination of Peierls potential and the bias [5]. The threshold for this effect scales as $\mu_c \sim 1/L^a$ with some power $a \approx 1.7$. The roughening is found to be hysteretic below some temperature $T_{\rm hyst}$. At $T_{\rm hyst} < T < T_R$, with T_R determining temperature of thermal roughening, χ exhibits strong and narrow resonant peak leading to a dip in the core superfluid sound velocity. This mechanism is proposed as an explanation for a strong and narrow dip observed in critical superflow rate [4]. It is found that the dip characteristics are sensitive to the bias by μ and, therefore, this can be used as a test for the proposed mechanism. It is also predicted that the dip depth at given T should be periodic in μ with the period $\sim \mu_c$.

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