Evidence for a critical dislocation speed in helium-4 crystals

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We have discovered two different regimes in the motion of dislocations in ^{4}He crystals when ^{3}He impurities are attached to them. At low driving strain ε and frequency ω , where the dislocation speed is less than 60 μm/s, dislocations and ^{3}He impurities apparently move together. At higher values of $\varepsilon\omega$, dislocations are pinned by ^{3}He impurities. This critical velocity is smaller but comparable to the velocity of free ^{3}He impurities in the bulk crystal lattice. We obtained this result by studying the dissipation of dislocation motion as a function of the frequency and amplitude of a driving strain applied to a crystal at low temperature. This resolves an apparent contradiction between experiments which indicated a thermally activated, frequency- dependent unbinding temperature and models in which the transition temperature was assumed to be independent of frequency. The impurity pinning mechanism for dislocations appears to be more complicated than previously assumed.

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