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Elastic Behavior and Dislocations in Solid Helium¹

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Torsional oscillator experiments show decoupling of solid ^4He below 200 mK, the signature of the “non-classical rotational inertia” which would characterize a supersolid phase of matter. Solids are distinguished from liquids by their non-zero elastic shear modulus and we have developed a new technique to measure this modulus at very low frequencies and amplitudes. Our measurements show a large and unexpected stiffening in the shear modulus of ^4He below 200 mK. It has the same dependence on temperature, frequency, amplitude and ^3He impurity concentration as the decoupling seen in torsional oscillator measurements and the two phenomena are clearly related. The elastic behavior is explained in terms of the motion of dislocations and their pinning by impurities, suggesting that these defects play an important role in supersolidity. We have now extended our elastic measurements to both bcc and hcp ^3He . These measurements, and comparisons to new torsional oscillator results, clarify the roles of quantum statistics and crystal structure in the behavior of solid helium.

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