Torsional Oscillator Studies of the Shear Modulus of Solid 4HE

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The observation by Kim and Chan, using a torsional oscillator containing solid 4He, of nonclassical rotational inertia (NCRI) or a supersolid state of the solid, along with the discovery by Day and Beamish, of an anomalous increase in the shear modulus of solid 4He, were two of the most significant developments in the study of solid 4He in the last decade. These two phenomena share many common features, including sensitivity to 3He impurities, mechanical stress, and the display of annealing and relaxation dynamics over the temperature region of the supersolid transition The similarity of these two phenomena gives rise to a problem in interpreting the NCRI and dissipative signals seen in single frequency torsional oscillator experiments. In many cases, the fraction of the total moment of inertia that is decoupled from the torsional oscillator in the supersolid state may be as small as 0.01 to 0.1 percent of the solid moment of inertia. Depending on the design of the oscillator, the signal arising from the shear modulus anomaly may comparable or even larger. In the experiments discussed here, an attempt to separate these two phenomena is made by constructing oscillators operating at two or three different frequencies. In addition, oscillators have been designed to be especially sensitive to the shear modulus anomaly and provide an alternate to the peizo-electric technique employed by Day and Beamish for the determination of the shear modulus of the solid. This work has been supported by the National Science Foundation through Grant DMR-096569.