Supersolidity in Solid 4He and the Shear Modulus Anomaly

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Recent years have seen the discovery of two new phenomena in the low temperature properties of solid 4He: first the discovery by Kim and Chan of evidence for supersolidity and second the observation by Day and Beamish of an unexpected anomaly in the shear modulus of the solid. A remarkable feature of these phenomena is the striking similarity in their temperature dependence as well as in a number of other properties such as sensitivity to 3He impurities and to the effects of disorder and annealing. In the work reported here, we attempt to separate and delineate the effect of these two phenomena on the low temperature behavior of torsional oscillators containing solid 4He samples. We have constructed double and triple compound torsional oscillators, operating at several different frequencies to take advantage of the fact that supersolidity phenomenon is believed to be relatively frequency independent, while the anomaly in the shear modulus should have to a well-defined frequency dependence. The key feature of our oscillator design has been to provide an internal moment of inertia that is primarily coupled by the shear modulus to the rest of the system and thus makes the oscillator modes sensitive to temperature variations in the shear modulus. The temperature dependence of the modes for our triple oscillator can be accounted for by the variation in the elastic properties of the solid, while supersolid mass decoupling makes a negligible contribution. The National Science Foundation through Grants DMR-096569 and Phy-0758104 has supported this work.