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Squeezing superfluid from a stone: Coupling superfluidity and elasticity in a supersolid

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Superfluidity—the ability of liquid ^{4}He, when cooled below 2.176 K, to flow without resistance through narrow pores—has long served as a paradigm for the phenomenon of "off-diagonal long-range order" (ODLRO) in quantum liquids and superconductors. Supersolidity—the coexistence of ODLRO with the crystalline order of a solid—was proposed theoretically over 35 years ago as an even more exotic phase of solid ^{4}He, but it has eluded detection. Recently, Kim and Chan [1,2] have reported an anomalous decoupling transition of solid ^{4}He in a torsional oscillator measurement, and interpret their results as evidence for non-classical rotational inertia and a possible supersolid phase of ^{4}He. In this talk I will give brief historical review of the theory of and experimental searches for supersolidity. I will then discuss a phenomenological Landau theory of the normal solid to supersolid (NS-SS) transition in which superfluidity is coupled to the elasticity of the crystalline ^{4}He lattice, and underscore the implications of this theory for experimental searches for supersolidity [3]. I will also discuss a hydrodynamic model for supersolids, in which the additional broken gauge symmetry in the supersolid phase produces a collective mode that is analogous to second sound in superfluid helium.

[1] E. Kim and M. H. W. Chan, Nature (London) **427**, 225 (2004).
[2] E. Kim and M. H. W. Chan, Science **305**, 1941 (2004).
[3] A. T. Dorsey, P. M. Goldbart, and J. Toner, "Squeezing superfluid from a stone: Coupling superfluidity and elasticity in a supersolid," Phys. Rev. Lett. **96**, 055301 (2006).