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Frequency dependence and Hysteretic behavior in Non-Classical Rotational Inertia of Solid ^{4}He[1]

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We have constructed a compound torsional oscillator having two resonance frequencies for studying non-classical rotational inertia (NCRI) of solid ^{4}He. The oscillator allows us to study NCRI and supersolid effects of the *identical* solid ^{4}He sample grown in a cylindrical container at 496 and 1173 Hz. We have grown and studied solid samples with final solid pressures between 27 and 42 bar. The observed features are qualitatively similar in all solid samples. NCRI fractions at sufficiently low oscillation drive and at the lowest temperature are only about 0.1 % and consistent with cylindrical cells in other laboratories. NCRI fraction below 35 mK does not depend on frequency nor temperature. At T > 35 mK, NCRI fraction observed in the lower mode is smaller than that in the higher mode. "Transition" into supersolid state occurs at a higher temperature in the higher mode than the lower one. The peak in extra dissipation due to solid ^{4}He is greater in the lower mode by a factor 1.7 than in the higher mode. The frequency dependence of the magnitude of NCRI will be compared with existing theoretical predictions. In addition to the frequency dependent effects at low oscillation drive, we have observed hysteretic behavior in NCRI fraction depending on the history of oscillation drive and temperature from the normal state above 300 mK to low temperatures. We find that the supersolid state below 40 mK can have different NCRI fractions depending on the particular sequence of oscillation amplitude. Above about 50 mK, however, NCRI fraction does not depend on the history of oscillation amplitude changes. We also observe a time dependent overshoot in the dissipation of solid when the NCRI fraction is increased by decreasing the oscillation drive. The general behavior of this relaxation phenomenon is rather complex depending on temperature, history of oscillation amplitude and memory effects. Some of the observations share common features with vortex motion and glassy behavior.

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