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A new regime of sound attenuation in a super uid

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Sound waves are ubiquitous in physics, in the macroscopic quantum world where all super uids of neutral particles have an acoustic excitation branch. At low temperature phonons are the only microscopic degrees of freedom of the super uid, and the understanding of the phonon dynamics and their interactions is a crucial step in the understanding of the system properties, including transport phenomena, temperature dependent viscosity, and attenuation of sound and macroscopic quantum coherence. We can distinguish two types of super uids depending on whether the phonon excitation branch bends upwards or downwards for increasing momentum. For upward bending, dominant interactions among phonons at low temperature are three-phonon processes. This is the case for atomic Bose-Einstein condensates and super uid liquid helium at standard pressure. The attenuation of sound in this kind of super uid was calculated by Beliaev and Landau and it was already measured in experiments. For downward bending, phonon interactions occur mainly via four-phonon processes as understood by Landau and Khalatnikov in 1949. However, the attenuation of sound has not been calculated for almost 70 years as this case was exotic. We give the rest quantitative prediction of the attenuation of sound in the downward bending case using quantum hydrodynamics, correcting and extending the original calculation of Landau and Khalatnikov [ZhETF, 19 (1949) 637]. Our predictions may be tested in two di erent super uid systems: liquid helium under pressure and strongly interacting pair-condensed Fermi gases. This would open a new era in the exploration of low-temperature dynamics of macroscopically coherent quantum many-body systems.

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