The interaction of Kelvin waves and the non-locality of the energy transfer in superfluids

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We argue that the physics of interacting Kelvin Waves (KWs) is highly non-trivial and cannot be understood on the basis of pure dimensional reasoning. A consistent theory of KW turbulence in superfluids should be based upon explicit knowledge of their interactions. To achieve this, we present a detailed calculation and comprehensive analysis of the interaction coefficients for KW turbulence, thereby, resolving previous mistakes stemming from unaccounted contributions. As a first application of this analysis, we derive a new Local Nonlinear (partial differential) Equation. This equation is much simpler for analysis and numerical simulations of KWs than the Biot-Savart equation, and in contrast to the completely integrable Local Induction Approximation (in which the energy exchange between KWs is absent), describes the nonlinear dynamics of KWs. Secondly, we show that the previously suggested Kozik-Svistunov energy spectrum for KWs, which has often been used in the analysis of experimental and numerical data in superfluid turbulence, is irrelevant, because it is based upon an erroneous assumption of the locality of the energy transfer through scales. Moreover, we demonstrate the weak non-locality of the inverse cascade spectrum with a constant particle-number flux and find resulting logarithmic corrections to this spectrum.

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