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Reply to Comment on "Amplitude of waves in the Kelvin-wave cascade" (Pis'ma v ZhETF 111, 462 (2020))

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This is a Reply to Sonin's Comment [arXiv preprint arXiv:2003.09912, 2020] on Eltsov and L'vov [Pis'ma v ZhETF **111**, 462 (2020)] in which we provide relation of the energy flux carried by the cascade to the amplitude of the excited Kelvin waves, important for analysis of future experiments.

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In his Comment, Sonin used our paper [1] as an excuse to return to a rather old dispute on the theoretical models of the Kelvin-wave cascade. This dispute was initiated by the controversy between the Kozik–Svistunov [2] and the L'vov–Nazarenko [3, 4] energy spectra of the cascade. The discussion also included other contributions [5, 6], in particular from the author of the Comment, whose arguments were criticized in [7, 8]. Numerical simulation efforts intended to resolve the controversy were built up as well. The authors of the latest published numerical works known to us [9, 10] claim that their results support the L'vov–Nazarenko spectrum [4], including the numerical prefactor. Remarkably, these calculations were performed using different numerical approaches (Gross–Pitaevskii formalism in [9] and vortex-filament method in [10]). We should say from the outset that our paper has nothing to contribute to this extended discussion and its focus is on a different topic.

Independently of the details of the theoretical models, the generally accepted picture of quantum turbulence includes the Kelvin-wave cascade as an essential component in the low-temperature limit. There is, however, no experimental evidence so far for the existence of such cascade. The relevant difficulties are mentioned both in our paper and in the Comment. With recent progress in experimental techniques we hope that studies of the dynamics of nearly straight vortices, not hindered by the hydrodynamic energy cascade and reconnections, will become possible in near future. The purpose of our paper is to facilitate interpretation of the results of such potential experiments by providing a particular relation between the energy flux and the amplitude of Kelvin waves. We stress that the target of the initial experiments would be to discriminate between dissipation originating from the Kelvin-wave cascade versus other dissipation mechanisms like acoustic or tunneling two-level system damping. Here we hope that our order-of-magnitude estimation of the expected amplitudes will be useful as well as pointing out two important parameters, the energy flux and the starting wave vector of the cascade $k_{\min}$, which preferably should be controlled in the experiment independently. The focus of the initial experiments will probably not be on verifying particular models of the cascade. In fact, we agree with the author of the Comment that in an experiment which probes only the longest energy-containing length scales, the discrimination between different cascade models is unlikely.

We think therefore that our paper [1] should not serve as a reason for reanimating the old debate. Of course, we do not have in mind to preclude others from continuing discussions, preferably finding new arguments. One interesting development for proponents of other theoretical models of the cascade would be to make alternative predictions for observables in single-vortex dynamics and to suggest possible experimental realizations where the difference between cascade models becomes potentially resolvable.

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