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The Kolmogorov fluxes in non-stationary wind-wave spectra

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The Hasselmann kinetic equation for water waves is a subject of the theory of weak turbulence. The key result of this theory is the exact Kolmogorov-Zakharov solutions of the stationary kinetic equation. The simplest 'direct cascade' solution found by Zakharov and Filonenko in 1966 is quite similar to the classical Kolmogorov spectrum of incompressible fluid turbulence and describes transport of energy from large to small scales where energy dissipates. The opposite tendency, also observed in the water wave ensembles, is the 'inverse cascade' — the transport of wave action from small to large scales (Zakharov & Zaslavskii 1982). These fundamental stationary and isotropic solutions imply sinks and sources at infinitely large or at infinitely small scales and no generation and dissipation in the domain of cascades, in the so-called inertial interval. The nonlinear transfer is the only mechanism of wave field evolution in this case. The concept of the Kolmogorov-type scenario is not accepted by majority of oceanographers because the so-called inertial interval where the nonlinear transfer is the only mechanism governing the wind-wave spectra is assumed to be never realized for wind-driven waves which sources and sinks are widely distributed in wave scales.

Within the numerical simulation of the Hasselmann kinetic equation for deep water wind waves we show a strong tendency of wind-wave spectra to self-similar behaviour due to dominating (as compared to generation and dissipation) nonlinear transfer mechanism. A family of non-stationary anisotropic self-similar solutions of the Hasselmann equation that provide both direct and inverse cascades is studied theoretically as a generalization of the Kolmogorov-Zakharov solutions. It is shown that the ratios of the spectral densities to the magnitudes of fluxes of energy, wave ac-

tion and wave momentum of the non-stationary solutions tend to be the same as ones of the stationary Kolmogorov-Zakharov solutions. In other words, the so-called Kolmogorov's constants C_q, C_p, C_m are physically relevant quantities that control dependence of spectral densities on spectral fluxes for the general case of non-stationary (non-homogeneous) solutions for the Hasselmann kinetic equation.

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