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Explosive three-wave interaction of short surface waves as the origin of “bag-breakup” fragmentation of the air-sea interface under high wind conditions

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Spume droplets can play an important role in the exchanging processes in the air-ocean boundary layer. Reliable statistical data of these droplets are needed to make correct estimations of spray-mediated heat, momentum and mass fluxes. The studies [1], [2] reveal that the dominant effect responsible for droplet’s generation is the “bag-breakup” phenomenon. This mechanism begins with an increase of small-scale elevation of water surface transforming into a “sail” which inflates and eventually raptures producing spray.
In order to explain the experimental dependencies of “bag-breakup” parameters on the wind velocity nonlinear three-wave interaction were considered. It was shown [3] that three-wave interaction can lead to an explosive growth of wave amplitudes, which is qualitatively similar to the formation and development of “bags”. In the present study we used a simple hydrodynamic model with piecewise velocity profile. Also, it was considered that an interaction takes place between two oblique waves propagating at equal and opposite angles to the flow and the third wave propagating along the flow because of a “horse-shoe” form of “bag-breakup” phenomenon.
The theoretical analysis of this system let us estimate the time of the explosive growth and examine connections of present model with the “bag-breakup” effect.

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