**Review**

on the manuscript by D. Kachulin and A. Gelash

"Phase-dependent dynamics of breather collisions in the compact Zakharov equation for envelope" submitted for publication in journal "Nonlinear Processes in Geophysics".

The manuscript represents the results of numerical study of collisions between soliton-like wave groups, and how the collision consequences depend on the phase difference between the colliding groups. The simulated equations are beyond the leading-order approximation provided by the nonlinear Schrodinger equation. The problem statement is generally understood; the results have rather fundamental significance and may be interesting for many readers bearing in mind that the soliton-like groups of steep waves have been recently measured in laboratory facility. At the same time I assume that in the present form the paper is not 'reader-friendly' and should be improved. Supposing that many of the readers of NPG deal with geophysical problems, the style of the paper is too much remote from practice. The authors forget to reformulate the obtained results in plane words to be perceived by a broad audience. This is the main my concern; I suggest to rewrite the text appreciably according to the particular suggestions below. I assume that after the revision the text may be published in NPG.

1. I would like to argue with the terminology used in the paper. It is difficult to understand why the solitary groups of waves within the NLS equations are *envelope solitons*, but in a generalized framework they are *breathers*. This difference is especially difficult to catch looking at the ansatz for *breathers* for the solution Eq. (3), which coincides with the one for *envelope solitons* of the NLS equations. Furthermore, it becomes puzzling if one recalls the *Peregrine breather*, *Akhmediev breather* etc, which are wave patterns of absolutely different style than the ones discussed in this work. The latter nomenclature has been already established and seems to be conventional (see e.g. the series of laboratory simulations by A. Chabchoub at al., well represented in the recent literature).

2. In the text there is a mixture of dimensional and non-dimensional quantities. Eq. (14) is dimensional, but $k_0 = 100$ and $g = 1$ – are not (just two lines above). All the results are expressed through unnaturally scaled variables ($C_0$, $U$, $\Omega$, $x$). They should be replaced by the properly scaled, i.e. $k_0C_0$, $k_0U/\omega_0$, $\Omega/\omega_0$, $k_0x$ or similar.

3. Interactions of soliton-like groups were studied numerically in the frameworks of the full Euler equations in the papers V.E. Zakharov, A.I. Dyachenko, A.O. Prokofiev, Eur. J. Mech. B/Fluids 25, 677 (2006) and A.V. Slunyaev, J. Exp. Theor. Phys. 109, 676 (2009). The approach to investigation of the soliton turbulence with the help of exact solutions (in integrable systems) was applied in the papers E.N. Pelinovsky, E.G. Shurgalina, A.V. Sergeeva, et al., Phys. Lett. A 377, 272 (2013) and E. Shurgalina, E. Pelinovsky, Phys. Lett. A 380, 2049 (2016). These references may be useful for the authors.

4. The figures are not suited for the black and white printing, though they may be easily improved if different line styles are used.

5. Page 2, lines 27-28: it should be clarified that the function of the velocity potential is defined on the water surface.

6. Page 3, line 6: should read "can be recovered".

7. Page 3, 4: The role of parameters $V$ and $\Omega$ should be better explained from the physical point of view. Namely, the natural physical parameters of the solitary group are its amplitude, carrier wave length, carrier frequency and the velocity. The carrier wavenumber, $\widetilde{k}$, is fixed equal to 100. The wave group velocity $V$ is a function of $\widetilde{k}$ and the group amplitude. Parameter $\Omega$ is the frequency in the reference moving with velocity $V$, which also depends on the wave amplitude.

8. The same comment to the beginning of Sec. 4: It is more natural to say that the wavenumber $k_0 = 100$ is fixed first, which results in the value $V_0 = 0.05$.

9. Page 4: When the equation on the envelope, Eq. (11), is introduced, the limits of its validity remain unclear. It is stated that the equations (1) and (11) equally accurate. The parameter $\widetilde{k}$ denotes the wavenumber of the soliton-like group, though $k_0$ in Eq. (11) is the parameter of this equation. If Eq. (11) is valid for any choice of $k_0$ (since no extra assumptions on the applicability of Eq. (11) implied), how the choice of $k_0$ results in the solution of the equation? Besides, please indicate what $\omega_{k0}$ exactly means.

10. The end of Sec. 2: it should be said clearly that the solutions of Eq. (11) and Eq. (13) will be compared in what follows.

11. Eq. (14): $x_0$ – is the solution location at $t = 0$. The notation for the wave amplitude with letter $C_0$ does not seem to be a good choice, having in mind that it is a typical notation for velocity.

12. Page 4, lines 25-26: The discussion of the Fourier modes for $C_s$ will be easier to understand if the formula for $C_{sk}$ is given. I suggest doing so. It is instructive to say in words that the shape and the width of the solitary group do not depend on $k_0$ and $V_0$, and are functions ofamplitude only.

13. Page 5, line 1: It is unnatural to claim that the velocity $U$ leads to the wavenumber shift. Quite the opposite, the wavenumber offset $\Delta k$ leads to the velocity correction $U$ to the celerity $V_0$, so that the total group velocity is $V = V_0 + U$.

14. Page 5: "To obtain solitons of almost the same characteristic width as breathers we should vary the carrier wave number $k_0$ instead of the relative velocity $U$ in the solution (14). But this procedure is not appropriate for our work since in this case we are not able to use the NLS equation to study soliton interactions" – this discussion may be correct from the technical point of view, but it sounds senseless from the physical point of view. The point is that the group shapes for the given amplitude are different in the frameworks of the NLS equation and the compact Zakharov equation. The groups with same characteristic widths will have different amplitudes.

15. I have a simple reasoning which explains qualitatively the curves in Fig. 1. The actual wavenumber $k_s = k_0 - \Delta k$ is larger when $U < 0$, thus for the given amplitude $A_s$ the wave will be steeper (steepness $k_sA_s$ controls the nonlinearity). Accordingly, steeper waves need stronger dispersion to balance the soliton, and hence the group is shorter when $U < 0$.

16. Sec. 4: It will be useful to say in words that you simulate two soliton-like groups with the same amplitude which travel in the same direction with close velocities $V_0 + U_0$ and $V_0 - U_0$; the consideration will be given for the reference moving with velocity $V_0$.

17. Page 6, lines 10-11: It is important to clarify that the "each of solitons acquires a positive shift in the direction of soliton propagation" when considered in the system of reference moving with velocity $V_0$, thus the solitons propagate in different directions in this reference.

18. Eq. (16): the signs in the formula seem to be inconsistent with Eq. (14) (at the second term in (16)). It may be constructive to comment that the phase corrections in Eq. (16) are related to the nonlinear frequency shift (the latter term) and to the offset of the carrier wavenumber (it is probably better to rewrite the corresponding summand in terms of $\Delta k$).

19. Page 6, lines 18-20: The formula for the phase shift should be given. As far as I understood, the 'additional phase shifts, which the solitons acquire' are not *neglected*, but are mutually *compensated*. This issue will be clear if the mentioned formula is provided.

20. Page 6, lines 25-26: The phrase "in the general case of different solitons" is not accurate. It is better to say clearer that when the solitons are characterized by different amplitudes or/and different velocity shift parameters $|U|$.

21. Page 7, line 4: "The colliding breathers have slightly different widths, so their relative phase is not time invariant." It is not clear how different widths make the relative phase varying. Please clarify.

22. Page 8, line 7: The shift of the location of maximum of $A(\Delta\phi)$ may be due to the improper choice of the definition (19) of the relative phase. If the blue curve in Fig. 4 is centered, in the intervals of large $|\Delta\phi|$ figures 3 and 4 look qualitatively similar.

23. Page 8, line 13: "as can be seen from the figures 5 and 6." This phrase may be applied to Fig. 5 only.

24. Eq. (20): Please give the definition for the 'energy', and clarify what is the relative energy loss and exchange (relative to the total energy or to the individual soliton energy, etc).

25. Fig. 8: It seems that when $\Delta\phi = 0.58$ the total energy in the system increases after the collision. How could it happen?

26. Page 11, line 16: "We have found that the total energy loss due to the radiation is enhanced at large values of the wave steepness" – this statement was not discussed in the text, no proof of this fact was provided.

27. It seems that Fig. 9 and 10 are not consistent with Fig. 8. According to Fig. 8, the maximum amplification should be obtained by the second soliton when $\Delta\phi = 0.58$. However, the amplification of the second soliton seems to be larger in Fig. 9 compared to Fig. 10.

28. Fig. 11: the figure looks somewhat surprising. I cannot imagine how the curves tend to the limit of small wave amplitudes, when they should collapse to a single straight line. Could you please comment on this.

29. Page 12, lines 4-5: The phrase "the maximum value of the amplitude amplification … is equal to the sum of the soliton amplitudes" does not sound well. The maximum *value* of the field is equal to the sum of the soliton amplitudes.

30. Page 13, line 13: It is better to clarify the sentence as follows: "and is determined *in addition* by the breather phases."

31. I found some faults in English, they may be more. In some places they use 'to depend from' instead of 'to depend on' (page 6, lines 14, 22, caption of Fig. 4); 'can be power by' instead of 'can be powered by' (page 3, line 6); "shown" instead of "showed" (page 11, line 12). Please proofread carefully.