"**Incidence and reflection of internal waves and wave-induced currents at a jump in buoyancy frequency**"
by *J. P. McHugh*
NPGD-2014-22 (revised)

Editor Decision

Al three referees have now submitted reports on the revised paper, with rather different recommendations.

Referee #3 is now overall satisfied and has made some further technical comments which need to addressed.

Referee #2 has raised serious concerns over the scaling of the amplitude equations. To summarise the usual NLS scales time as $T = \epsilon^2 t$ in the reference frame moving with the group velocity $Z = \zeta - c_g\tau, \zeta = \epsilon z, \tau = \epsilon t$ and then the amplitude scales with $\alpha = \epsilon$ giving

$$iA_T + A_{\zeta\zeta} + \pm|A|^2 A = 0\,,$$

omitting the coefficients. Also since the nonlinear term is due to the induced mean flow, this would take the form

$$\bar{u}_\tau = |A|^2_\zeta$$

followed by an integration to get $\bar{u} = |A|^2/c_g$. Note that there is no small parameter so all terms are in balance. But here you have three different group velocities, one c_g for the incident wave, one $-c_g$ for the reflected wave, and a third c_g' for the transmitted wave. Hence it is not possible to move to group velocity reference frame, and instead you get the three amplitude equations (39,42,43) where the small parameters cannot be removed. You retain both independently, although the structure suggests that the choice $\alpha \sim \epsilon$ should be made, and you have put $\alpha/\epsilon = 4$. These small parameters can be chosen independently as you have done, but the balance $\alpha \sim \epsilon$ must hold. I agree with the referee that your discussion of the scaling *etc* needs to be improved. There is a literature on this kind of coupled NLS systems for interacting wave packets, as you indicate but more could be said here.

As well as this general comment, this referee has made several detailed comments which need attention, especially comment 7 relating to this scaling issue.

Referee #1 has made the serious claim that there is an error in your application of the interface conditions. Indeed there is also the claim that the your uniformly stratified case is incorrect. Here, you should compare your equation (39) with $R = 0$ with the analogous NLS equation in Sutherland (2006), that is (2.11) with the third-order term omitted. The discrepancy between your simulations and those of Sutherland (2006) may be due to this third-order dispersive term? Whether this is the case or not, the discrepancy must be resolved. The referee states that the integral or $\bar{u}$ is preserved, and this is the case, so this also needs to be checked.

Turning to the interface issue, I would agree that these can be truncated keeping terms up to cubic order. Thus I would believe that (9) is correct, but it is not clear to me that (14) as written is correct; the first line should be $(1+\eta\partial/\partial z+\eta^2/2\partial^2/\partial^2 z)[\cdots]$? More pertinent is the referee's claim that there should be nonlinear terms in the interface boundary conditions, also hinted at by referee #2. The difficulty is that you claim that it is sufficient to use (54,55) deduced from (52,53) with the $O(\alpha^2)$ terms omitted. But these have been derived from (46,47) which presumably follow from (9) and (14) keeping only quadratic terms, whereas one might believe that cubic terms are consistently necessary.

It seems to me that you have deduced from the structure of the equations (39,42,43) that it is sufficient to keep only $O(\alpha)$ terms in the interface relations (54, 55) and indeed you have deduced that are no such terms. If this interpretation is correct, then it must be more clearly stated. In particular, I assume that the quadratic nonlinear terms at the interface generate only second harmonics and a mean flow term, and it would be helpful if these were even displayed. On the other hand if this not correct and there should be extra terms in (54,55) as the referee's nonlinear simulations imply, then I would suggest you argue that you use the linear conditions as a first approximation. Also, you need to check that the vertical integral of $\bar{u}$ is indeed preserved across the interface, even although the $\bar{u}$ is discontinuous.

Incidentally I would suggest that your emphasis on the dispersion-free case is overdone and could even be omitted.

In summary the severity of the comments of referees #2 and #3 require a major revision as outlined here. However, I will reserve judgement on whether it will be necessary to send a revised paper back for further review.

Professor Roger Grimshaw
(Chief Executive Editor, NPG)