Abstract: 10th Workshop on Water Waves and Floating Bodies

On the Linear Generation and Propagation of Caustic Waves by Unsteady Moving Disturbances at the Free Surface.

Marshall P. Tulin
Ocean Engineering Laboratory
University of California, Santa Barbara

A two-dimensional disturbance of time-varying strength moving with varying speed at the free surface generates a complex set of waves. The origin and propagation of these waves is readily understood with the aid of ray diagrams in x-t space.

In the case of motion at constant speed, U, it is well known that caustics appear at the critical speed in the case of water of finite depth and, in deep water, in the case of an oscillating disturbance (frequency Ω) when $\Omega = g/4U$.

Here we show that caustics can appear in deep water due to local deceleration in the body trajectory, even in the absence of variation in the disturbance strength ($\Omega = 0$). These "deceleration" caustics typically appear behind the body.

In the general case ($\Omega \neq 0$), it is further shown that "deceleration" caustics can appear both behind and ahead of the body.

In the special case of a monochromatic disturbance (Ω), we show that a double caustic appears at the location of the disturbance itself when $\dot{x} = g/4\Omega$, where $\dot{x}$ is the body speed. This caustic is transient and will produce a transient force at the body. This phenomenon can be expected to occur due to the transverse wave system created by any 3d body, as well as in strictly planar flow.

In the case of a body placed in a long gravity wave, the critical condition above occurs only under the special condition that the steepness of the long wave takes the value, (ak)=0.125. This is a value typical of long wind waves in the ocean.

Further details about the wave pattern will be presented.

It is felt that these results are relevant to the problem of "ringing."

DISCUSSION

Grue, J. : I much appreciate your efforts in analyszing free surface waves, which may cause "ringing" loads. I have two questions:

1) In my experiments we observed a considerable low-pressure during a small part of the wave period, which leads to a secondary oscillation in the force on the cylinder. Will this be in accordance with your analysis?

2) In the experiments, and other reported results, the ratio $a/d \approx ½$ (a = wave amplitutde, d = cylinder diameter). Does your analysis apply to such a value of a/d?

Tulin, M. P.: Thank you. In answer to both questions, I don't know; it would be necessary to make detailed calculations. Here I am only presenting a kinematical picture, in order to see what the relevance of bodywaves might be. A full analysis would include calculation of the wave amplitudes in the pattern, extending the analysis to include the effect of the varying surface currents on the propagation of the bodywaves; this is a formidable enterprise.

Palm, E. : As far as I understand it, your theory is a combination of non-linear effects and linear effects. The currents which are necessary for generating 2 or 4 waves in your theory are due to non-linear effects, whereas the wave-maker theory is linear. I believe that **if** your suggested effects are fundamental for explaining ringing, your theory really gives a fine physical description of the phenomenon.

Tulin, M. P.: Yes, Enok, your understanding is correct. The theory I talked about is for a time-varying disturbance in unsteady motion. The proper application to a body in waves would involve taking into account the changing current on the waves as they propagate; I haven't done that. But the basic idea is to use the orbital velocity field of the ocean wave to force the body waves, whose propagation I treated as linear (similar to Kelvin-Neumann ship wave theory). Taking account of the changing orbital velocities on the propagation (non-linear rays) brings it closer to non-linear ship theory. Thank you very much for your positive reaction. Your **if** is a big **if** ; also in my own mind. Arriving here I had little knowledge of the facts of ringing. The meeting has helped somewhat. I now have the impression that ringing involves: relatively steep waves, wave amplitude/diameter not larger than 1, and even less; a force concentrated at the surface, and high frequency content in the loading. The first two facts are probably discouraging for the theory, but the last two are not. Time will tell.