Ships advancing near the critical speed in a shallow channel with a randomly uneven bed

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Abstract:

Unlike a transonic flow in compressible aerodynamics, a ship cruising steadily in a channel at nearly the linearized long wave speed generates unsteady wave motion. In a channel of limited width, solitons are radiated periodically up-stream. Such waves may have been the cause of a fatal accident at the Port of Harwich, England, and were described by a witness “like the white cliffs of Dover”. Although noted long ago in tank experiments, scientific interest was renewed by laboratory observations of ship-induced solitons by Ertekin et al (1986) for a channel of horizontal and smooth bottom. Past theories (both two and three -dimensional) have shown that the free surface elevation is governed by the forced Korteweg-deVries equation.

In this presentation we shall first recall the earlier findings by Mei and Choi (1987) of a ship in a channel of smooth bed, but focus attention on the more recent work on a randomly rough bed (Alam and Mei (2008), when the ship speed is near-critical. Invoking Boussinesq approximation in shallow waters, we apply the approach of Mei and Li (2004) for long waves propagating in still water over a randomly rough bed, to show that the wave evolution in the moving frame of reference is also governed by an integro-differential equation which combines features of Korteweg-deVries and and Burgers equations. Forces on a slender ship is handled by matched asymptotics. For an isolated ship the bottom roughness weakens the transient waves radiated both fore and aft. When many ships advance in tandem, a steady mount of high water can be formed in front and a depression behind. Wave forces on both an isolated ship and a ship in a caravan are obtained as functions of the mean-square roughness, ship speed and the blockage coefficient. Future extensions to ship moving near a river bank are worthwhile.