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Investigating Viscous Surface Wave Propagation Modes in a Finite Depth Fluid

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Abstract : The object of this study is to investigate the effect of viscosity on the propagation of free-surface waves in an incompressible viscous fluid layer of arbitrary depth. While we provide a more detailed study of properties of linear surface waves, the description of fully nonlinear waves in terms of KdV-like (Korteweg-de Vries) equations is discussed. In the linear case, we find that in shallow enough fluids, no surface waves can propagate. Even in any thicker fluid layers, propagation of very short and very long waves is forbidden. When wave propagation is possible, only a single propagating mode exists for any given horizontal wave number. The numerical results show that there can be two types of non-propagating modes. One type is always present, and there exist still infinitely many of such modes at the same parameters. In contrast, there can be zero, one or two modes belonging to the other type. Another significant feature is that KdV-like equations. They describe propagating nonlinear viscous surface waves. Since viscosity gives rise to a new wavenumber that cannot be small at the same time as the original one, these equations may not exist. Nonetheless, we propose a reasonable nonlinear description in terms of 1+1 variate functions that make possible successive approximations.

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