Damping of surface waves by a floating viscoplastic plate

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ABSTRACT

The damping of surface waves by floating material plays an important role in geophysics and engineering. In the marginal ice zone, for example, broken floating ice damps sea waves, with important implications on the maintaince of ice cover and the Arctic climate[1−2].

A theoretical model is presented to explore how surface waves in an inviscid fluid layer are damped by the bending stresses induced in a overlying floating film of yield-stress fluid. The model applies in the long-wavelength limit, combining the shallow-water equations for the inviscid fluid with a theory for the bending of a thin viscoplastic plate described by the Herschel-Bulkley constitutive law. An exploration of the energetics captured by the model suggests that waves decay to rest in finite time, a result that is confirmed using a combination of approximate, numerical and asymptotic solutions to the model equations. In the limit that the plate behaves like a perfectly plastic material, the sloshing motions take the form of triangular waves with bending restricted to narrow viscoplastic hinges.

Fig. 1 shows a sketch of the geometry. The thickness $\mathcal{D}$ of the viscoplastic plate is comparable to the typical depth of the inviscid fluid layer $\mathcal{H}$. Both are much smaller than the characteristic lengthscale $\mathcal{L}$ over which the plate bends.

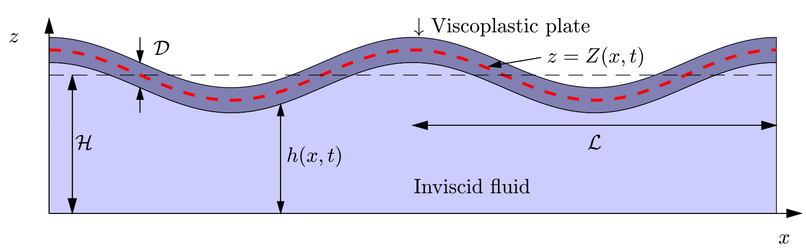

Figure 1: Sketch of the geometry

REFERENCES

1. Squire, V. A. A Fresh Look at How Ocean Waves and Sea Ice Interact. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, **376**, 2018.
2. Squire, V. A. Ocean Wave Interactions with Sea Ice: A Reappraisal. *Annual Review of Fluid Mechanics*, **52**, 37–60, 2020.