Free Boundary Problems in Fluid Dynamics

They arise when the dynamics of:

- The boundary of a fluid
- Fluid boundary between two fluids
- A boundary within the fluid itself

must be simultaneously determined with the dynamics of the fluid.

Examples of Free Boundary Problems

- **Inertial Flows**
  - Euler Equations
  - Newtonian Fluid
  - Irrotational Flow

- **Slosh** Flow
  - **Standing wave**
  - **Surface Tension**

Why are these problems interesting and difficult?

- **Gravity forces**
  - **Surface Tension**
  - **Rayleigh-Taylor Instability**

Equations and Boundary Conditions

For this derivation, consider the motion of a general fluid 2-D flow in which:

- **External Force**: 
  - Fluid Surface
  - Wall Boundary Conditions

Introduction & Purpose

- Surface waves have interested a considerable number of mathematicians for many centuries and will continue to do so for many years to come.

- There are a few types of surface waves that are particularly interesting to mathematicians and engineers:
  - **Standing waves**
  - **Gravity waves**
  - **Surface Tension**

- The problem is to derive a set of equations that are both accurate and mathematically tractable.

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Breaking wave without Surface Tension

To show that the solution works exactly as in a shallow regime, a breaking wave is computed with and without the breaking layer.

The fix: computations in the (x,t) frame

- **Small Scale Decomposition (SSD)**
- **Implementation Issues**
- **Summary and Conclusions**

Benefits of Small Scale Decomposition

- Computations are not CPU: The time stepping considered is not as severe as before.
- The grid is one order coarser, hence no grid clustering occurs. This is consistent with previous studies.
- Some computational time is needed.
- The interface is well defined, even in the breaking regime.

Summarizing the movement of water waves and the underlying mechanisms is important for the Mechanical Engineering Community but might be an impact to the Society.

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Future Work

- Get a fully working code for the Small Scale Decomposition computations.
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