EXPERIMENTAL STUDY OF INTERNAL SOLITARY WAVES INTERACTION WITH SURFACE SOLITARY WAVES

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INTRODUCTION

Internal solitary waves (ISWs) consist of a non-periodic single-crest profile resulting from the balance between non-linearity and dispersion. They can be a significant source of momentum transport in any stratified systems, such as oceans and estuaries.

Previous experiments have primarily utilized lock-release mechanisms to generate internal solitary waves in two-layer systems. This provides limited control over wave properties and limits its studies with barotropic wave interactions. The present effort attempts to validate the performance of a new wave generation method, termed the Jet Array Wave Maker (JAW). Experiments show that the JAW system reliably generates ISWs with interfacial displacements and velocity fields in close agreement with theoretical predictions. Future experimental work will target surface solitary waves (SSWs) interaction with ISWs.

EXPERIMENTAL SETUP

The JAW system (Figure 1) consists of two independent piston baffle systems, one filled with salt solution and the other with fresh water. Prescribed wave profiles are generated by controlling the temporal signal sent to the motors driving the pistons. The pistons are connected to a small wave flume with dimensions 2.2m×0.2m×0.3m (L×W×H). The fresh water baffle is connected to the upper inlet and the salt water baffle is connected to the lower inlet. Honeycomb structures with a thickness of 5cm are installed at the inlets to ensure uniform inflow conditions. An adjustable ramp is added to match the inlet geometry with the depth ratios (h_1/h_2) for stratified two-layer systems. This prevents mixing and turbulence at the inlet due to mismatch in interface depths.

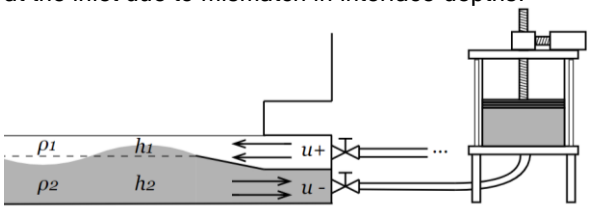

Figure 1. Schematic of the JAW connected to a stratified two-layer system.

Synchronized planar particle image velocimetry (PIV) and laser-induced fluorescence (PLIF) measurements are used to capture the interfacial displacement and velocity field as shown in Figure 2. These systems are composed of a 532nm solid-state laser and two USB cameras that capture images with 1280×1028 pixel resolution at 30 Hz. The cameras have a collocated field of view of size 20×15 cm^2 placed 1m downstream from the inlet. Rhodamine 6G dye is added to the freshwater, and 536nm - 564nm bandpass filter is used to extract the fluoresced signal for PLIF measurement.

To form a stratified two-layer system with uniformly distributed PIV particles, a floating sponge method is adopted. A lower layer of clear salt water is first instilled into the flume. Then the fresh water mixed with Rhodamine 6G dye and 55 μm polyamide PIV particles is slowly introduced through sponges to form the upper layer.

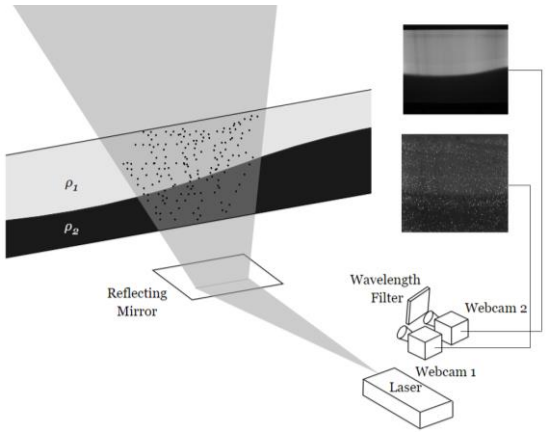

Figure 2. Layout of the measurement system with PIV and PLIF raw images.

RESULTS

The performance of the JAW is verified through the generation of ISWs. The temporal control signal for the JAW baffles is computed by integrating the interfacial displacement predicted mKdV theory. For the experiments, the density of the salt water is fixed at 1018 kg/m^3. The total water depth is 11cm and h_1/h_2 ratios vary from 2/9, 3/8, to 4/7 (cm/cm). ISWs are generated with 0.5cm increments in amplitude until the upper limits predicted by theory. For the paper, each parameter set will be repeated 3 times for consistency.

The measured interfacial displacements and velocity profiles will be compared with the theoretical predictions for verification as shown in Figure 3. The experiments will also capture shear layer structures (Pawlak & Armi, 1998) through PIV that characterize their impact on ISW flow physics.

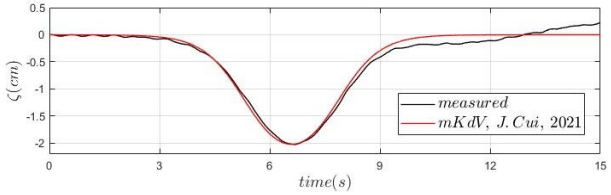

Figure 3. Measured time series and the mKdV theory.

FUTURE WORK

Interactions between ISWs and SSWs will be studied

after the ISWs generation performance of the JAW is verified. The same measurement techniques will be applied specifically to focus on the coupling structures at the interface and bottom shear while SSWs catch up with ISWs.

REFERENCES

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