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Inference of velocity and pressure field of GravityCurrents using Physic Informed Neural Networks

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Gravity currents [Ungarish, 2009] are common finescale structures in coastal areas, where they are involved in the vertical transport of physical and biogeological tracers. These stratified flows frequently carry a suspended solid phase that controls the average properties of the flow, such as the geometry, velocity and apparent viscosity leading to a rich dynamic whose optimization/prediction remains a major scientific issue.

A better understanding of the particle-flow coupling requires an accurate characterization of the particle volume fraction, fluid density, velocity and pressure fields. The experimental apparatus available at LEMTA allows high accuracy instantaneous measurements of density fields in laboratory experiments with the light attenuation technique (LAT) as described in a companion presentation, while the joint measurement of velocity and pressure fields remains beyond the reach of known metrological techniques.

To address this issue we propose an original approach based on the Physics Informed Neural Network (PINN) technique [Raissi 2020], which extracts the complete hydrodynamic variable set from the sole observation of the density field. The accuracy of this approach is evaluated against the well-documented test case of the lock-exchange configuration in both laminar and turbulent regimes. As a validation step, the PINN technique is applied on numerical simulations outputs with the well-established Nek5000 flow solver with convincing results. Then, an application on experimental data from LAT experiments will be shown, illustrating the robustness of this promising paradigm.