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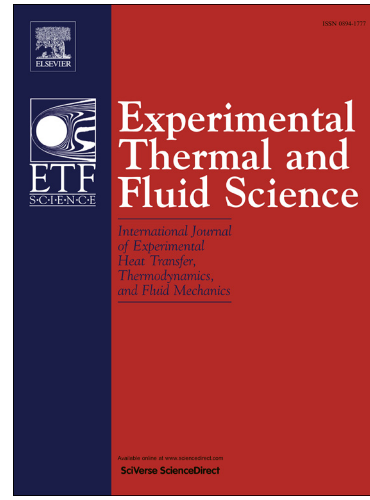


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# A stratified wake of a hydrofoil accelerating from rest

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**Abstract**

Wakes of towed and self-propelled bodies in stratified fluids are significantly different from non-stratified wakes. Long time effects of stratification on the development of the wakes of bluff bodies moving at constant speed are well known. In this experimental study we demonstrate how buoyancy affects the initial growth of vortices developing in the wake of a hydrofoil accelerating from rest. Particle image velocimetry measurements were applied to characterize the wake evolution behind a NACA 0015 hydrofoil accelerating in water and for low Reynolds number and relatively strong stable stratified fluid ($Re$=5,000, $Fr \sim O(1)$). The analysis of velocity and vorticity fields, following vortex identification and an estimate of the circulation, reveal that the vortices in the stratified fluid case are stretched along the streamwise direction in the near wake. The momentum thickness profiles show lower momentum thickness values for the stratified late wake compared to the non-stratified wake, implying that the drag on an accelerating hydrofoil in a stratified medium is reduced at the acceleration stage. The findings may improve our ability to predict drag due to maneuvering of micro-air/water-vehicles in stratified conditions.

## 1. Introduction

Stably stratified flows are common phenomena in the atmosphere and oceans and are more difficult for analytical, numerical and experimental investigation as they are typically characterized by variations (both in space and time) of the vorticity, energy and density or temperature. In non-stratified flows, instabilities are usually associated with the Reynolds number, *Re*. As the Reynolds number increases, inertial forces overcome viscous dissipation, and instabilities grow until they overtake the flow. In a stratified flow, a gravity stabilizing effect is present, which generates buoyancy forces. Thus, for these flows one also needs to take into account the internal Froude number, *Fr*, in addition to *Re* (Turner, 1973).

The ambient stratification at the pycnocline layer in the ocean has a unique effect on a vehicle wake through the formation of distinct long-time, large aspect ratio quasi-horizontal vortices (commonly termed as 'pancakes') and the radiation of internal waves from both the vehicle itself ('lee waves') or from its wake, as observed by Lin and Pao (1979). Thus, the

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