# The instability of the stratified horizontal plane Poiseuille flow

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We present here the first study on the stability of the plane Poiseuille flow when the fluid is stratified in density perpendicularly to the plane of the horizontal shear. Using laboratory experiments, linear stability analyses and direct numerical simulations, we describe the appearance of an instability that results from a resonance of internal gravity waves and Tollmien-Schlichting waves carried by the flow. This instability takes the form of long meanders confined in thin horizontal layers stacked along the vertical axis. The plane Poiseuille flow, i.e. the steady flow between two infinite parallel plates, is one of the simplest and most common shear flows. In the non-stratified case, it is known to be linearly unstable for Reynolds numbers larger than 5772 [1]. Above this value, two dimensional waves - known as Tollmien-Schlichting waves - are viscously unstable and can develop and propagate in the flow. As density stratification is ubiquitous in nature, the instability of the stratified Poiseuille flow may be relevant to water flows in submarine canyons, to winds in deep valleys or to laminar flows in rivers or canals where stratification can be due to temperature or salinity gradients. Resonances and instabilities of different types of waves in shear flows are the subject of a long standing history originating from the seminal paper of Cairns [4] on the Kelvin-Helmholtz instability, then extended to surface flows by Satomura [5] and also to different arrangement of stratified flows (see for instance the review [7]). A particularity of the present case is that the Tollmien-Schlichting waves can themselves also interact and possibly resonate with inviscid gravity waves. Our study follows recent investigations on instabilities of stratified or plane Couette flows [3,9], or the radiative instability in boundary layer flows [10,2]. All of these examples belong to a class of instabilities caused by the resonant interaction of Doppler shifted internal waves.

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