Internal waves and boundary layer for an oscillating disc in a stratified fluid

Bruno Voisin, Sylvain Joubaud, Thierry Dauxois

Internal waves and boundary layer for an oscillating disc in a stratified fluid

Bruno Voisin[1], Sylvain Joubaud[2] and Thierry Dauxois[2]

[1] *LEGI, CNRS and Université de Grenoble, BP 53, 38041 Grenoble, France*
bruno.voisin@legi.grenoble-inp.fr

[2] *Laboratoire de Physique, CNRS and ENS de Lyon, 46 allée d'Italie, 69364 Lyon, France*

Internal or baroclinic tides, namely internal waves generated in the ocean by the oscillation of the barotropic tide over bottom topography, exhibit a complex pattern of primary wave beams and secondary beams resulting from the interaction of the primary beams with themselves and with the boundary layer at the topography. In this context, the problem of an oscillating horizontal disc, however remote it may be from oceanic configurations, recently gained visibility as the only problem for which a full analytical solution may be found including both waves and the boundary layer (Davis & Llewellyn Smith 2010). To date, all available approaches used an approximate free-slip condition at the topography instead of the actual no-slip condition, thus eliminating the boundary layer.

In this communication, we examine the relation between those approaches and compare them with original high-resolution experimental measurements. Specifically, we consider the vertical heaving oscillations of a horizontal circular disc (figure 1) and compare fully inviscid investigations where both the generation and propagation of the waves are inviscid — using either orthogonal curvilinear coordinates (Sarma & Krishna 1972), boundary integrals (Gabov & Pletner 1988) or eigenfunction expansions (Martin & Llewellyn Smith 2011, 2012) — with fully viscous investigations where both generation and propagation are viscous — using either the actual disc oscillating in free space (Davis & Llewellyn Smith 2010) or a fictitious baffled disc oscillating through an aperture in a horizontal plane (Chashechkin, Vasil'ev & Bardakov 2004; Bardakov, Vasil'ev & Chashechkin 2007). We discuss the relevance of an intermediate model where propagation is viscous but generation inviscid (as used recently for a sphere by Voisin, Ermanyuk & Flór 2011), as a function of the Reynolds–Stokes number. At all but very high values of this number (of order 10^5 or more say), it appears that the presence of the boundary layer must be taken into account for accurate prediction of the waves.

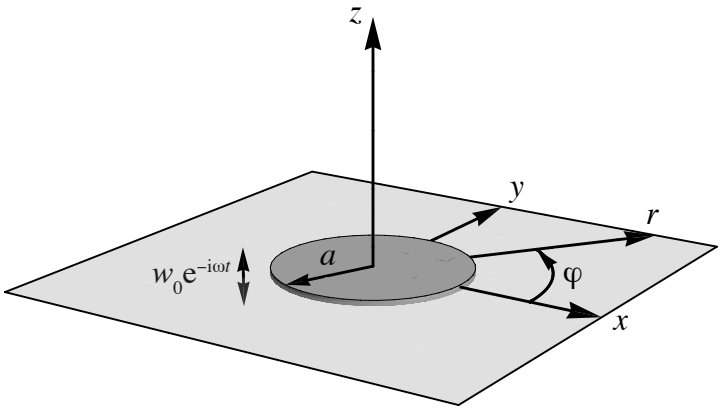

Figure 1 – Oscillating disc geometry.

Bardakov, R. N., Vasil'ev, A. Yu. & Chashechkin, Yu. D. (2007) *Fluid Dyn.* **42**, 612–626.
Chashechkin, Yu. D., Vasil'ev, A. Yu. & Bardakov, R. N. (2004) *Dokl. Earth Sci.* **397A**, 816–819.
Davis, A. M. J. & Llewellyn Smith, S. G. (2010) *J. Fluid Mech.* **656**, 342–359.
Gabov, S. A. & Pletner, Yu. D. (1988) *USSR Comput. Maths Math. Phys.* **28** (1), 41–47.
Martin, P. A. & Llewellyn Smith, S. G. (2011) *Proc. R. Soc.* A **467**, 3406–3423.
Martin, P. A. & Llewellyn Smith, S. G. (2012) *SIAM J. Appl. Maths* **72**, 725–739.
Sarma, L. V. K. V. & Krishna, D. V. (1972) *Zastosow. Matem.* **13**, 109–121.
Voisin, B., Ermanyuk, E. V. & Flór, J.-B. (2011) *J. Fluid Mech.* **666**, 308–357.