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► **To cite this version:**

Benoît Pier, Nigel Peake. Global nonlinear dynamics of thin airfoil wakes. Euromech Fluid Mechanics Conference 7, Sep 2008, Manchester, United Kingdom. hal-00632329

**HAL Id: hal-00632329**

**<https://hal.science/hal-00632329>**

Submitted on 14 Oct 2011

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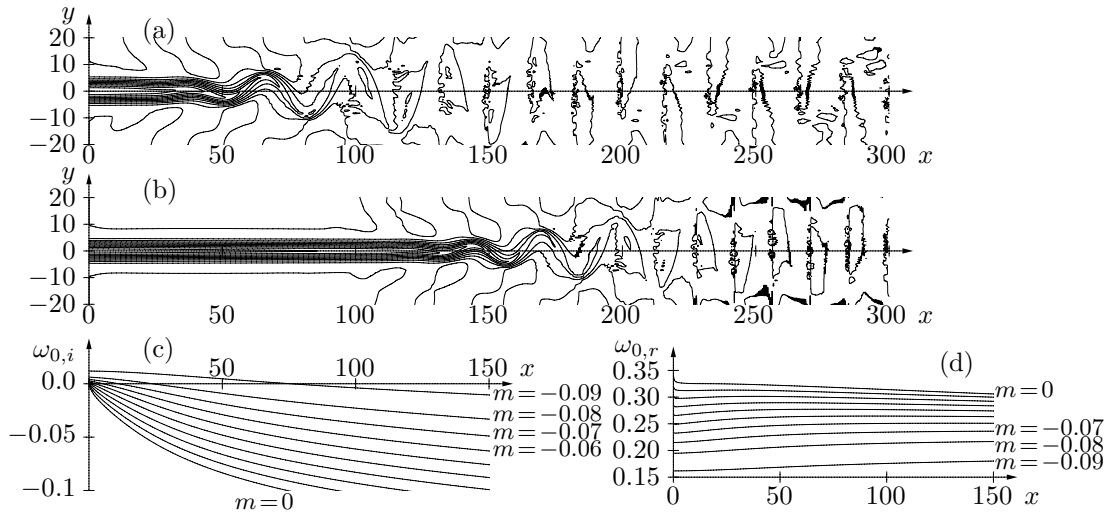
# Global nonlinear dynamics of thin airfoil wakes

Benoît PIER\* and Nigel PEAKE†

In the present investigation of thin airfoil wakes we compare the global nonlinear dynamics, obtained by direct numerical simulations, to the associated local instability features, derived from linear stability analyses.

In the numerical implementation, we consider a semi-infinite flow domain corresponding to the region downstream of the airfoil trailing edge, where a symmetric velocity profile is imposed represented by the double-Falkner–Skan boundary layer solutions with negative pressure gradient  $m$ . The parameter  $m$  is varied from  $m = 0$  (double-Blasius wake) to  $m = -0.09$  (near flow separation); Reynolds numbers up to  $Re = 5000$  are considered. It is found that the wake gives rise to self-sustained vortex shedding provided the Reynolds number and the adverse pressure gradient are large enough. Snapshots of streamwise velocity contours in the fully developed régime at  $Re = 4000$  for (a)  $m = -0.09$  and (b)  $m = -0.08$  are shown below; the associated global frequencies are  $\omega = 0.170$  and  $\omega = 0.198$ .

Local stability features are computed from the corresponding basic flows. At  $Re = 4000$ , the local absolute growth rates  $\omega_{0,i}$  and frequencies  $\omega_{0,r}$  are given in figures (c) and (d). It is seen that absolute instability prevails in the near wake and that the spatial variations of  $\omega_{0,i}$  strongly depend on  $m$ : the largest absolutely unstable domains and the weakest spatial variations are obtained at large (negative) values of  $m$ . The global frequency predictions<sup>1</sup> derived from these curves are  $\omega = 0.162$  for  $m = -0.09$  and  $\omega = 0.195$  for  $m = -0.08$ , in excellent agreement with the above direct numerical simulations. Another feature of interest is that nonlinear saturation may occur well downstream of the absolutely unstable domain.



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<sup>1</sup>Chomaz, *Annu. Rev. Fluid Mech.* **37**, 357 (2005).