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AVVISO DI SEMINARIO

"About finite area wakes past bluff bodies and growing vortex patches"

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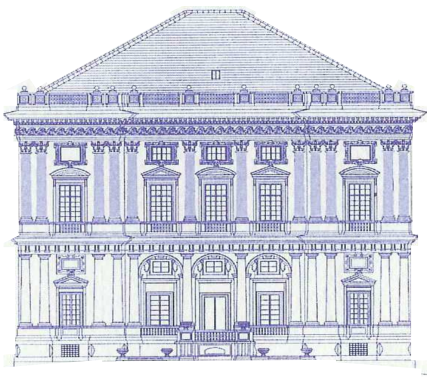

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About finite area wakes past bluff bodies and growing vortex patches

Vorticity, ω , holds a constant value on ψ = const streamlines of inviscid 2D flows, that is $\omega = \omega(\psi)$. The equation governing the flow is then the non linear Poisson equation $\nabla^2 \psi = -\omega(\psi)$. The value of the vorticity on closed streamlines is not defined by the far field boundary conditions; as a consequence, for finite area wakes, this equation provides multiple solutions for separated flows past bluff bodies. The multiplicity of solutions is relative to the different distributions of vorticity $\omega(\psi)$ which can be assumed for the region with closed streamlines. By assuming as a simple model for the vorticity distribution a two level piecewise-constant distribution, the wake consists of an inner core patch, with $\omega \neq 0$ and a surrounding $\omega = 0$ potential flow. We argue that these wakes form a three parameter family, with the parameters being the area A of the core, the value of the vorticity ω or, equivalently, of the circulation Γ and the jump ΔB of the Bernoulli constant across the vortex sheet that separates the core from the potential flow. The assumption is verified for A = 0 solutions, which are pertinent to standing point vortices. In these cases ΔB is not defined. It can be shown that past any protruding body from a wall, there is a locus of standing point vortices. Such locus is the generalization of the Föppl curve pertinent to semicircular obstacles. Thus, each standing point vortex is relevant to a finite area wake characterized by A = 0 and by a value of the circulation Γ.

Under the hypothesis that such point vortex solutions can be considered as seeds from which the above three parameter family can grow, solutions with different values of A and ΔB and the same Γ can be obtained by continuation from each standing vortex. Such conjecture has a physical interest, in fact, if true, it relates the point vortex solutions, which are easily detected, to the Batchelor flow solution, which possesses a strong physical meaning. Actually, Batchelor has shown that the limit solution of the viscous flow for the Reynolds number going to infinity is characterized by $\omega(\psi)$ = const in the region with closed streamlines, that is, that the finite area wake reduces to a vortex patch. It can be shown that when an obstacle presents a sharp edge, then there is a finite or null number of standing point vortices satisfying the Kutta condition. We conjecture that if there is not a standing point vortex that satisfies the Kutta condition, then the associated family of growing patches, including the Batchelor-like vortex patch, does not exist either. This conjecture implies that this kind of obstacles does not admit a finite area wake at high Reynolds number, but controversial numerical results can be found in literature which contradict this assertion. Our opinion is that such results are due to poor convergence. To attain high accuracy, a mixed analytical numerical method, based on a domain decomposition and on a Steklov-Poincaré iteration, has been developed; it has provided support to the above conjecture about vortex patches growing from point vortices.

Sketch biografico di Luca Zannetti

Laureato in Ing. Aerospaziale al Politecnico di Torino (1971), Luca Zannetti è Professore di Propulsione Aerospaziale dal 1986 al 2003, e Professore di Fluidodinamica dal 2003. Coordina il Corso di Dottorato in Fluidodinamica del Politecnico di Torino dal 2003. I principali interessi di ricerca di Luca Zannetti sono la CFD per flussi comprimibili, la dinamica della vorticità, i problemi inversi e l'ottimizzazione fluidodinamica.