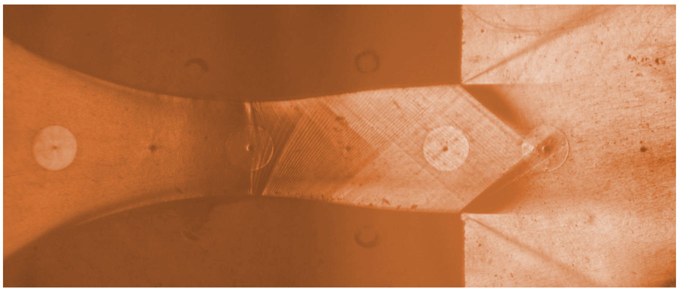
# ________________ AeroPhD Seminars ________________



Join us on the **28th of January** 2019, in the Sala Consiglio of the **Department of Aerospace Science & Technology**, Politecnico di Milano (Campus Bovisa La Masa, Via La Masa 34, Building B12, 2nd floor) **from 15:30 until 18:30** for an inspiring afternoon devoted to fluid mechanics.
Prof. Iaccarino (Stanford University), prof. Luchini (Università di Salerno) and prof. Pirozzoli (Sapienza Università di Roma) will present the latest findings in fluid mechanics, discussing on ensemble computing, universality law for turbulent flows, and turbulent channel flows in complex geometries.
The Seminar is organized by the Aerospace Engineering PhD program and AIDAA Lombardia.

## 15:30 - Ensemble Computations - Present and Future of Engineering Computing

Gianluca Iaccarino, Stanford University

**Abstract.** Computer simulations are pervasive in science and engineering. Computations, together with theoretical analysis and experiments, constitute the foundation for building knowledge, whether it be to investigate a new physical phenomenon or to assess the performance of an innovative device. However, a single computation, despite its sophistication and complexity, can rarely provide sufficient and credible evidence to support a decision. To build confidence in computed outcomes, one typically conducts sensitivity analyses, investigates uncertainty, and explores design variations. All these approaches require an ensemble of computations whose results we combine rigorously via statistical analysis or optimization. In this talk we discuss the use of ensemble of simulations for multidisciplinary design under uncertainty; we have developed novel algorithms to handle ensemble with different fidelity implemented in a new programming environment that enables the efficient use of next generation HPC supercomputers. I will also provide a perspective on the present and the future of computational engineering research at Stanford.

## 16:30 - Universality of the turbulent velocity profile, restored

Paolo Luchini, Università di Salerno

**Abstract.** The logarithmic velocity profile of wall-bounded turbulent flow, despite its widespread adoption in research and in teaching, exhibits discrepancies with both experiments and numerical simulations that have been repeatedly observed in the literature; serious doubts ensued about its precise form and universality, leading to the formulation of alternate theories and hindering ongoing experimental efforts to measure von Karman's constant.
In this context we found out that a representative collection of numerical and experimental data in plane and circular geometries can be accurately fitted in the classical wall-layer and defect-layer matched asymptotics, or equivalently represented as the sum of a "law of the wall" and a "law of the wake" in the language of Coles, provided a) the law of the wake and not the law of the wall is allowed to vary from one geometry to another, and b) the portion of the law of the wake superposing with the logarithmic layer is a universal linear function of the wall-normal coordinate z, which can be derived from dimensional analysis once it is assumed to be proportional to the pressure gradient.
Inclusion of this correction produces a tenfold increase in the adherence of the predicted profile to existing experiments and numerical simulations in all geometries. Universality of the logarithmic law and of the value of von Karman's constant then emerges beyond doubt and a satisfactorily simple formulation is established.

## 17:30 - Turbulence in ducts with complex cross-section

Sergio Pirozzoli, Sapienza Università di Roma

**Abstract.** We consider turbulent flows in pressure-driven ducts with complex cross-section, with special reference to the case of square ducts. Direct numerical simulations (DNS) are carried out in a wide enough range of Reynolds number to reach flow conditions which are representative of fully developed turbulence. Extremely long integration times are required to achieve adequate convergence of the flow statistics, and specifically high-fidelity representation of the secondary motions which arise.
The intensity of the latter is found to be in the order of 1-2% of the bulk velocity, and unaffected by Reynolds number variations. The smallness of the mean convection terms in the streamwise vorticity equation points to a simple characterization of the secondary flows, which in the asymptotic high-Re regime are found to be approximated with good accuracy by eigenfunctions of the Laplace operator.
Despite their effect of redistributing the wall shear stress along the duct perimeter, we find that secondary motions do not have large influence on the mean velocity field, which can be characterized with good accuracy as that resulting from the concurrent effect of four independent flat walls, each controlling a quarter of the flow domain. As a consequence, we find that parametrizations based on the hydraulic diameter concept, and modifications thereof, are successful in predicting the duct friction coefficient. A theoretical predictive formula is presented for ducts with arbitrary cross-sectional shape.

**28th of January, 2019, from 15:30 until 18:30**
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