Proposition de thèse de doctorat	
Début : 2017-2018	
Titre de la thèse : Direct Numerical Simulation of Transition induced Vibrations over Flexible Marine Propeller Sections	
Laboratoire : LHEEA	
Equipe :H2I	
Localisation de la thèse : Ecole Centrale de Nantes	
Directeur de thèse **Le Touzé David** Tél : 0240371512 Mail : david.letouze@ec-nantes.fr	**Co-Encadrants** **Ducoin Antoine** Tél : 0240371650 Mail : antoine.ducoin@ec-nantes.fr

Description du sujet

General informations:

The PhD is in the context of hydroelasticity of lifting profiles, and will aim at investigates the behavior of laminar to turbulent transition on marine propeller sections, and its possible interactions with structural vibrations, using Direct Numerical Simulations (DNS).

Background, Context:

The laminar to turbulent transition occuring on marine propeller blades is known to be critical for the body performance and its structural integrity. For many marine applications operating at low angles of attack, laminar profiles are often choosen for the blade in order to reduce the friction at the body surface to get better performances. However, this lead to further development of transitional regimes, even at high Reynolds numbers where the boundary layer is usually considered as fully turbulent. With the recent development of flexible marine propellers, which are mainly used to obtain a passive control of the deformations induced by the hydrodynamic loading to enhence the overall performances, the vibrations are more likely to interact with the transition, and large fluid structure interaction effects can occur.

Previous research have shown that under relatively high Reynolds numbers (Re=300,000 to 800,000), highly transitional flows are observed on laminar section, which induces important structural vibrations with low damping, that can in some case get close to resonnance, see [1] and [2]. These laminar profiles are indeed obtained by moving the maximum thickness to the center of the chord, which reduces the adverse pressure gradient and hence increase the critical Reynolds number of transition, see Figure 1. It results in a delay of transition as compared conventional, non laminar profiles and hence a rapid development of turbulence, as observed by a preliminary DNS results shown in Figure 2.

On one hand, the prediction of laminar to turbulent transition have mainly concerned infinitely rigid blades. In this context, DNS have already been performed and validated successfully on a aerodynamic Sd7003 section under different Reynolds numbers, using a massively parallelized open source code that uses the spectral element method to solve the incompressible Navier Stokes equations, see [3].

On the other hand, Many works, mostly in the aeroelasticity community, have concerned the developpement of numerical coupling methods that are able to analyze the fluid structure interaction on wing sections. The development of numerical problem for flexible wing under viscous flows are based on well known coupling methods, which used potential or RANS (Reynolds Averaged Navier Stokes Equations) methods for the flow [4].However, the particular case of laminar to turbulent transition is more complex because the simulation of the transition itself requires to directly solve the Navier Stokes Equations to capture the instabilities responsible for the transition, and experimental data are still very usefull to understand the fundamentals of transition induced vibrations ([1], [2]).

Research subject:

The PhD student will have to lead and analyze Direct Numerical Simulations on a laminar NACA section, and to develop an efficient coupling method to account for the structural flexibility. The mechanism that lead to transition to turbulent flow will be investigated through space-time analysis using different numerical techniques, and the effect of fluid structure interaction will be analyzed for different degrees of flexibility.The results obtained by the PhD student will aim at characterize the specificity of transition on laminar section as compared to classic aerodynamic profiles, and to evaluate the effect on the overall blade performance and structural vibrations.

Please send your applications to : antoine.ducoin@ec-nantes.fr

References:

[1] Ducoin, A., Astolfi, J. A., & Gobert, M. L. (2012). An experimental study of boundary-layer transition induced vibrations on a hydrofoil. Journal of Fluids and Structures, 32, 37-51.

[2] Ducoin, A., Astolfi, J. A., & Sigrist, J. F. (2012). An experimental analysis of fluid structure interaction on a flexible hydrofoil in various flow regimes including cavitating flow. European Journal of Mechanics-B/Fluids, 36, 63-74.

[3] Ducoin, A., Loiseau, J. C., & Robinet, J. C. (2016). Numerical investigation of the interaction between laminar to turbulent transition and the wake of an airfoil. European Journal of Mechanics-B/Fluids, 57, 231-248.

[4]Ducoin, A., & Young, Y. L. (2013). Hydroelastic response and stability of a hydrofoil in viscous flow. Journal of fluids and structures, 38, 40-57.

Compétences requises
The student must be in fluid mechanics major or related. He/she must be familiar with Computational Fluid Dynamics (CFD), laminar to turbulent transition on lifting profiles and

turbulence. Background in Direct Numerical Simulation, numerical methods and FORTRAN programing is a plus.

Commentaires Supplémentaires
Etude en relation Financement prévu : Ministère Indemnité : Oui (pour les étudiants non déjà boursiers) Montant net mensuel envisagé :

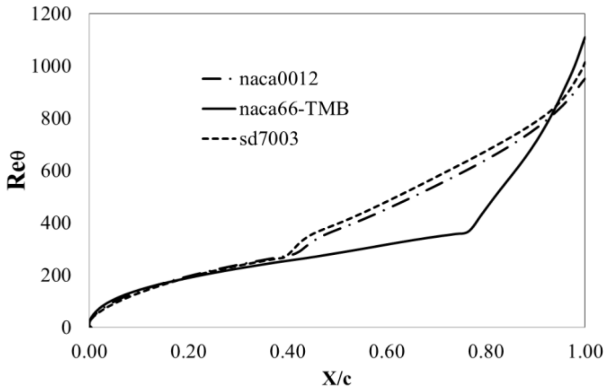

Figure 1. Critical Reynolds number Re_ along the chord. Comparison of laminar (naca66) and conventionnal (naca0012 and sd7003) profiles at Re=200,000

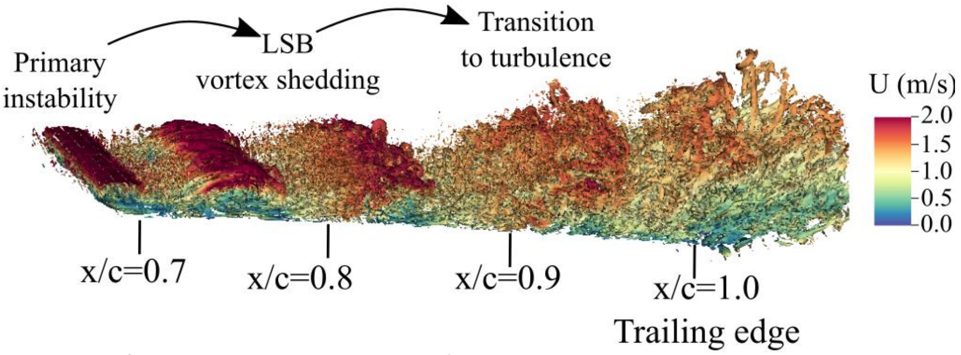

Figure 2. Iso λ2 structures obtained from aDNS calculation on a laminar section