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POST-DOCTORATE PROPOSAL

Title: Exploiting data from wind-tunnel experiments of a transonic, aeroelastic wing-model with physics-informed data-driven approaches.

Reference : **PDOC-DAAA-2021-05**
(to be recalled in all correspondence)

Start of contract: January 2022	**Application deadline:** December 2021

Duration: 12 months, possibly extendable to 18 months - Net yearly salary: about 25 k€ (medical insurance included)

Keywords

Aeroelasticity, physics-informed data-driven modelling, wind-tunnel tests

Profile and skills required

The candidate should have a PhD degree in a subject of relevance for conducting the project such as fluid mechanics, structural-mechanics and aeroelasticity. Thorough experience in computational structural/fluid dynamics or knowledge of experimental non-intrusive techniques is an advantage.

The successful applicant should be strongly motivated, have the capability to work independently as well as in collaboration with colleagues and students at ONERA. Good knowledge in both written as well as spoken English is a necessity.

Skills:
• Basic knowledge of computational structural dynamics
• Established capacity to publish in international peer-reviewed journal

Presentation of the post-doctoral project, context and objective

Wind tunnel tests are an essential tool to aeroelastycity: in this framework, the aerodynamics and the structural mechanics of the model couple into the observed phenomena, making both aerodynamic and structural measurements essential to characterise the coupled system. This generates databases of physically linked aerodynamic and structural measurements that need to be post-processed and combined to reconstruct and, hopefully, comprehend the underlying physics.

The joint ONERA/DLR project CRP FIGURE offers a typical example of this kind of databases. It saw the collaboration of the two institutes to design two different wind-tunnel models to be the subject of extensive wind-tunnel tests, performed in 2020 at ONERA. On the one hand, the campaign was intended to verify the expected performances of the wings in terms of gust-load alleviation; on the other hand, it was the opportunity to generate a database of transonic aeroelastic measurements, using state-of-the-art techniques on the structural and aerodynamic sides.

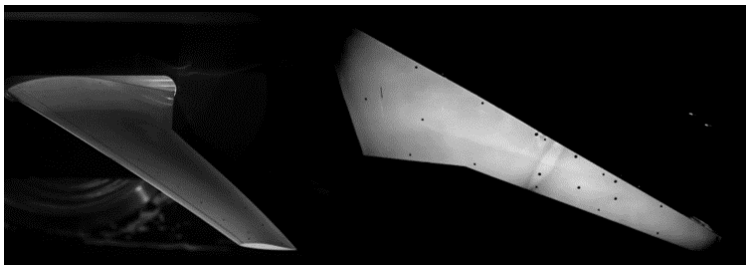

Figure 1. Raw snapshots for MDM (left) and PSP (right) for the CRP FIGURE project.

Optical techniques, alongside with more traditional pressure probes and accelerometers, were employed during the tests: steady and unsteady pressure fields on moving surfaces have been measured via pressure-sensitive-paint (PSP) [1], while model-deformation-measurements (MDM) [2] were used to quantify wing shape under aerodynamic loadings. This made available a well-documented database, not limited to the raw measurements but extended also to structural and aerodynamic models of the set-up.

This postdoc aims to exploit and analyse this database via data-driven techniques in order to (i) reconstruct of

the aeroelastic system and (ii) to shed light into the physical interaction between aerodynamics and structural mechanics. The analysis should put to good use the models available as a part of the database, allowing for a physic-based approach to the analysis [3]. The main idea is to use the structural model and the available calibration data from the ground vibration tests (GVT) to better reconstruct the deformation and load measurements partially available from the experimental campaign on the model.

The successful applicant would be in charge of developing the tools to combine the experimental observation with the structural – and, if needed, aerodynamic – model in order to reconstruct the state of the wing during the aerodynamic tests, namely the pressure on the surface and the deformation of the model. The results will contribute to the numerical return of the experiments and they are to be presented in peer-reviewed journals and conferences of the fluid-structure community.

Furthermore, the knowledge and the tools developed within this postdoc will be a further step towards the fusion of measurements coming from different techniques and physical quantities in order to characterise a phenomenon that intrinsically couples different physics.

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[1] M-C Merienne, V Brion, and J-C Abart (2019) *Unsteady PSP Measurements of the Shock Dynamics on a Transonic Laminar Airfoil.* AIAA Scitech 2019 Forum.

[2] Y Le Sant, A Durand, and M-C Merienne (2012) *Image Processing Tools Used for PSP and Model Deformation Measurements.* 35th AIAA Fluid Dynamics Conference and Exhibit.

[3] B Khodabandeloo, D Melvin, and H Jo (2017). *Model-Based Heterogeneous Data Fusion for Reliable Force Estimation in Dynamic Structures under Uncertainties*. Sensors (Basel, Switzerland), 17(11), 2656.

External collaborations

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Host laboratory at ONERA

Department : Département Aérodynamique Aéroélasticité Acoustique (DAAA)

Location (ONERA centre): Châtillon

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