Aerospace Europe Conference 2023
Joint 10th EUCASS – 9th CEAS Conference

Abstract #XXX *(to be filled by the organizers)*
Preferred Topics: FDGNCAV / STRMAT

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Type: Oral
Status of corresponding author: Regular

Title

Stability and flying qualities analysis of flexible aircraft by coupling the Vortex Lattice method and the discontinuous Galerkin method

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Abstract

Some aeronautical applications, e.g. high altitude experimental aircraft, MALE and HALE UAVs, favor the use of high aspect ratio wings, by virtue of their higher lift-to-drag ratio that contributes to reducing fuel consumption. However, high aspect ratios also imply higher structural flexibility so that, in the evaluation of the aircraft stability and flying qualities, it is not possible to decouple the flight dynamics from the elastic response [1-3].
This contribution presents a novel computational approach for the evaluation of the aircraft stability derivatives that include aeroelastic effects based on the combined use of the Vortex Lattice Method (VLM) and the discontinuous Galerkin method (DGM). VLM is a well-known, widely employed, medium-fidelity numerical method for potential flow that allows evaluating the aerodynamic loads on the lifting surfaces for low-speed, high-Reynolds, attached flow. DGM is a variable-order numerical method for partial differential equations that offers high-order accuracy with generally shaped mesh elements. The present study couples the two methods to solve the aeroelastic problem for the lifting surfaces: the flexibility of DGM offers the opportunity to tune the order of the structural analysis to capture on demand increasing orders of structural complexity, e.g. the presence of skin, spar and ribs and complex material distribution. The proposed procedure is the first step towards the development of a tool for the optimization, control and morphing of flexible aircraft featuring improved stability and flying performances.
Numerical results are presented for wings with flat-plate and thin NACA profiles; the obtained results are compared with those available in the literature showing the potential of the proposed approach.

References

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