

ASYMPTOTIC AND SPECTRAL ANALYSIS OF AIRCRAFT WING MODEL IN SUBSONIC AIRFLOW

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The aircraft wing model, which will be discussed in this talk, has been developed in the Flight Systems Research Center of UCLA in collaboration with NASA Dryden Flight Systems Center. The mathematical formulation of this model has been originally presented in the works by A.V. Balakrishnan. The model has been recently tested in a series of flight experiments at Edwards Airforce Base. The experimental results have shown very good agreement with the theoretical predictions of the model for at least several lowest aeroelastic modes. The objective of the entire wing modeling project is to treat the flutter phenomenon in aircraft wing.

In this talk, I will present the results of my four recent works and of a joint paper with A.V. Balakrishnan devoted to the mathematical analysis of the model. The model is governed by a system of two coupled linear integro-differential equations and a two-parameter family of boundary conditions modeling the action of self-straining actuators. The differential parts of the equations of motion form a coupled linear hyperbolic system; the integral parts are of the convolution type. The aforementioned system is equivalent to a single operator evolution-convolution equation in the state space equipped with the energy metric. The Laplace transform of the solution of this equation can be represented in terms of the so-called generalized resolvent operator, which is an operator-valued function of the spectral parameter. This generalized resolvent operator is a finite-meromorphic function on the complex plane having a branch-cut along the negative real semi-axis. Its poles are precisely the aeroelastic modes and the residues at these poles are the generalized projectors on the corresponding eigenspaces.

I will describe the following results:

- Asymptotics of the eigenvalues and eigenvectors of the nonselfadjoint operator, which is a dynamics generator of the differential part of the model.
- Riesz basis property of the generalized eigenvectors of the above operator in the state space.
- Asymptotics of aeroelastic modes and mode shapes for the entire model.
- Riesz basis property of the mode shapes.
- Application of the results of asymptotic and spectral analysis to the representation of the solution to the main initial-boundary value problem in the space-time domain.
- The problem of flutter control will be discussed.