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# Weak and strong solutions of a nonlinear subsonic flow–structure interaction: Semigroup approach

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ABSTRACT

We consider a non-rotational, subsonic flow–structure interaction describing the flow of gas above a flexible plate. A perturbed wave equation describes the flow, and a second-order nonlinear plate equation describes the plate's displacement. It is shown that the linearization of the model generates a strongly continuous semigroup with respect to the topology generated by "finite energy" considerations. An interesting feature of the problem is that linear perturbed flow–structure interaction is not monotone with respect to the standard norm describing the finite energy space. The main tool used in overcoming this difficulty is the construction of a suitable inner product on the finite energy space which allows the application of $\omega$-maximal monotone operator theory. The obtained result allows us to employ suitable perturbation theory in order to discuss well-posedness of weak and strong solutions corresponding to several classes of nonlinear dynamics including the full flow–structure interaction with von Karman, Berger's and other semilinear plate equations.



## 1. Introduction and motivation

This paper aims to provide analysis of models which arise in aeroelasticity describing the dynamics and interaction between an oscillating structure and a surrounding inviscid flow. We aim to study solutions to a coupled system of PDEs describing the interaction between a gas flow around a thin structure moving through the environment with a given velocity $U$. One of the central problems of aeroelasticity is the determination of the speed of the aircraft corresponding to the onset of an endemic instability termed wing "flutter" [1–6]. It is well known that flutter in the wing of an aircraft may occur at high speed, and can cause the wing to break down. Thus, determining conditions which prevent such instability are of prime concern.

At present, related studies are primarily experimental and computational: NASTRAN and CFDO codes which produce numerical algorithms and schemes. While these methods address various situations, they are based on finite dimensional approximations of a continuum model fully described by PDEs [7–10]. The PDE nature of the physical phenomena may not be adequately reflected by these approximations. This is particularly true in dealing with a highly oscillatory model, where large frequencies (often causing instability) are not accounted for by finite dimensional analysis.

### *1.1. Summary*

We present results on the Hadamard well-posedness of the nonlinear system for subsonic velocities in the absence of rotational inertia. After presenting the flow–structure model, we proceed by describing the problem abstractly in terms of

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