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NONLINEAR DYNAMICS OF A RECTANGULAR PLATE

In this paper we consider a thin simply supported rectangular plate subjected to aerodynamic loading. This can serve as a mechanical model for many real systems found in civil engineering (bridges, roadways) and the aerospace industry (aircraft wings). The plate has a concentrated mass lying on one surface and is submitted to a constant velocity airflow acting perpendicularly to free supported edges of the plate. One can expect that for certain control parameters characterising the airflow, an otherwise stable configuration of the plate becomes unstable so that periodic oscillations can appear, This phenomenon, known as flutter, is well described by aeroelasticity theory. However, because of the occurrence of nonlinear terms in the governing equations, we additionally expect much more complicated dynamical behaviour. As will be shown, we have detected a period doubling scenario and an intermittency scenario leading to chaotic motion of the plate.

The paper contains the following main parts. First we introduce a mathematical model, ie three nonlinear autonomous partial differential equations with appropriate boundary conditions. We then apply a Galerkin procedure in order to derive two second-order ordinary differential equations governing the amplitudes. These equations allow us to determine the Hopf bifurcation threshold. Periodic orbits born after Hopf bifurcation have been analysed numerically and also two routes leading to chaotic orbits have been investigated in some detail, showing some interesting nonlinear phenomena.

From the amplitude equations we formulate the Hopf condition analytically and obtain periodic oscillations of the analysed system. Then, by taking arbitrarily two control parameters, we analyse two different routes to chaos, transitional and steady state chaotic behaviour, as well as the development of chaos through change of the control parameters.