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SYMMETRIES AND CONSERVATION LAWS OF PLATES AND SHELLS INTERACTING WITH FLUID FLOW

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Abstract. The present study is concerned with thin isotropic shallow shells interacting with inviscid fluid flow of constant velocity. It is assumed that the dynamic behaviour of the shells is governed by the Marguerre–von Kármán equations. The influence of the fluid flow is taken into account by introducing additional differential and external load terms in the shell equations. It is shown that the system of equations governing such a fluid-structure interaction is equivalent to the von Kármán equations. Thus, the symmetries and conservation laws of the considered fluid-structure system are established.

1. Introduction

A wide variety of mathematical models describing fluid-structure interactions have been suggested in the past 50 years. To the best of our knowledge, the first one is due to Niordson [12], where a single fourth-order linear partial differential equation governing the flow-induced vibration of pipes within Bernoulli–Euler beam theory is derived. Later on this equation has been obtained in another way by Benjamin [4] and used by many authors to ascertain substantial features of various beam-like structures contacting fluid flows. Fifteen years after the Niordson's paper, a study by Kornecki [9] on flow-induced vibrations of plates appeared, followed by the papers of Brazier–Smith and Scott [6] and Crighton and Oswell [7] on the same topic. In these papers the plate displacement is supposed to satisfy the fourth-order linear partial differential equation governing the dynamics of transversely loaded thin elastic plate. In this connection, we would like to mention that in earlier papers Benjamin [3] and Landahl [11] consider the motion of fluid bounded by an initially flat infinite flexible surface. However, in the latter papers, the surface motion is supposed to be prescribed and a fluid motion, coupled to this given surface motion, is sought. In contrast, Brazier–Smith and Scott [6] and Crighton and Oswell [7] consider surface motion that is a solution of the differential equation