A study on the energy transfer of a square prism under fluid-elastic galloping

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Abstract

Extracting useful energy from flow induced vibrations has become a developing area of research in recent years. In this paper, we analyse power transfer of an elastically mounted body under the influence of fluid-elastic galloping. The system and the power transfer is analysed by numerically integrating the quasi-steady state model equations. The power transfer is analysed for both high ($Re = 22300$) and low ($Re = 200$) Reynolds numbers cases.

A combined mass-damping coefficient, Π_2, that can be derived from the equation of motion, is shown to be the parameter that governs power output. The system is a balance between the power delivered to the system due to fluid-dynamic forcing and power removed through mechanical damping which are governed by the fluid-dynamic forcing characteristics (i.e. the lift force as a function of incident angle) and mechanical damping coefficient respectively. Comparing the DNS results with the QSS data uncovered that a good agreement of the data could be obtained even at low Reynolds numbers when the inertia of the system (mass ratio) is substantially high.

Keywords:

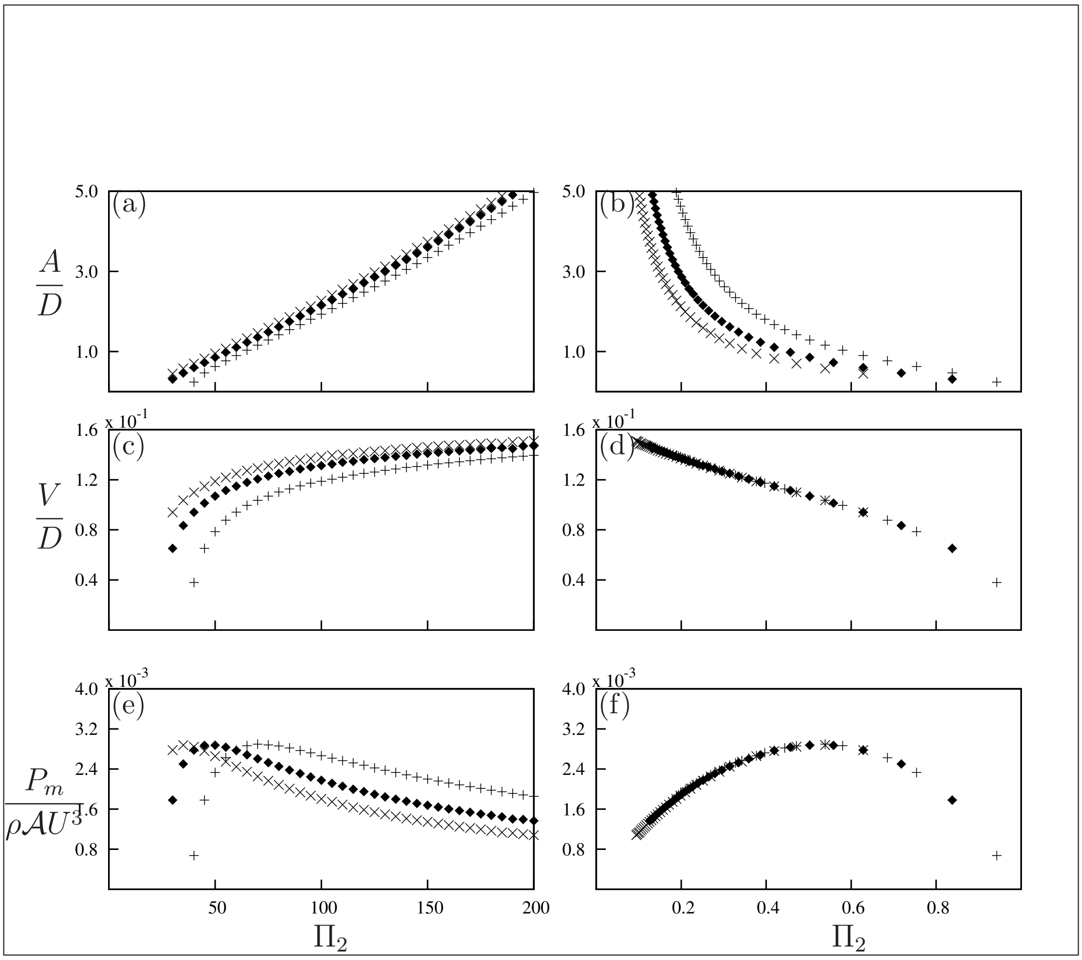

Figure 1: Comparison of the mean power data using different independent variables. (a) using classical VIV parameters U^* and ζ at $Re = 200$ and $m^* = 20$ at three different damping ratios: $\zeta = 0.075$ ($\times$), $\zeta = 0.1$ ($\blacklozenge$) and $\zeta = 0.15$ ($+$) and (b)the same data collapsed using Π_2 as the independent variable.

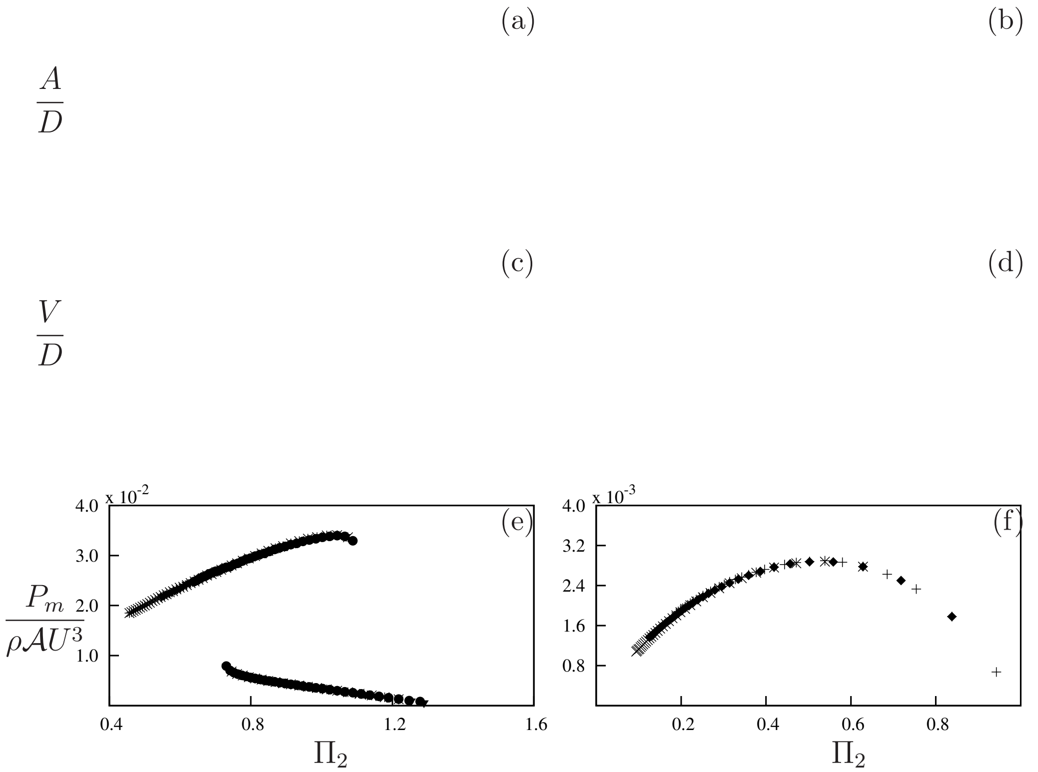

Figure 2: Displacement amplitude, velocity amplitude and mean power as functions of the mass-damping Π_2. Data presented in (a),(c) and (e) were calculated using input data at $Re = 22300$ obtained by Parkinson and Smith (1964) at three different damping ratios: $\zeta = 0.0125$ ($\ast$), $\zeta = 0.015$ ($\blacktriangledown$) and $\zeta = 0.0175$ ($\bullet$). Data presented in (b), (d) and (f) were obtained using input data at $Re = 200$ at three different damping ratios: $\zeta = 0.075$ ($\times$), $\zeta = 0.1$ ($\blacklozenge$) and $\zeta = 0.15$ ($+$). The collapsed data implies that there is no frequency selection and the tuning parameter of the mechanical side of the system is the damping constant to obtain an optimum power output.

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