SPECTRAL SIMULATIONS OF VOLCANIC ERUPTIONS AND TSUNAMI WAVES

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Vortex induced vibrations (VIV) of marine cables, usually termed strumming, increases fatigue due to the large hydrodynamic forces. VIV is a critical factor in the design of underwater cable systems, drilling risers, and offshore platforms. It is therefore important to understand and be able to predict from first principles the hydrodynamic forces and motion of cables and beams caused by flow induced vibrations. While there is a substantial data base for cable dynamics derived from field experiments (see [1] and references therein) there are very few laboratory experiments to study cable flows under controlled conditions. Simulations from first principles have only recently become possible [2].

In this paper we present a numerical study of flows past flexible cables and beams at lock-in and non-lock-in states. In particular, we are concentrating on the aspects of transition to turbulence in the wake and its effects on the motion of the structure. Transition to turbulence in the wake of a fixed cylinder occurs at Reynolds number between 250 and 400, as has been established by experimental results and our previous simulation studies. However, the transition process changes fundamentally if the cylinder is flexible and vibrates freely. In this numerical study, we consider flow past flexible beams and cables undergoing free oscillations subject to near lockin excitation. We investigate different vibrating conditions, corresponding to varying the bending stiffness (beams), tension (cables) and the mass ratio parameter, in order to determine the new transition mechanisms. In general, cables tend to promote wake transition whereas beams tend to delay transition compared to the fixed cylinder behavior.

The simulations are based on a spectral element method reformulated in body-fitted coordinates for this problem [3]. The flow equations are the incompressible Navier-Stokes equations while the equation that describes the motion of the cable for free vibrations is the wave equation with a forcing term due to the fluid forces on the cable. The three-dimensional Navier-Stokes equations are solved using a parallel spectral element/Fourier method. Spectral elements are used to discretize the x-y planes, while a Fourier expansion is used in the z-direction, i.e. along the cable. Each Fourier mode is assigned to a separate processor allowing efficient parallel computation. Typically, more than one million degrees of freedom are employed with 128 nodes along the cable axis.

References

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