Investigation of flow around moving bluff bodies by Viscous Cell Boundary element method (full model) and by Reduced Models for Statistically Stationary and Non-stationary flows

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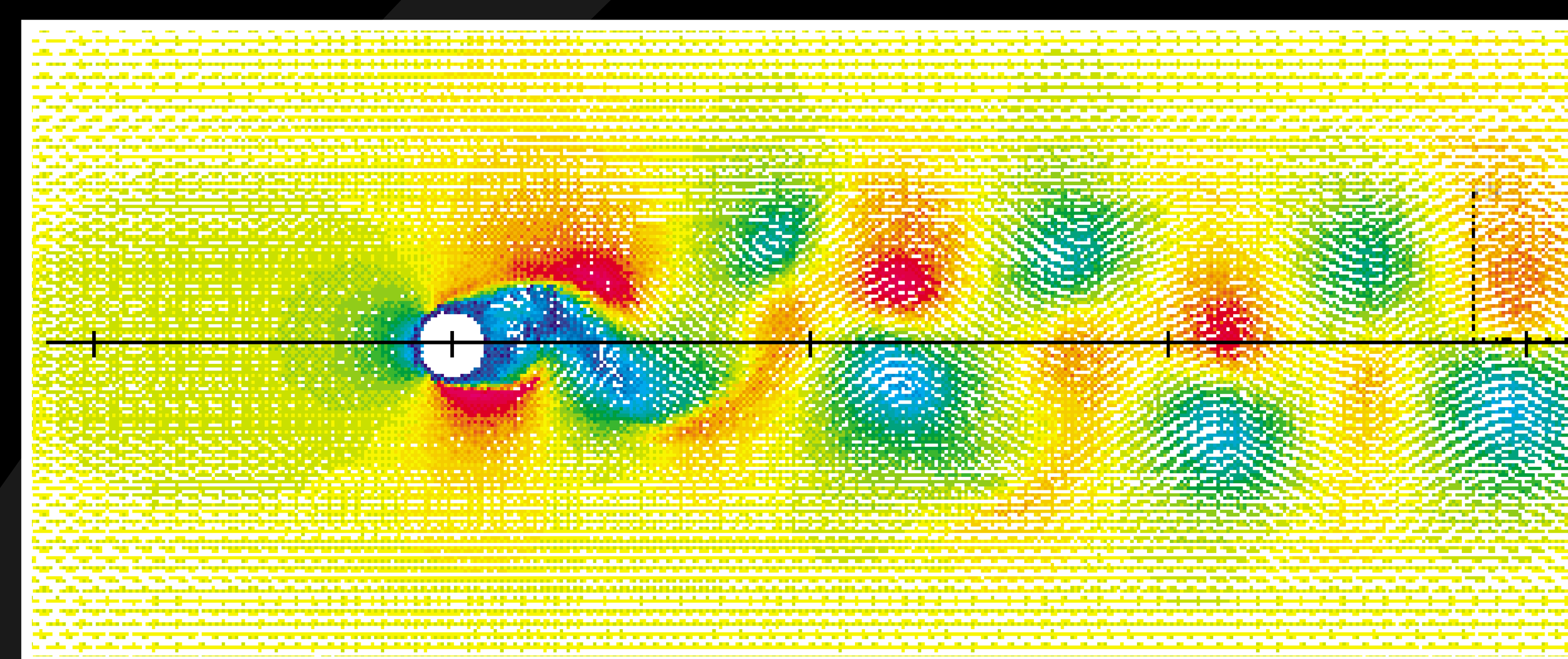
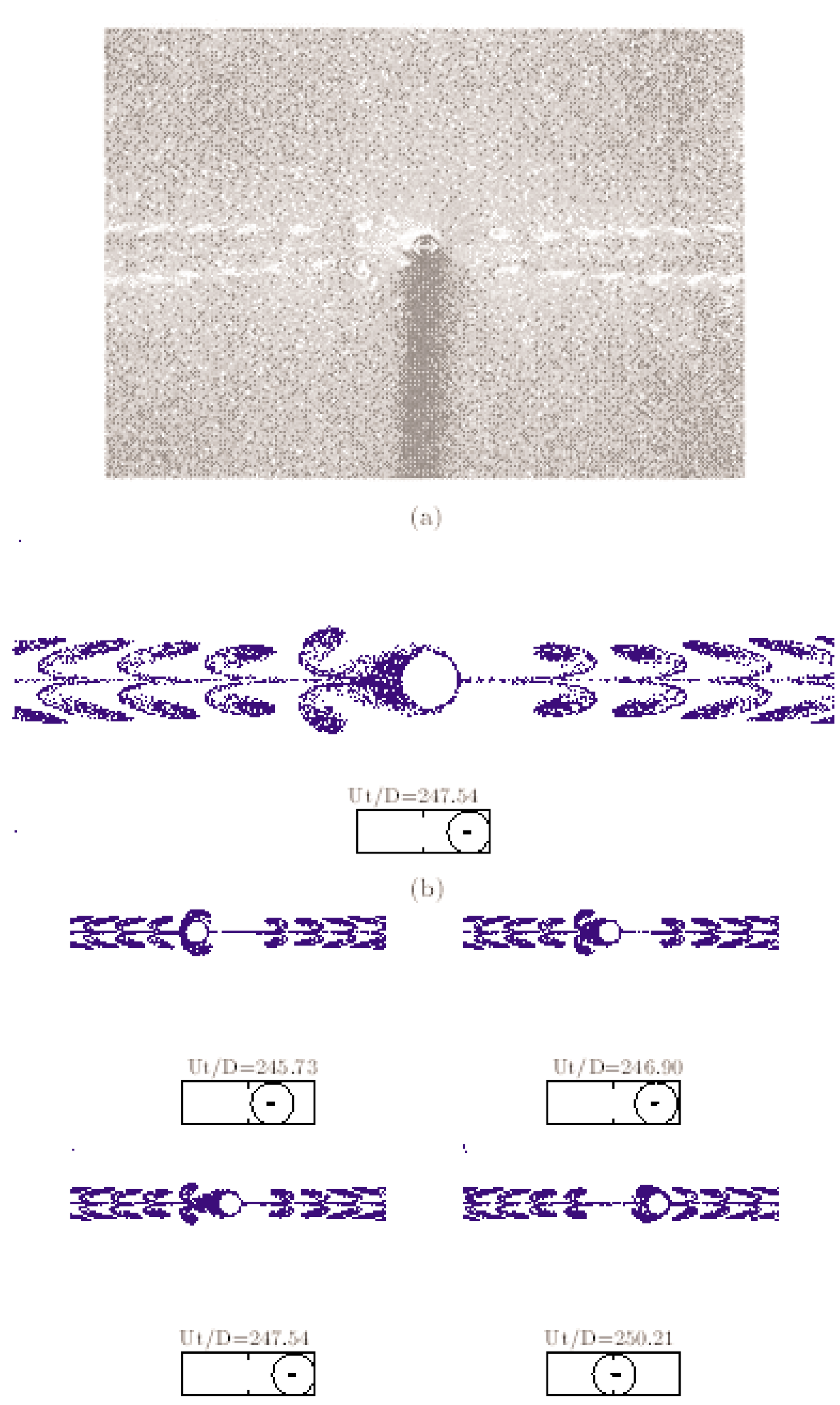
Validation of Viscous Cell Boundary Element Method

Fluid forces arising from transversely oscillating circular cylinders in fluid at rest are studied by numerical solution of the two-dimensional unsteady incompressible Navier-Stokes equations defined by a primitive--variable formulation. A validated cell viscous boundary element scheme developed by the authors is used in the numerical computations. In this scheme, a hybrid approach is adopted utilising boundary element and finite element methods.



Cell equations are generated using the principles of boundary element theory and the global equations are derived following the procedures of finite element methods. Flow characteristics are presented in terms of the key parameters of Reynolds number and Keulegan--Carpenter number. Drag and added-mass coefficients are calculated using the approach of Morison applied to the in-line force history.
Overall numerical simulation comparable with the visualization in; Numerical simulation at different stages over a half cycle illustrating the vortex mechanism and shedding.



[redacted] (a) Flow visualization of the streakline pattern generated by a transversely oscillating circular cylinder at $Re = 81.4$, $KC = 11.0$ in two-dimensional flow regime A as observed by Tatsuno & Bearman (1990); (b) overall numerical simulation comparable with the visualization in (a); (c) numerical simulation at different stages over a half cycle illustrating the vortex mechanism and shedding.

Flow visualization of the streakline pattern generated by a transversely oscillating circular cylinder at Re=81.4, KC=11.0 in two-dimensional flow regime A as observed by Tatsuno & Bearman (1990);

Reduced Models for Statistically Stationary and Non-stationary flows

Objective of present study is to produce reduced flow models founded on an empirical basis spanning the large components of the flow and to use these models in the feedback flow control.
For a prescribe flow conditions, a basis is created by developing proper orthogonal decomposition method (POD) for statistically stationary data. Statistical properties of the flow forced by a time-dependent control can be non-stationary. Therefore POD was extended by Glezer, Kadioglu and Pearlstein for non-stationary flow fields. Extended proper orthogonal decomposition method with approximation to the original eigenmodes and POD are investigated in order to derive a reasonable approximation to the flow. The genesis of this work is based on an earlier study by the authors in their investigation of fluid flow regimes around an oscillating cylinder.
The proposed paper describes a study of the wake structures and flow dynamics associated with simulated two-dimensional flows past a circular cylinder of diameter D in harmonic cross-flow oscillations. The flow is examined for Re=500 and for a fixed motion amplitude of ymax/D=0.25. preliminary results are presented for POD, EPOD and ensemble average POD. Investigation is underway for approximate POD.
An Adjoint Formulation For Flow Control is also investigated.
The Lagrange multiplier method or adjoint method is particularly interesting because of its practicality for problems with many design variables. The adjoint method is based on the variation analysis of the Lagrangian. An optimality of the coupled systems of equations and their boundary conditions which are state and costate (adjoint. virtual, imaginary or pseudoproblem) equations must be analyzed. If we have k design variables and n state variables, it is inefficient to compute this matrix directly. The idea behind this approach is to avoid this computation.

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