



Potential Flow in Flapping Wing Aerodynamics

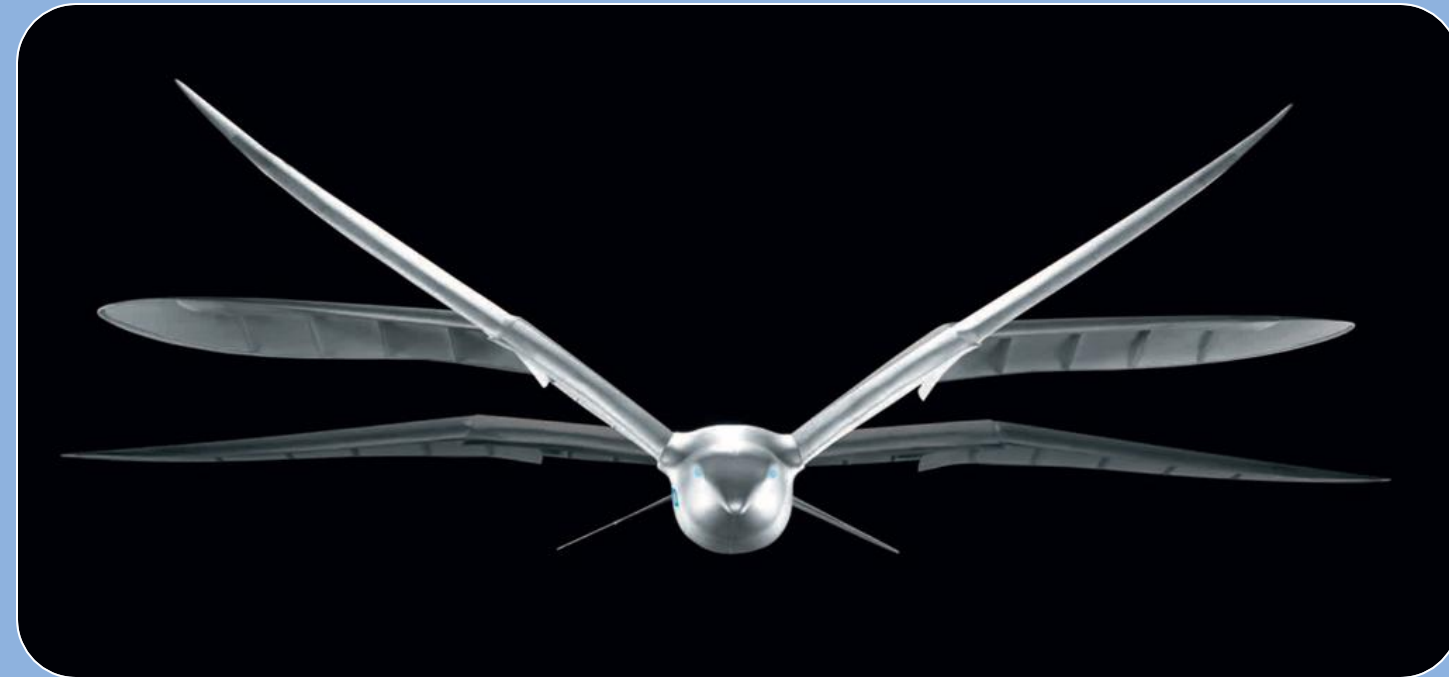
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Introduction

- Micro Air Vehicles are increasing in popularity.
- Bird flight involves complex wing structures, kinematics and aerodynamics.
- The aim is to develop a low-fidelity, cheap and easy-to-use model.
- The objective is to study its limitations & how well it agrees with complex high-fidelity methods such as N-S solvers.



Methods

- Numerical Panel Methods.
- Linearly varying vortex strengths are applied at each panel endpoint.
- Discrete vortices represent the wake.
- Calculations are in local reference frame.
- Time stepping model is implemented.
- The series of linear simultaneous equations are then solved.
- Kutta condition ensures flow leaves smoothly along trailing edge.
- Wake strength and position are determined at each time step.

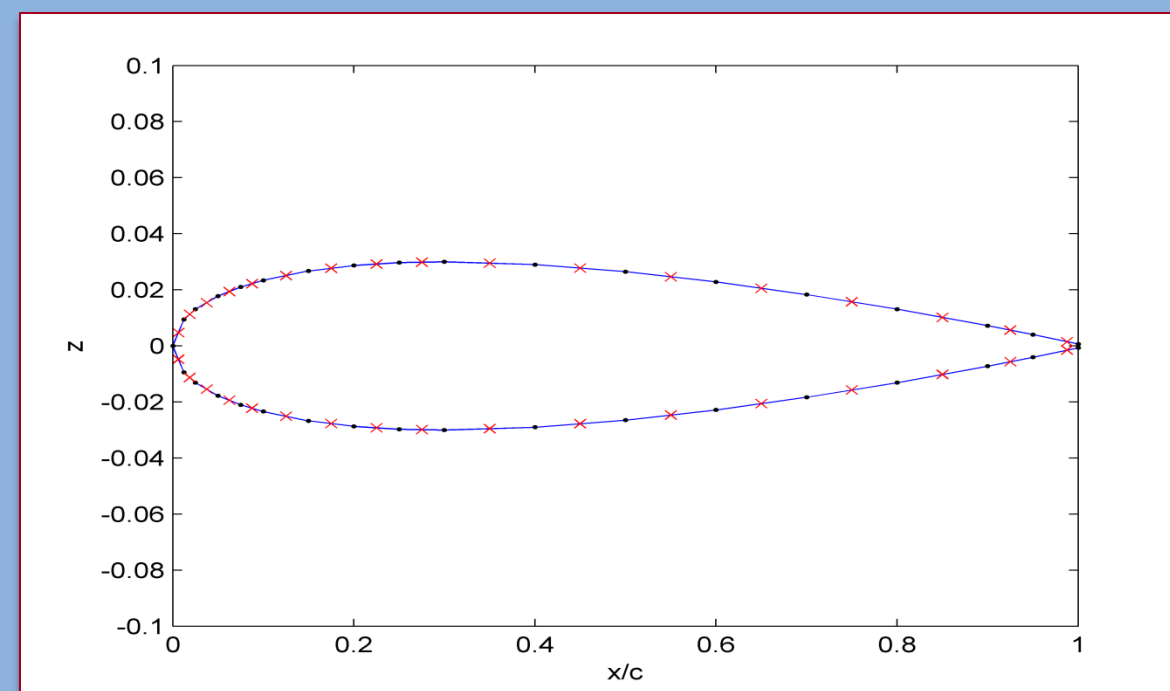


Fig.1 NACA 0006 airfoil discretized into panels, the black dots represent the panel endpoints and the red cross represents the control points.

Results

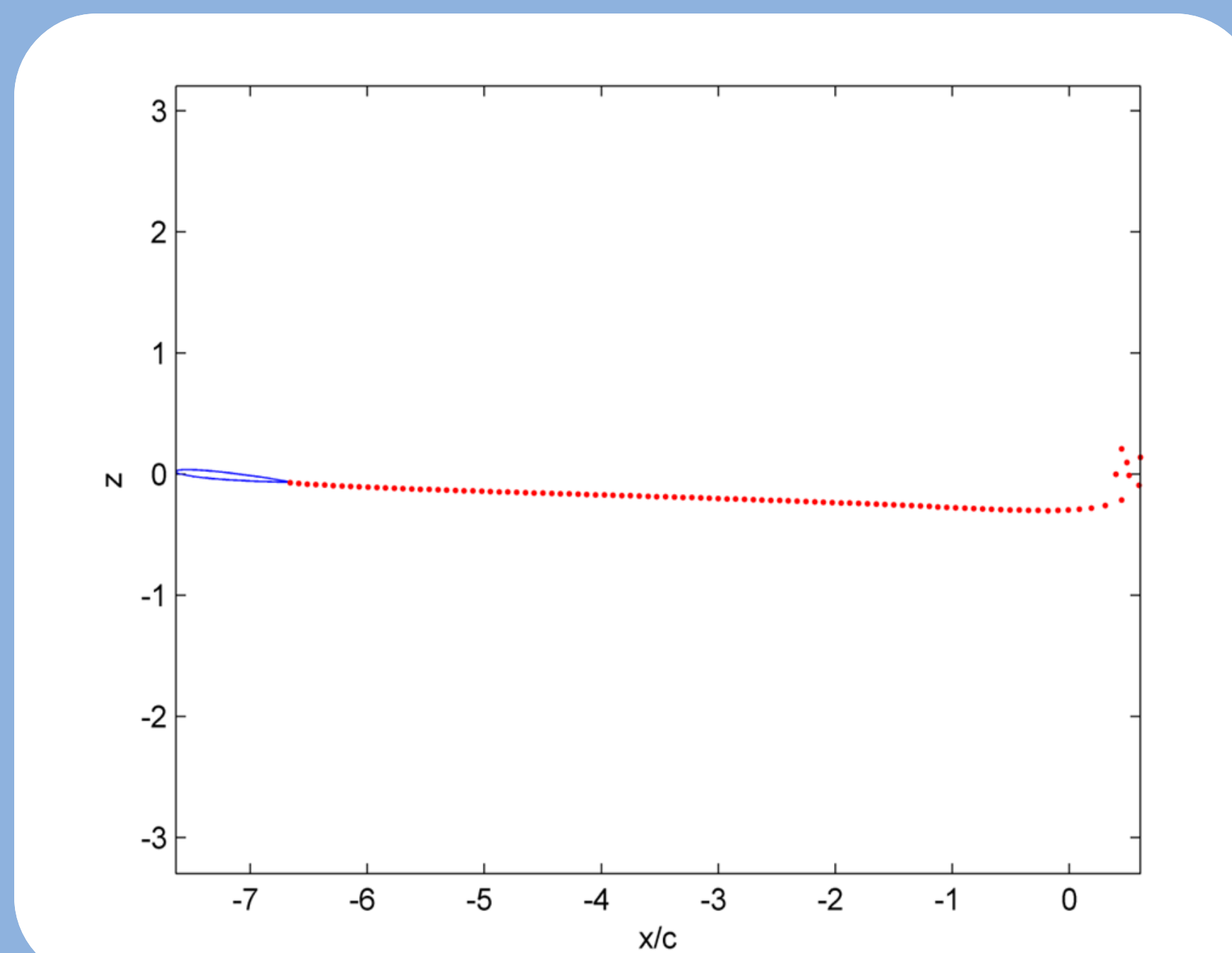


Fig.2 The airfoil undergoes a sudden motion from rest and moves to the left in the x-direction. The wake rollup can be observed as it trails behind the airfoil.

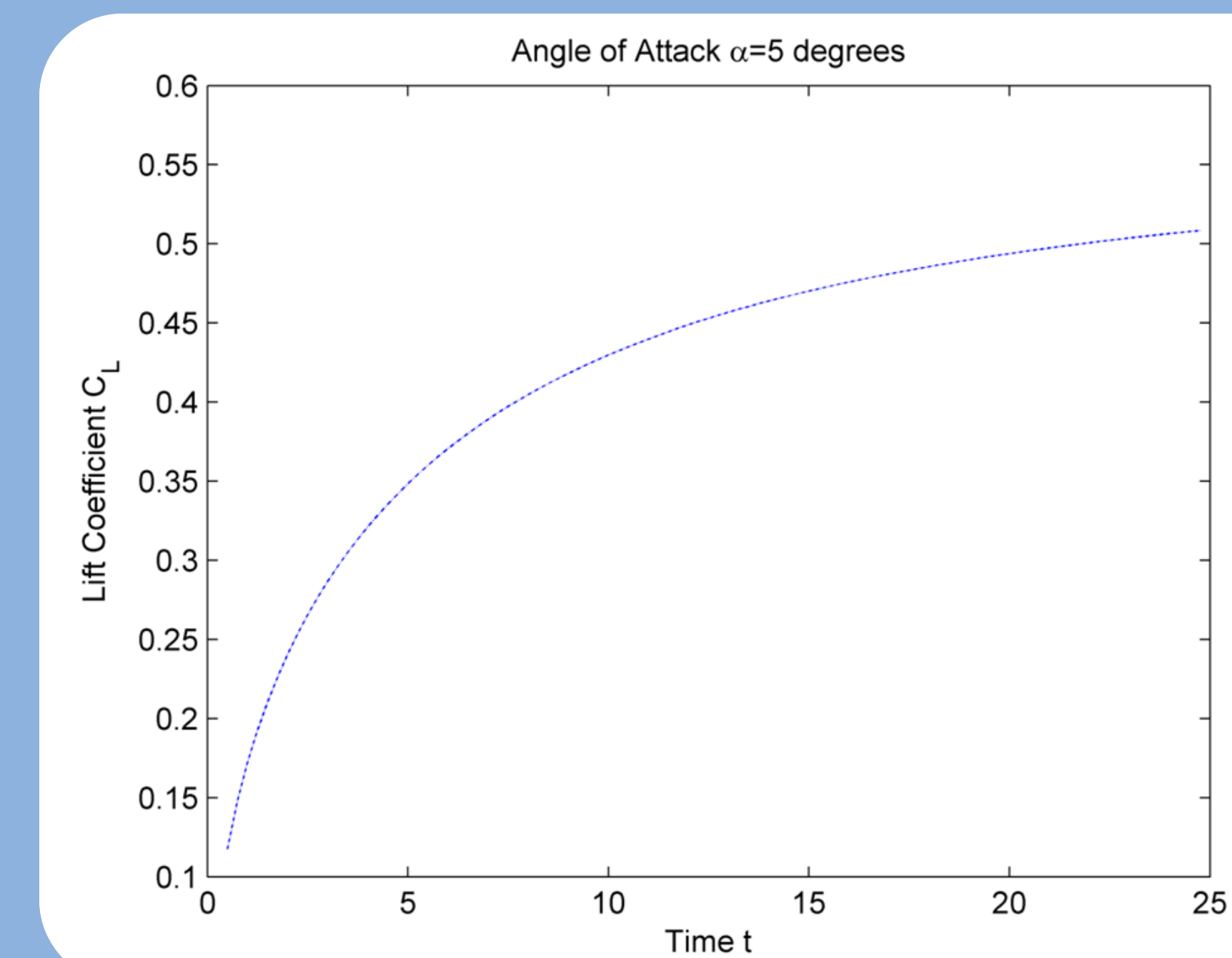


Fig.3 The lift coefficient is given versus time, as the airfoil speeds up from rest the lift coefficient reaches its asymptotic value.

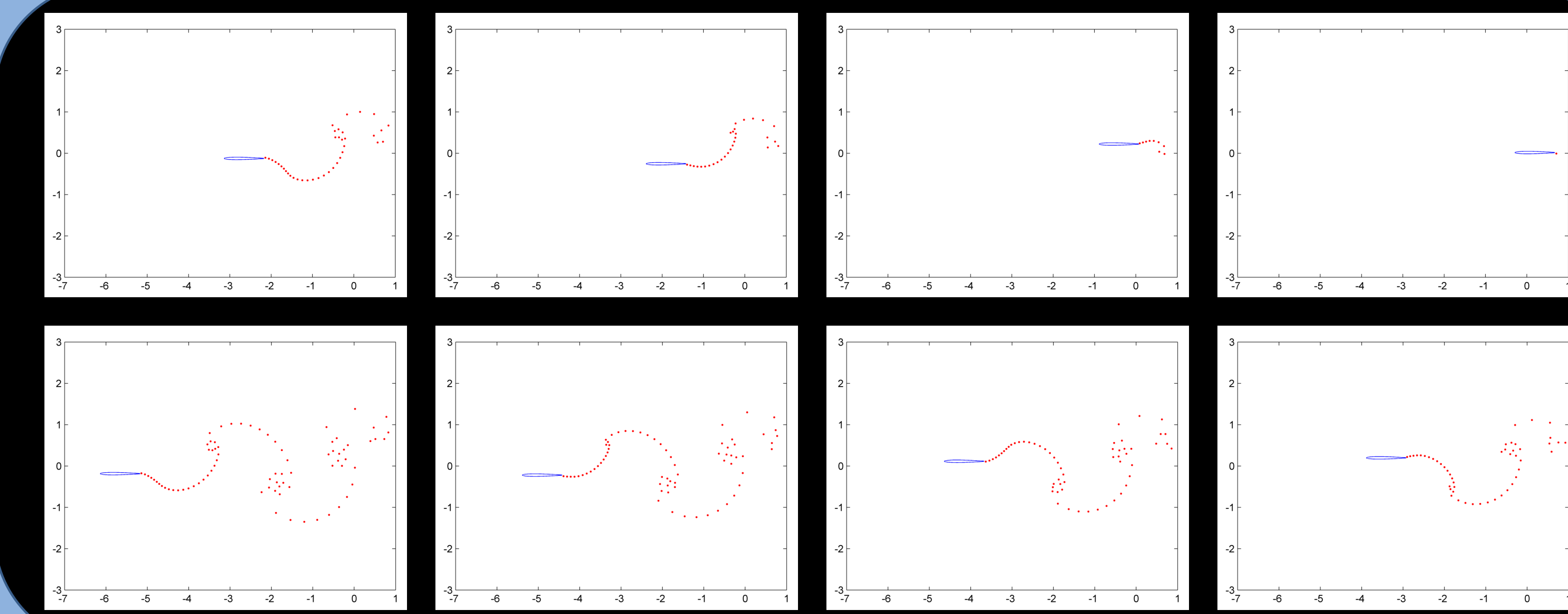


Fig.4 The sequence of plots, going top to bottom from left to right, shows the airfoil moving to the left in the x-direction and undergoing a sinusoidal motion in the z-direction. The wake rollup similar to the Von-Karman vortex shedding pattern is observed.

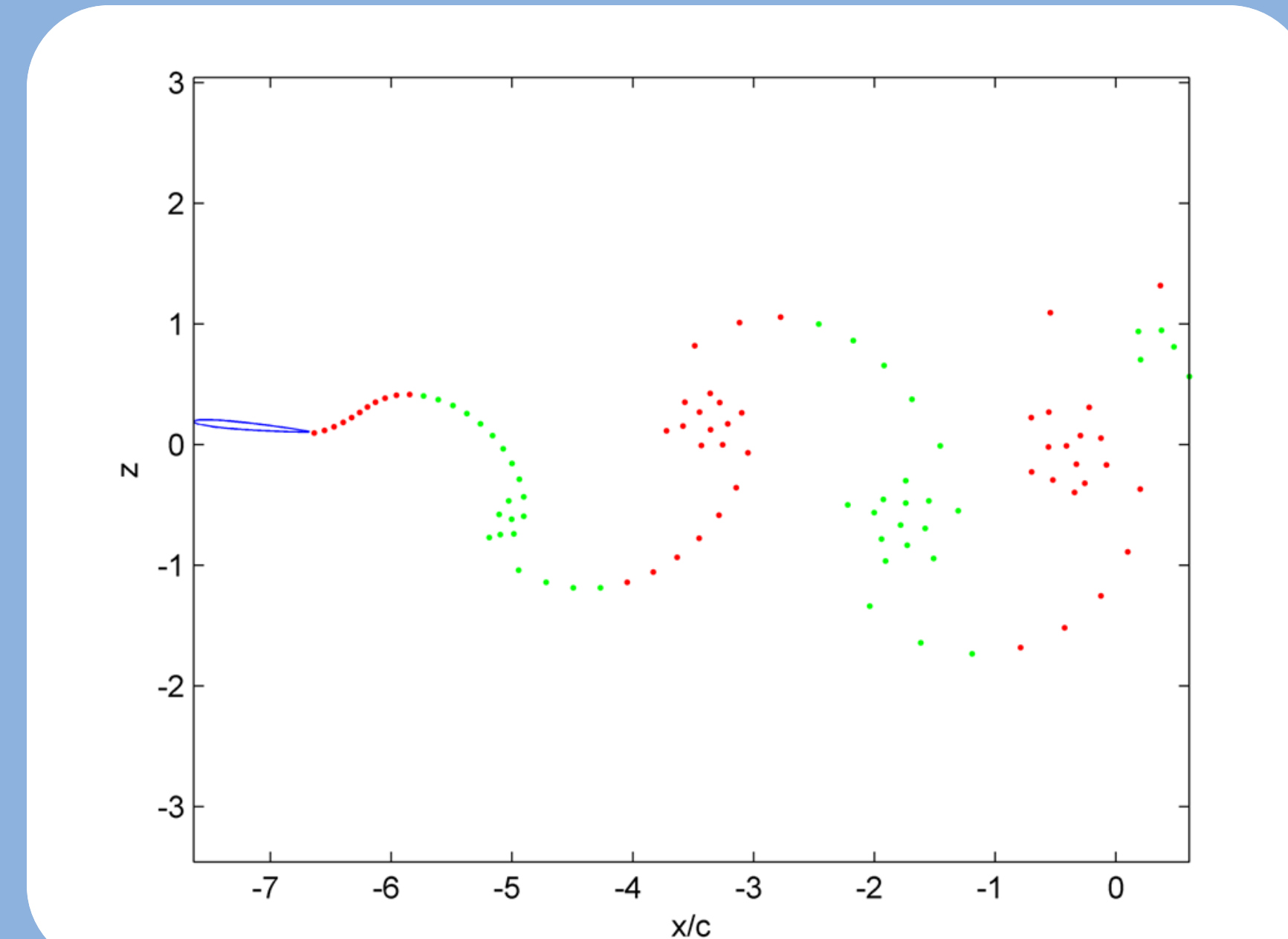


Fig.5 The airfoil moves to the left in the x-direction and undergoes a sinusoidal motion in the z-direction. The wake rollup is observed, red wake particles indicate negative circulation and green indicates positive circulation.

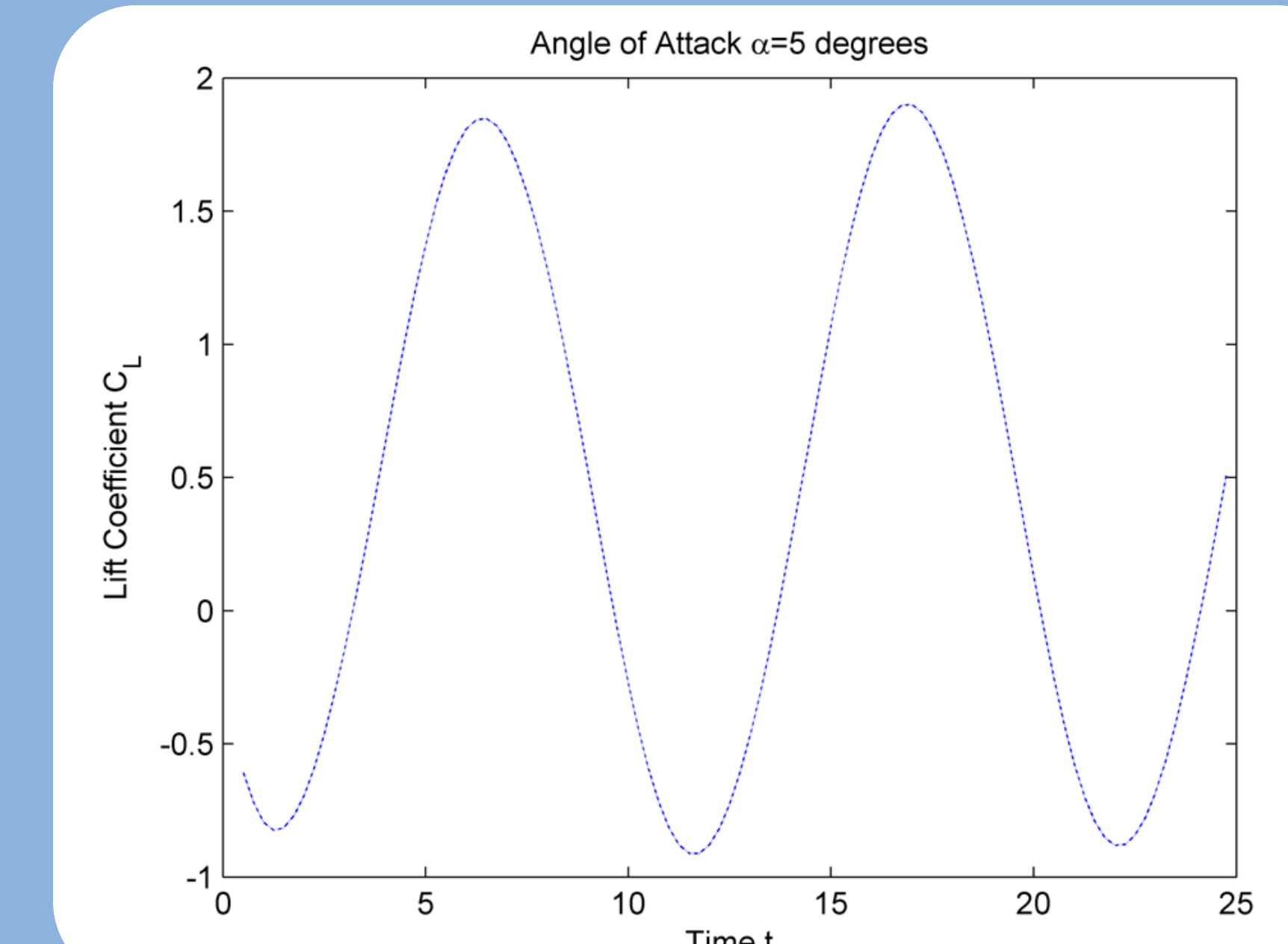


Fig.6 The lift coefficient undergoes a sinusoidal variation versus time, the net lift every period is positive.

Conclusion

- Results are well approximated when little or no flow separation is present.
- Adverse pressure gradients point at area of possible flow separation.
- Forces are over predicted at high angles of attack due to assumption of fully attached flow.
- Unsteady Panel Methods provide a promising low-fidelity model.
- Future work includes extending the model to 3D.

References

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