SDPMflut: an open-source unsteady Source and Doublet Panel method for flutter analysis

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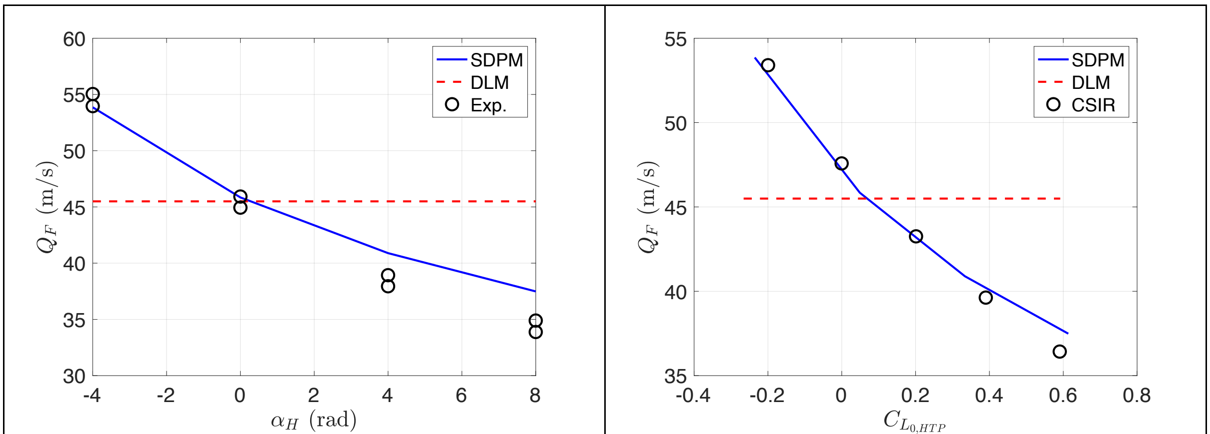
1. Introduction

Linearized subsonic aeroelastic analysis is routinely carried out using the Doublet Lattice Method (Albano and Rodden, 1969; Kalman et al., 1971) or the ZONA51/6 (Chen et al., 1993; Liu et al., 1996) solvers. The DLM idealizes both wing and fuselage geometries as flat while the ZONA solvers model wings as flat with doublet panels and non-lifting bodies as thick with source panels. In contrast, the Source and Doublet Panel Method (SDPM) formulated by Morino (1974) models the exact geometry of both lifting and non-lifting bodies using source and doublet panels. Sánchez Martínez and Dimitriadis (2022) improved the SDPM by including a nonlinear pressure coefficient calculation and a zero normal flux boundary condition. Furthermore, Dimitriadis et al (2025a) adapted the method to flutter calculations and Dimitriadis et al (2025b) developed a transonic correction technique for the SDPM.

2. SDPMflut

SDPMflut (https://aeroconsult.gr/sdpmflut-software/) is an open-source Python code for unsteady aerodynamic and aeroelastic analysis of complete aircraft geometries using the SDPM. It has been validated on numerous experimental test cases and the release includes the validation test cases. The software also includes the quadratic DLM (Giesing et al 1971) for comparison purposes. As an example, figure 1 plots the flutter predictions of the SDPM and DLM for the Van Zyl T-tail (Van-Zyl and Mathews 2011), demonstrating that, unlike the DLM, the SDPM can predict the sensitivity of the flutter speed to the horizontal stabilizer incidence without any modifications.

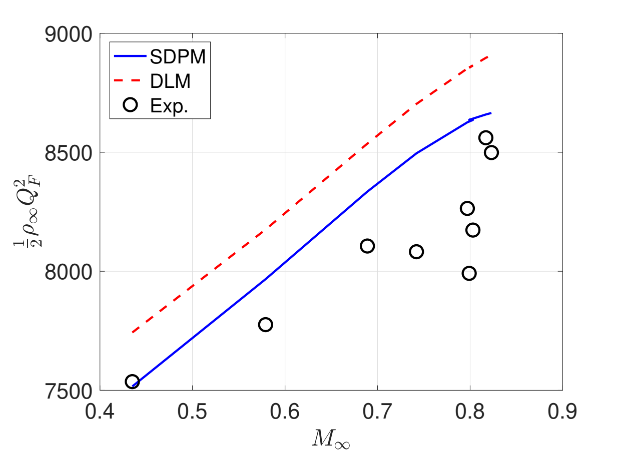


(a) Flutter speed variation with horizontal stabilizer incidence.

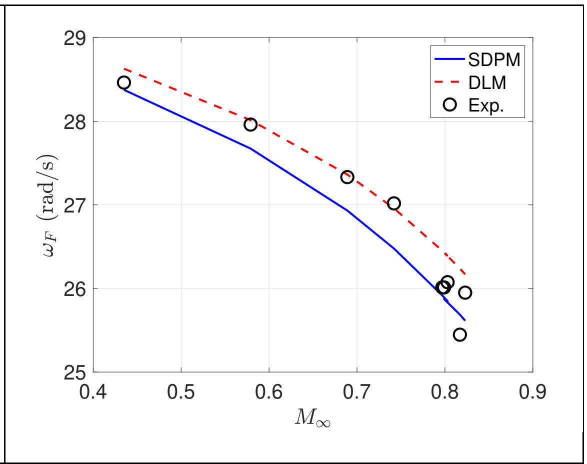
(b) Flutter speed variation with steady horizontal stabilizer lift.

Figure 1: Flutter predictions by the SDPM and DLM for the Van Zyl T-tail

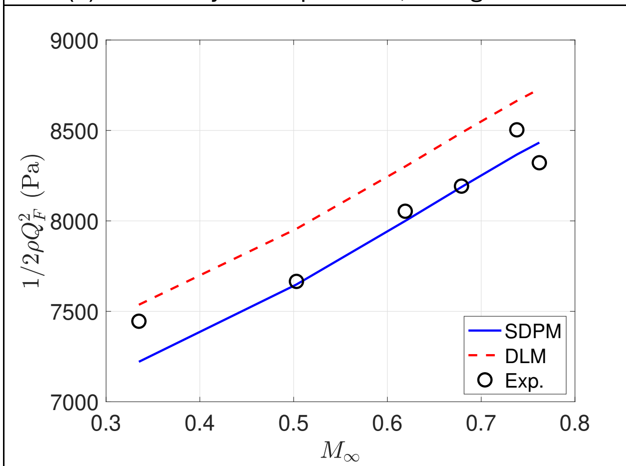
Figure 2 compares the SDPM and DLM flutter predictions obtained for the BSCW test case (Bennett 2000). It can be seen that the SDPM flutter airspeed predictions lie systematically closer to the experimental measurements that were carried out in both air and R-12 gas.



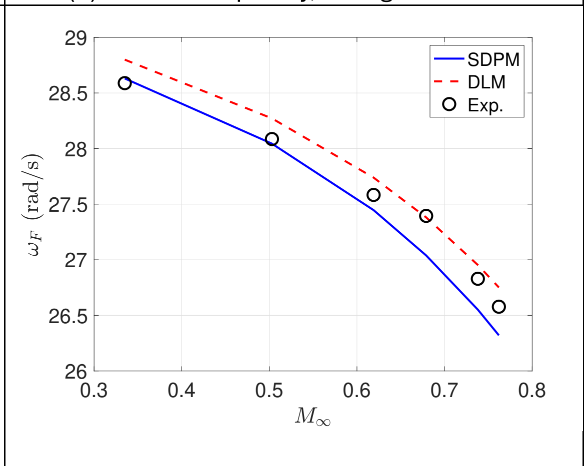
(a) Flutter dynamic pressure, R-12 gas



(b) Flutter frequency, R-12 gas



(c) Flutter dynamic pressure, air



(d) Flutter frequency, air

Figure 2: Flutter predictions by the SDPM and DLM for the BSCW wing

The full paper will include more information on the underlying theory of SDPMflut and describe in detail its capabilities. It will also include information on importing structural models and several additional validation test cases.

3. References

Albano, E., Rodden, W.P., 1969. A doublet-lattice method for calculating lift distributions on oscillating surfaces in subsonic flows. AIAA Journal 7, 279–285.

Chen, P.C., Lee, H.W., Liu, D.D., 1993. Unsteady subsonic aerodynamics for bodies and wings with external stores including wake effect. Journal of Aircraft 30, 618–628.

Bennett, R.M., 2000. Test cases for a rectangular supercritical wing undergoing pitching oscillations, in: Ruiz-Calavera, L.P. (Ed.), Verification and Validation Data for Computational Unsteady Aerodynamics. Research and Technology Organization North Atlantic Treaty Organization, Neuilly-sur-Seine, France. RTO-TR-26.

Dimitriadis, G., Kilimtzidis, S., Kostopoulos, V., Laraspata, V., Soria, L., 2025a. Flutter calculations using the unsteady source and doublet panel method. Journal of Aircraft 62, 117–131.

Dimitriadis, G., Crovato, A., Sánchez Martínez, M., Laraspata, V., Soria, L., Kilimtzidis, S., Kostopoulos, V., 2025b. Transonic corrections for the unsteady compressible source and doublet panel method. Journal of Aircraft 62.

Giesing, J.P., Kalman, T.P., Rodden, W.P., 1971. Subsonic unsteady aerodynamics for general configurations. Part I, Volume I - direct application of the nonplanar Doublet-Lattice Method. Technical Report AFFDL-TR-78-194-PT-1. Air Force Flight Dynamics Laboratory.

Kalman, T.P., Rodden, W.P., Giesing, J.P., 1971. Application of the doublet lattice method to nonplanar configurations in subsonic flow. AIAA Journal 8, 406–413.

Liu, D.D., Chen, P.C., Yao, Z.X., Sarhaddi, D., 1996. Recent advances in lifting surface methods. Aeronautical journal 10, 327–339.

Morino, L., 1974. A general theory of unsteady compressible potential aerodynamics. Contractor Report CR-2464. NASA.

Sánchez Martínez, M., Dimitriadis, G., 2022. Subsonic source and doublet panel methods. Journal of Fluids and Structures 113, 103624.

van Zyl, L., Mathews, E.H., 2011. Aeroelastic analysis of t-tails using an enhanced doublet lattice method. Journal of Aircraft 48, 823–831.