Unsteady forces on impulsively-started plates

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The flow around impulsively accelerated plates is experimentally investigated using force measurements, in order to better understand how geometry affects the unsteady and transient drag forces. A wide variety of plate geometries, including circles, square, triangles, as well as fractal plates, are investigated at $\mathrm{Re} = 27,000$. A new scaling for peak unsteady forces is proposed. While peak forces may scale with the square root of acceleration for circular and square plates accelerating fast enough, such a relationship breaks down for more complex plates, such as triangles and fractals. Shape is shown to affect the peak force, as well as the transient forces once the plate moves at constant velocity. Forces on a circular plate have large oscillations as they slowly converge to steady values, whereas forces on non-convex plates converge quickly to steady values.

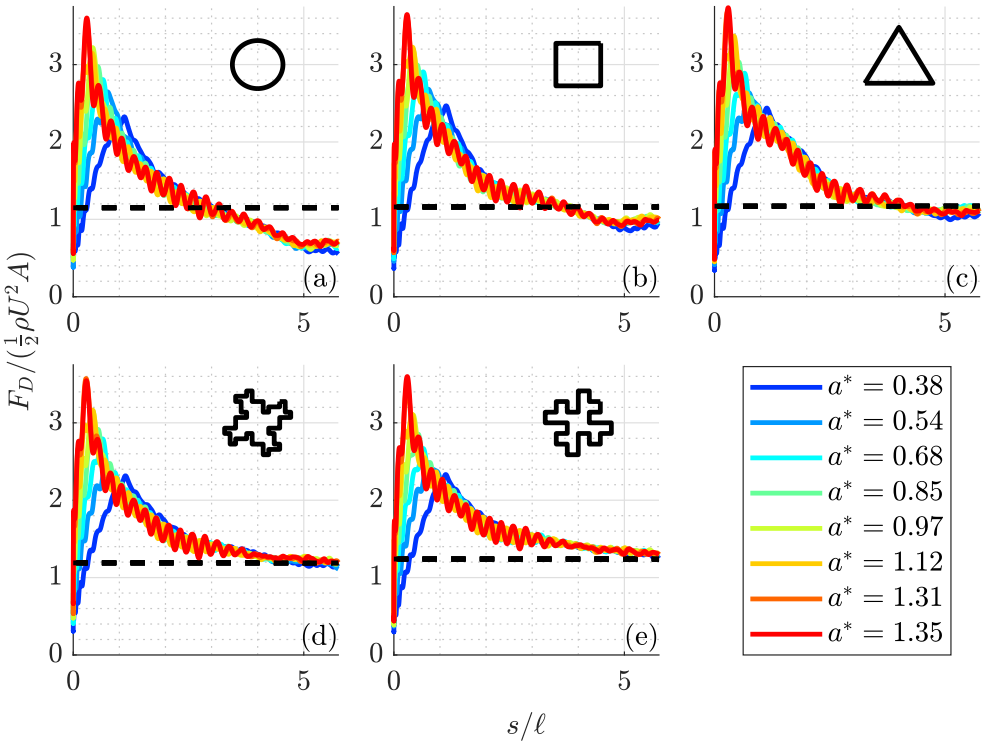

Figure 1: Non-dimensionalized total drag forces on each plate: a) circle, b) square, c) triangle, d) $D_f = 1.3(2)$, e) $D_f = 1.5(1)$. Colours represent different non-dimensional acceleration rates $a^* = a\ell/U^2$. Dashed line represents expected steady drag coefficient for each plate geometry.

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