# ON THE BASE PRESSURE OF 3D TURBULENT BLUFF BODY WAKES WITH SHARP SEPARATION

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*Abstract* Particle Image Velocimetry (PIV) and pressure measurements are used to study the turbulent wake of Ahmed bluff body. A cavity on the base is created to control the base pressure and modify the recirculating bubble and its equilibrium.

Turbulent wakes of 3D bluff bodies involve a massive unsteady and complex separated region also named recirculating bubble. The base suction in this zone is the main source of the drag force and an increase of the base pressure leads to a drag reduction. However, the base pressure origin of the separated region still remains poorly understood. It depends on many different contributions such as the fully turbulent mixing layers that develop after the boundary layers separations and the large scale turbulent dynamics in the recirculating bubble. This dynamics has been very recently shown to be multi-modal depending on the symmetries of the body geometry (see [1] and [3] for axisymetric blunt body, [2] for parallelepiped body and [4] for a sphere).

The fundamental interest of this work is to better understand the base suction origin. Our strategy is to modify the turbulent dynamics of the recirculating bubble without changing either the body geometry or the separation condition. This is realized passively by producing a cavity of various depths $L_c$ at the body base (see fig. 1a). For this study, we have chosen the square-back Ahmed body as in [2] which exhibits a bi-modal behavior, consequence of a random switching of two Reflectional Symmetry Breaking (RSB) modes. The flow is investigated using PIV measurements, time resolved pressure distribution at the body base, complete aerodynamic forces and moments measurements. The body is placed in a closed loop wind tunnel with a $3/4$ open air jet test section. Velocity range is $[20 - 60]\ m/s$ corresponding to Reynolds numbers based on the body height $H$ ranging from $4.10^5$ to $1,2.10^6$. All quantities marked with an asterisk have been non dimensionalized using $H$ and $U$.

The parametric study of the cavity depth $L_c$ with the measurements of the mean fluid force reveals a strong base pressure increase or equivalently a substantial drag reduction while the geometry at separations remains identical. A case of optimal drag reduction is observed for $L_c^* = 0.2$ with $8\%$ drag reduction compared to that of the natural case with $L_c^* = 0$.The cavity effect (base pressure increase due to cavity depth) is also associated to the disappearance of the bi-modal behavior (fig. 1b), an elongation of the recirculating bubble length (fig. 1a), an intensification of the backward flow in the bubble and a decrease of the vertical velocity component $Uz^*$ in the recirculating bubble as show on fig. 1(c) and fig. 1(d). This velocity component corresponds to the entrainment velocity at the inner edge of the fully turbulent mixing layers.

All these observation show a plausible mechanism explaining the base pressure increase. This mechanism is based on a recirculating bubble equilibrium involving a modification of the turbulent mixing layer entrainment velocity and also a recirculating bubble replenishment due to the back flow.

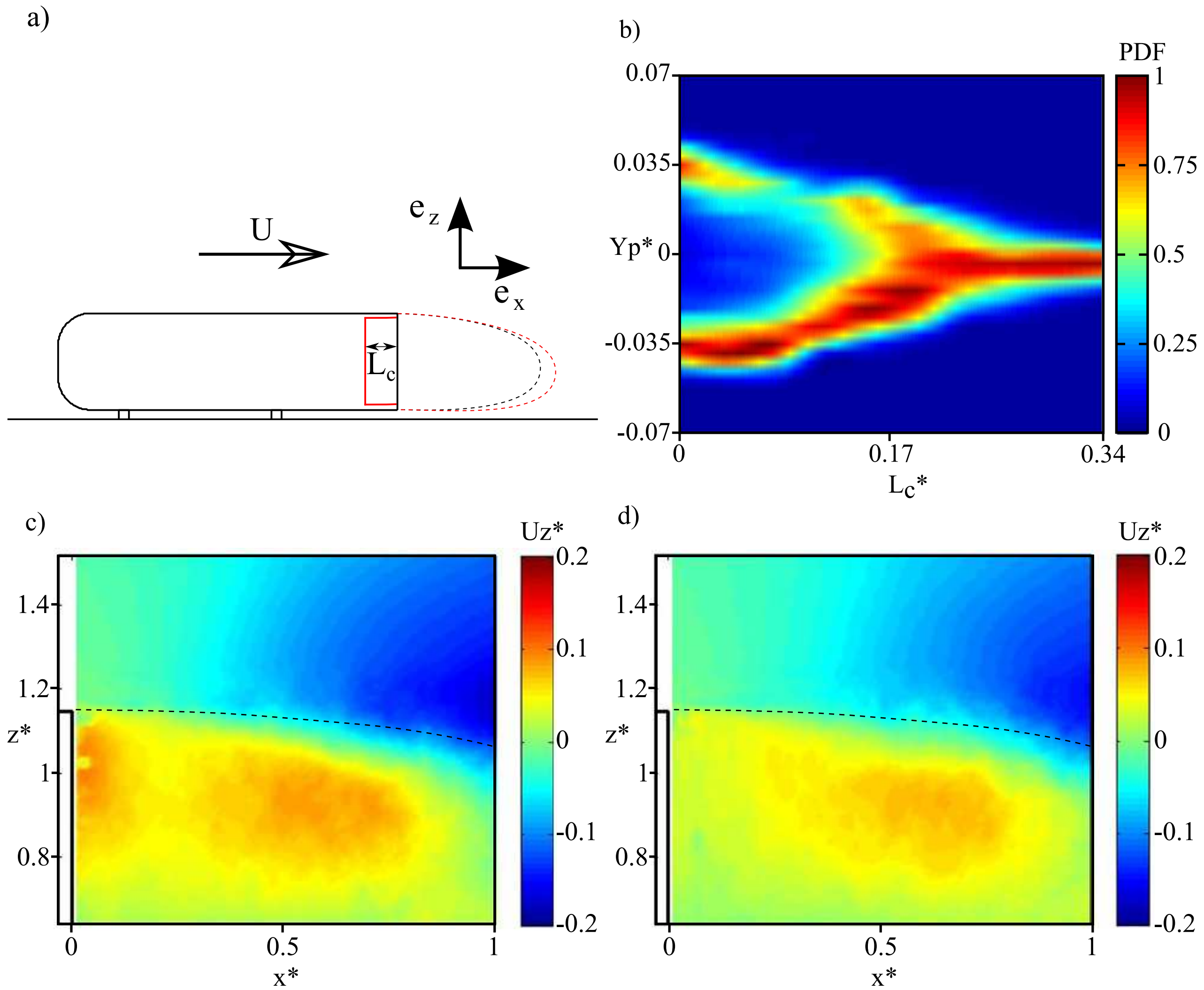


**Figure 1.** (a), Body and cavity geometry for two cases of typical depths ($L_c^* = 0$, black and $L_c^* = 0.3$, red), the dashed lines represent the recirculating bubble limit deduced from PIV measurements, colors correspond to the cavity configuration. (b) Probability density function of the horizontal low pressure minimum position at the body base. The two most probable positions $y_p^* = \pm 0.035$ at $L_c^* = 0$ indicate the bi-stable regime between the two $RSB$ modes. (c-d) Vertical velocity component $Uz^*$ showing the entrainment due to the mixing layer growth for (c) the natural $L_c^* = 0$ and (d) with a cavity depth of $L_c^* = 0.3$. The dashed lines are the boundaries of the recirculating bubble.

## References


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