PhD proposal (F/M)

Title	Influence of slip conditions on a bluff-body wake: application to space debris re-entry.	
Duration	3 years, full time, starting late 2019 ï early 2020	
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Location	ICARE (UPR 3021) 1C, avenue de la Recherche scientifique CS 50060 45071 - ORLEANS Cedex 2 FRANCE http://icare.cnrs.fr/ PRISME (UPRES 4229) 8 rue Léonard de Vinci 45072 Orléans Cedex 2 FRANCE http://www.univ-orleans.fr/fr/prisme	

Topic

Falling objects have attracted interest of the scientific community for centuries since there are involved in a wide range of applications encompassing seed dispersal, phase filtration or re-entry of space debris. Although interactions between falling bodies and the ambient fluid have been studied extensively in the past, a comprehensive understanding of the resulting trajectory is still lacking. This is particularly true when considering the case of debrisô re-entry where complex phenomena occur at the body surface coupled with large changes in ambient operating conditions as function of altitude. This makes the prediction of the falling trajectories a challenging issue with significant risk for populationsô safety. This project aims at bringing new insights to improve the trajectory prediction of space debris re-entry by focusing on the effect of slippage. This phenomenon appears when the local velocity of the ambient fluid does not match that of the falling body inducing thereby a modification of the local skin friction. Very few studies have been devoted to the influence of slip conditions onto the properties of the wake (Legendre *et al.* 2009), which are cornerstones to predicting accurately the object motion during its fall.

To tackle this issue, different approaches will be coupled in an original way to better understand the role of slippage on the aerodynamic properties of space debris re-entry. To this end, a simple bluff-body will be used as a prototype geometry that will be implemented in several experimental facilities covering from continuous to rarefied regimes in order to mimic various phases of re-entry. Taking benefit of the experimental aerospace platform of the Orléansô campus, this project targets the influence of slippage at low Reynolds numbers but for an extremely large range of Mach/Knudsen numbers for the compressible case, and Froude/slip-to-roughness-height ratios for the incompressible case.

The roadmap of the PhD thesis is organized around three main complementary parts, briefly outlined in the following.

1. The first part of the PhD considers an extensive experimental campaign to study the influence of wall slippage in supersonic and hypersonic rarefied flow conditions (Lago *et al.* 2014; Joussot *et al.* 2015). By varying control parameters such as the Knudsen number or the Reynolds number, the dependency between the integral aerodynamic coefficients and the slip will be inferred over a wide range of operating conditions.
2. The second part of the PhD will complement the first part by providing a detailed investigation of the bluff-body wake in presence of slip conditions. To this end, experiments will be performed in subsonic regimes (PRISME) where slippage will be induced by employing specific surface coating (Castagna *et al.* 2018) in presence or not of density stratifications (Lam *et al.* 2019). Experimental techniques such as High-Speed Particles Image Velocimetry (HS-PIV) or Schlieren photography will be deployed to analyze the flow field as well as the loads experienced by the body.
3. The last part of the PhD will be dedicated to the physical modeling of the slippage effect taking benefit of the large database gathered during the previous parts. Stability analyses will be performed to predict the wake instability. In particular, the role of the Knudsen number (Legendre *et al.* 2009) on the wake properties will be emphasized.

Conditions

The experimental platform on which experiments will be conducted combines ICARE and PRISME laboratories, both involved in this project. These laboratories have renowned expertise in aerospace science. PRISME laboratory (http://www.univ-orleans.fr/fr/prisme) conducts fundamental research activities on the physics and the control of separated flows and wakes in subsonic regime (Castagna *et al.* 2018). ICARE laboratory (http://icare.cnrs.fr/) has long standing experience in the study of aerodynamics in rarefied supersonic and hypersonic conditions (Joussot *et al.* 2015; Coumar and Lago 2017). In particular, ICARE hosts the MARHy wind tunnel, a world-class facility dedicated to academic research on aerospace applications.

The hired PhD student will become a member within this consortium, which has a long term collaboration through the LabEx CAPRYSSES (http://caprysses.fr/home.html) also funding this PhD. The hired PhD student will share his/her time between ICARE and PRISME, both laboratories being located on the Orléans campus.

The PhD student will be co-supervised by **Dr. Viviana LAGO**, head of the FAST team (ICARE), and by **Dr. Nicolas MAZELLIER**, associate professor (PRISME).

Bibliography

Legendre, D., Lauga, E., & Magnaudet, J. (2009). Influence of slip on the dynamics of two-dimensional wakes. *Journal of fluid mechanics*, 633, 437-447.

Castagna, M., Mazellier, N., & Kourta, A. (2018). Wake of super-hydrophobic falling spheres: influence of the air layer deformation. *Journal of Fluid Mechanics*, 850, 646-673.

Lam, T., Vincent, L., & Kanso, E. (2019). *Passive flight in density-stratified fluids*. Journal of Fluid Mechanics, 860, 200-223.

Joussot, R., Lago, V., & Parisse, J. D. (2015). Quantification of the effect of surface heating on shock wave modification by a plasma actuator in a low-density supersonic flow over a flat plate. *Experiments in Fluids*, 56(5), 102.

Coumar, S., & Lago, V. (2017). Influence of Mach number and static pressure on plasma flow control of supersonic and rarefied flows around a sharp flat plate. *Experiments in Fluids*, 58(6), 74.

Expected skills

We are looking for a highly motivated PhD student (M/F), holding a Master degree in physics or engineering with strong background in fluid mechanics. The successful applicant should have a pronounced interest in experiments, measuring techniques and modeling. Experience using Matlab and/or Python is recommended. The PhD student will be deeply involved in dissemination of the results in project reports, peer-reviewed journals, and presentations in international conferences. Therefore, high capability of communication and writing in English are mandatory.

Salary

Gross salary: around ú20,220/year or ú24,296/year with teaching duty, both includes basic health insurance.

How to apply

Send your CV, motivation letter and the contact details of two referees before **01/11/2019** to viviana.lago@cnrs-orleans.fr & nicolas.mazellier@univ-orleans.fr.

Starting scheduled late 2019 - early 2020.