Postdoctoral Position

The Physics of Paragliding: Unsteady Flight Dynamics of Ram-Air Wings

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Location: Ecole Polytechnique, Palaiseau.

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We are seeking a highly motivated postdoctoral researcher to join a multidisciplinary project focused on understanding and improving the safety of flexible ram-air wings such as paragliders, paramotors, and modern parachutes.

Subject

This research addresses a timely and underexplored area in aviation: the dynamic behavior of soft, highly deformable wings during critical flight phases such as inflation, launch, rapid descent maneuvers, and turbulence-induced incidents. These aircraft, while lightweight and accessible, operate in regimes where fluid-structure interactions, unsteady flows, and pilot-induced dynamics play a major role in safety and performance. The evolution of modern parachutes toward more elongated and efficient profiles raise new challenges in stability and control—particularly as these systems begin to exhibit "paraglider-like" instabilities such as spiral dives or asymmetric collapses.

The project will be structured into three main axes. The first focuses on the physics of wing inflation and launch, using reduced-scale experiments to explore how an initially crumpled canopy fills with air and transitions into an effective lifting surface. This involves studying the influence of wing geometry, materials, and initial folding conditions, as well as environmental factors such as wind or slope. We have already demonstrated a universal launch trajectory and force threshold for successful inflation [1], and we now aim to refine this understanding using 3D-printed rigid wings and PIV (Particle Image Velocimetry) to dissect the flow fields and identify key mechanisms—such as starting vortices or added mass effects—that prevent stall despite extreme angles of attack (see Fig. 1a).

The second part of the project will investigate the spiral instability, a dangerous regime triggered during rapid descent maneuvers or after asymmetric wing collapses (see Fig. 1d). In some cases, the system enters a self-sustained spiral dive with high centrifugal loads, risking pilot unconsciousness and ground impact. Our goal is to develop both theoretical and numerical models of the coupled pilot-wing system in spiral flight, and to identify the structural parameters that promote or mitigate this instability. Preliminary results suggest that wing aspect ratio is critical, but other factors such as wing twist may also play a stabilizing role. Field experiments—both at scale and full size—will be conducted to validate these findings.

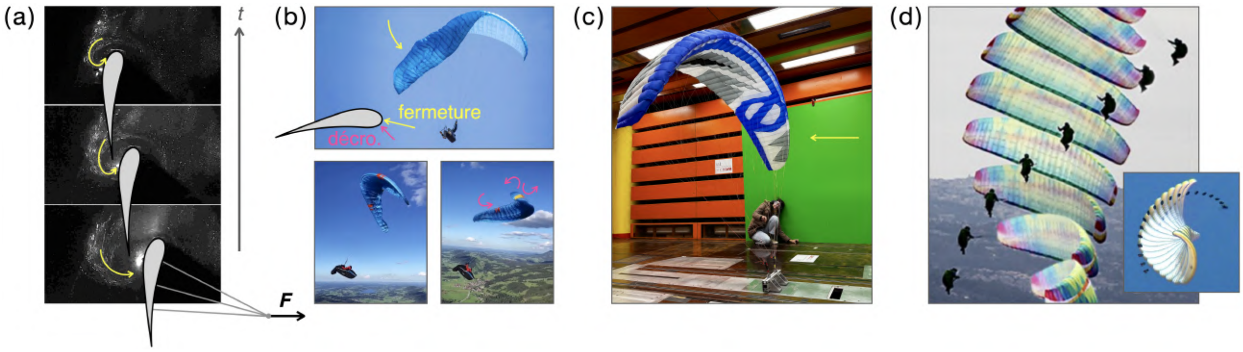

Figure 1: (a) PIV around a small (10 cm) rigid wing during the initial moments of "inflation." (b) In-flight incidents (asymmetric collapse at the top, stall at the bottom). (c) Scale model paraglider (3-meter wingspan) on a balance in the wind tunnel at the Institut Aérotechnique (IAT) in Saint-Cyr-l'École. (d) Paragliders in 360° spiral configuration.

The third phase of the project concerns other unsteady flight incidents such as stalls or wing collapses under turbulent conditions (see Fig. 1b). We will use wind tunnel experiments at the Institut Aérotechnique (IAT) of CNAM (see Fig. 1c) to explore the behavior of flexible wings in turbulent flows, and complement this with in-situ tests using instrumented wings equipped with force sensors, accelerometers, and inclinometers. These measurements will provide rare, high-resolution data on wing response and recovery mechanisms, and will contribute to ongoing discussions around safety certification, which currently rely heavily on subjective assessments by test pilots.

This postdoctoral project is inherently interdisciplinary and will be carried out in collaboration with wing manufacturers, regulatory bodies such as the Fédération Française de Vol Libre, and military partners. Many of the findings will directly inform the design and certification of modern parachutes, which increasingly resemble paragliders in both structure and flight characteristics. These parachutes, often used under heavy load and dropped from high altitude, are particularly sensitive to asymmetric openings and require robust design against spin entry and collapse. Beyond safety, this work also opens perspectives for autonomous soft-wing aircraft, either for civilian transport or military reconnaissance, where understanding passive stability and control authority is essential.

Requirements

The intended start date is October 1, 2025. Candidates should hold a PhD in fluid mechanics, aerospace engineering, or a related discipline, and demonstrate a strong interest in experimental methods. Experience with either wind tunnel work, CFD, PIV, or field instrumentation is desirable. The position is full-time, with an initial duration of 12 to 24 months, and offers a stimulating research environment in close contact with academic and industrial collaborators.

Interested applicants are invited to send a CV, brief statement of research interests, and contact information for two references.

References

[1] Q. Da Cruz Lopes, S. Ramananarivo, C. Cohen, and M. Benzaquen, American Journal of Physics 91, 340 (2023).
[2] R. Falquier, Longitudinal Flight Mechanics of Paraglider Systems (2019).
[3] D. M. Benedetti, Paragliders flight dynamics (Universidade Federal de Minas Gerais, 2012).
[4] M. Müller, A. Ali, and A. Tareilus, in Proc. 9th EUROSIM Congress on Modelling and Simulation, 142 (2018).
[5] R. Soleil, Accidentologie du parapente chez les compétiteurs (2016).