# Postdoctoral position: Aerodynamics of insect-inspired vibrating wings

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**A 12-month postdoctoral position is open at laboratoire PMMH, ESPCI Paris with the goal of examining the flow structures produced by the vibrating wings of a *nanodrone* (see picture in Fig. 1, left[1]), using particle image velocimetry (PIV).**

In insects, the wing beating consists of two phases of translation, downstroke and upstroke, separated by two phases of rotation, pronation and supination (see Fig. 1, right). By rotating the wing during each stroke reversal, the leading edge of the wing drives the movement, and determines several aerodynamic force production mechanisms that are intrinsically unsteady[2] . The details of the vortex dynamics close to the wings determine which of these physical mechanisms are at play depending on the geometry, material properties and kinematics of the wings and are thus an essential aspect in the understanding of insect-inspired flapping wings[3]. The main objective of the postdoctoral researcher in this project will be to characterize the flow produced by the vibrating wings of a small nanodrone, using particle image velocimetry (PIV). Both hovering and cruising configurations will be examined, based on a setup of the wing system inside a wind tunnel. The project aims also

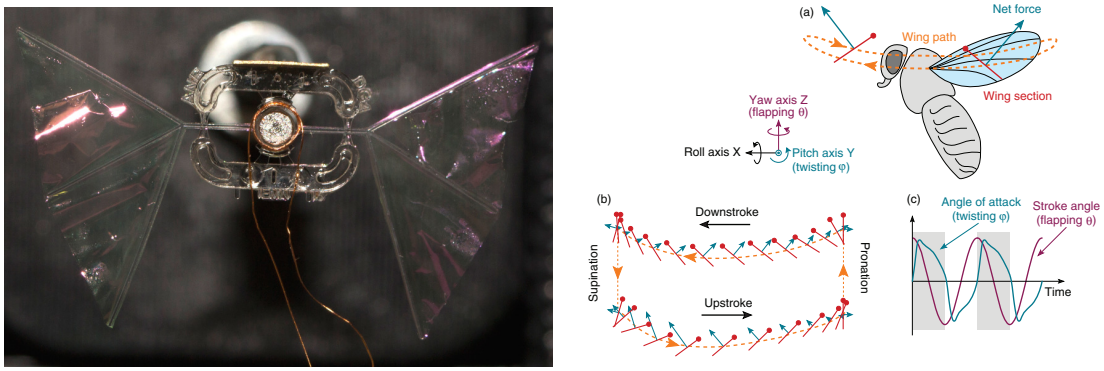


Figure 1: Left: Prototype of nano air vehicle (NAV) with SU-8 skeleton, Parylene C wings and electromagnetic actuator with a total mass of 22 mg and 22 mm wingspan. Right: Insect wings motion: (a) wing path described by looking at a particular section of the wing (in red) with the dots representing the leading edge; (b) tracking of this wing section during up and downstrokes demonstrating their translational motion and showing slope reversal due to pronation and supination interpreted as rotational motion; (c) trend in evolution of stroke angle $\theta$ (flapping) and angle of attack $\phi$ (twisting) in quadrature over time. Both figures from [1].

[1] Faux *et al.* (2018) *EPL* **121**, 66001;
[2] Chin & Lentink (2016) *J. Exp. Biol.* **219**, 920-932
[3] Bomphrey & Godoy-Diana (2018) *Curr. Opin. Insect Sci.* **30**, 26?32

at characterizing the deformation kinematics of the vibrating wings, in conjunction with the PIV measurements, in order to elucidate the specific problems of unsteady aeroelasticity at play.

The hosting team at PMMH is partner of a project financed by the ANR ASTRID program dedicated to the development of a nanodrone based on vibrating wings control. The project involves other teams at IEMN (Valenciennes) and ENSAM (Lille) with whom the postdoctoral researcher will need to collaborate. In particular, current efforts devoted to measuring the aerodynamic force produced by the vibrating wings are expected to be analyzed in conjunction with the PIV flow field measurements.

## Required skills

The ideal candidate should have a PhD in physics or engineering with a strong appetite for experimental work. Experimental fluid mechanics/aerodynamics skills are a must for this project. In particular, prior experience with PIV in wind tunnels will be appreciated.

## Hosting laboratory

The postdoctoral researcher will be based in the Sorbonne Université Pierre et Marie Curie Campus (Jussieu) in Paris, at the PMMH laboratory. PMMH (Physique et Mécanique des Milieux Hétérogènes) is a joint lab (UMR) of ESPCI Paris-PSL, CNRS, Sorbonne Université and Université Paris Cité with a multidisciplinary approach in the fields of fluid and solid mechanics (engineering), physics, biology and also chemistry. The lab is composed of a vibrant community of ∼80 people: 30 permanent researchers and faculty, 7 technical and administrative staff, about 30 PhD students and 6 to 8 post-doctoral students. The laboratory also welcomes around 25 foreign visitors per year. The hosting team (Biomimetics and Fluid–Structure Interaction, aka BIOMIM), composed at the moment of 2 permanent researchers, 6 PhD students and 2 postdocs, has been working for a few years in the physics of bio-inspired fluid–structure interactions, mainly focusing on problems of locomotion at intermediate Reynolds numbers, such as flapping flight and undulatory swimming, and in wind and wave energy conversion.

**Laboratoire PMMH**
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## How to apply

Applications through the CNRS employment portal:
`https://emploi.cnrs.fr/Offres/CDD/UMR7636-FREAUG-025/Default.aspx?lang=EN`

Please include in your CV contact information for references.
Informal inquiries welcome by e-mail: `ramiro@pmmh.espci.fr`, `bthiria@pmmh.espci.fr`