



# Bio-inspired aerial and aquatic locomotion

Workshop at Les Houches School of Physics (France) 11-15 September 2023

Chairs: Ramiro Godoy-Diana (ESPCI Paris) & Eva Kanso (USC)

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## Program

The study of the mechanisms underlying animal swimming and flying has long motivated research efforts in the physical and biological sciences. Beyond the simple goal of understanding the fundamental question of animal locomotion, these problems have also inspired developments in engineering. It has certainly become commonplace to mention Leonardo da Vinci's sketches of flying machines in most lectures and courses dealing with bio-inspired mechanics. The last quarter century has seen a huge increase in work on these topics at the interface of physics and biology, driven in part by the democratization of experimental fluid mechanics tools in biology labs (notably particle image velocimetry and high-speed video).

The objective of this workshop is to provide a collective picture of the state of the art and to indicate the avenues of research that we envision for the future. The focus will be on the macroscopic side of the broad topic of biolocomotion in fluids. We will address animal locomotion problems such as fish swimming or flapping flight, where fluid-structure interactions between a deformable body and its environment are placed in the context of vortex-dominated flows. In addition to the problem of pure locomotion, questions of interactions between individuals and collective behavior will be widely considered. Beyond the (bio)mechanics of the bodies involved, their actuation and passive elastic responses, and the fluid forces of the environment, we will also devote part of the discussion to sensory feedback systems, which are an intrinsic part of these unsteady problems.

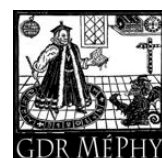
### Venue information: Les Houches School of Physics



Founded by the council of the University of Grenoble on April 18, 1951, on the initiative and under the direction of a young physicist of 27 years old, Cécile De Witt, the *Ecole de physique des Houches* has been training generations of high level physicists ever since. Les Houches is a village located in Chamonix valley. The School is situated at 1150 meters above sea level in natural surroundings, with breathtaking views on the Mont-Blanc mountain range. The 5 school partners of are Université Grenoble Alpes (UGA), the Centre National de la Recherche Scientifique (CNRS), the Commissariat à l'Energie Atomique (CEA), the Institut National Polytechnique (Grenoble-INP), and the Ecole Normale Supérieure de Lyon (ENS Lyon).

Address: Ecole de Physique des Houches, [149 chemin de la Côte](http://www.houches-school-physics.com/), F-74310 Les Houches, France.






More information (access, etc): <https://www.houches-school-physics.com/>



## Invited speakers

- Médéric Argentina (Institut de Physique de Nice, France)
- Richard Bomphrey (Royal Veterinary College, UK)
- Jérôme Casas (IRBI, Université de Tours, France)
- John Costello (Providence College, USA)
- Valentina Di Santo (Stockholm University, Sweden)
- Aurélie Dupont (Université Grenoble Alpes, France)
- Christophe Eloy (IRPHE, Marseille, France)
- Thomas Engels (Aix Marseille Université, France)
- Anders Hedenström (Lund University, Sweden)
- Tyson Hedrick (University of North Carolina, USA)
- Sunghwan Jung (Cornell University, USA)
- Kakani Katija (Monterey Bay Aquarium Research Institute, USA)
- Dmitry Kolomenskiy (Skoltech, Moscow, Russia)
- Petros Koumoutsakos (Harvard University, USA)
- Gen Li (JAMSTEC, Yokohama, Japan)
- Matt McHenry (University of California, Irvine, USA)
- Karen Mulleners (EPFL, Switzerland)
- Leif Ristroph (New York University, USA)
- Clément Sire (Université Paul Sabatier, Toulouse, France)
- Brady Weissbourd (Massachusetts Institute of Technology, USA)

## Sponsors

	<p>The USC Viterbi School of Engineering is the engineering school of the University of Southern California.</p>
	<p>The ESPCI Paris Fund was created in 2011 at the joint initiative of ESPCI Paris, the City of Paris and ESPCI Alumni. It aims to contribute to the development and influence of the School.</p>
	<p>The Biodiversity, Evolution, Ecology, Society (IBEES) initiative of the Sorbonne University Alliance contributes to a truly interdisciplinary reflection by bringing together the natural sciences and the humanities and social sciences in their diversity of approach.</p>
	<p>The GDR MePhy supported by CNRS aims at reinforcing the interface between the communities of mechanics and physics who work on similar topics and systems that often involve physics at different scales.</p>
	<p>The French National Research Agency (ANR) is a public administrative institution under the authority of the French Ministry of Higher Education, Research and Innovation. The agency funds project-based research carried out by public operators cooperating with each other or with private companies.</p>

## Contact

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# Biocomotion @ Les Houches

Breakfast: 7:45 am to 8:45 am ; Lunch: 12:30 am ; Dinner: 7:30 pm

Time / period	Sunday, 10-Sep-2023	Monday, 11-Sep-2023		
7:45		BREAKFAST		
8:30		OPENING		
		Aerodynamics/Flying 1		
8:45		Anders Hedenström	Lessons from animal flight: aerodynamic models, mechanisms, and flight performance	
9:05		Dmitry Kolomenskiy	Flight mechanics of small insects with bristled wings: current status	
9:25		Aimy Wissa	Feather-inspired Distributed Flow Control	
9:40		Mark Jankauski	Non-proportional damping generates traveling waves and improves propulsive efficiency in flexible, flapping wings	
9:55		Juan D'Adamo	Kinematics and vortex dynamics of flapping foils	
10:10		COFFEE BREAK		
		Energetics of swimming and flying		
11:00		Valentina Di Santo	The Balancing Act: Investigating the Energetics and Biomechanics of Hovering in Fishes	
11:20		Tyson Hedrick	The energetic cost of bird flight in groups	
11:40		David E. Rival	Exploring the Evolution and Function of Caudal Fins in Early Vertebrate Locomotion: Insights from <i>Metaspriggina walcottii</i>	
11:55		Johann Herault	Standing on water surface : some aspects of postural stability on water surface	
12:10		Eva Kanso	Energetics and cohesion of Phalanx and Inline formations of flapping swimmers	
12:30		LUNCH		
		Hydrodynamics/Swimming 1		
15:00		ARRIVAL	Karen Mulleners	To swim fast or to go far, answers from 1-guilla, a bioinspired robot
15:20			Gen Li	Investigation on the swimming pattern of a soft robot by an integrated numerical approach with fluid-structure-motion interaction
15:40			Karthick Dhileep	Transitioning from tail-first to head-first swimming
15:55	Melissa Green		Propulsive performance and flow field structure around a two degree-of-freedom fish-like platform	
16:10	Alexander Alexeev		Thickness tapering drastically enhances hydrodynamic performance of elastic fins	
16:25				
18:00	WELCOME APERO			
19:30	DINNER	DINNER		

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Breakfast: 7:45 am to 8:45 am ; Lunch: 12:30 am ; Dinner: 7:30 pm

Time / period	Tuesday, 12-Sep-2023	
7:45	BREAKFAST	
8:30		
	Hydrodynamics/swimming 2	
8:45	Médéric Argentina	Optimum control strategies for maximum thrust production in underwater undulatory swimming
9:05	John Costello	A fundamental propulsive mechanism employed by swimmers and flyers throughout the animal kingdom
9:25	Megan Leftwich	The kinematics, forces and robotics of sea lion locomotion
9:40	Yahya Modarres-Sadeghi	The transient behavior of a fast-starting robotic fish
9:55	Sarah Morris	Vortex ring generation through bio-inspired orifices
10:10	COFFEE BREAK	
	Aerodynamics/Flying 2	
11:00	Florian Mujres	Unsteady Aerodynamics in High-Frequency Flapping Wings of Insects and Robots
11:20	Thomas Engels	Understanding housefly flight with broken wings: a numerical perspective
11:40	Carlos García Baena	Three-dimensional elastic deformation and aerodynamic performance in insect-inspired flapping wings
11:55	Gabriel Weymouth	High-performance bat flight simulations using parametric kinematic and material models
12:10	Marie Farge	The exceptional performance of swifts in flight
12:30	LUNCH	
15:30	Leif Ristroph	Self-organized flight formations disrupted by self-amplifying waves
15:50	Alexandra Zidovska	Movements of the genome in the cell nucleus
16:05	<b>POSTER SESSION 1</b> <b>Starts with flash talks 2min+1min</b>	
	Bruno Ventéjou	A 3D hydrodynamic toy model for fish locomotion
	Zixuan Deng	A light-fueled torus swimmer in Stokes regime
	Marguerite De La Bigne	Design and optimisation of a vibrating wing insect-size air vehicle
	Rose Gebhardt	Dynamics, stability, and control of inline swimming
	Tristan Aurégan	Efficiency of intermittent locomotion
	Jena Shields	Expelling mechanism of dragonfly larvae
	Cailin Casey	Experimental studies suggest differences in thorax stiffness distribution between insects with synchronous and asynchronous indirect flight muscles
	Rajat Mittal	Fluid-structure interaction in bat-inspired flexible membrane wing: Insights from computational models
	Nils Tack	How shrimp minimize drag during metachronal swimming by bending and coalescing their pleopods: a bio-inspired approach
19:30	CONFERENCE DINNER	

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Breakfast: 7:45 am to 8:45 am ; Lunch: 12:30 am ; Dinner: 7:30 pm

Time / period	Wednesday, 13-Sep-2023	
7:45	BREAKFAST	
8:30	HIKE & FREE TIME	
12:30	LUNCH	
	<i>Sensing and sensory-motor systems</i>	
15:00	Jérôme Casas	Insect antennal multiscale architecture and active movement for enhanced olfaction
15:20	Christophe Eloy	Planktonic navigation
15:40	Brady Weissbourd	Preliminary insights into the neural control of swimming in a model jellyfish
16:00	Alexander Hoover	Modeling multiple pacemaker control in jellyfish locomotion
16:15	Feng Ling	From swimmers to the lung: Understanding the link between cilia ultrastructure and ciliary beat patterns
16:30	COFFEE BREAK	
19:30	DINNER	

## Biocomotion @ Les Houches

Breakfast: 7:45 am to 8:45 am ; Lunch: 12:30 am ; Dinner: 7:30 pm

Time / period	Thursday, 14-Sep-2023	
7:45	BREAKFAST	
8:30		
	Collective behavior	
8:45	Matthew McHenry	The sensory basis of fish schooling
9:05	Aur�lie Dupont	Collective motion of fish in challenging environments, the emergency evacuation test
9:25	Cl�ment Sire	Measuring and modeling social interactions in fish schools and applications: AI, robot-fish, virtual reality for fish, drones
9:45	Rajat Mittal	Exploring the Hydrodynamics of Coordinated Swimming in Fish via Computational Models
10:00	Baptiste Lafoux	Confinement-driven state transition and bistability in schooling fish
10:15	COFFEE BREAK	
	Experimental methods	
11:00	Kakani Katija	DeepPIV and EyeRIS: Novel in situ imaging systems that enable time-resolved visualizations of particles and animals in the deep sea
11:20	Richard Bomphrey	Insect aerodynamics at high frequencies
12:30	LUNCH	
15:30	Petros Koumoutsakos	Schooling of Artificial Swimmers
15:50	POSTER SESSION 1 Starts with flash talks 2min+1min	
	Thomas Steinmann	Hydrodynamic performance of the propulsive fan of a semi aquatic insect: functional morphology of a locomotory innovation
	Gatien Polly	Interaction between water waves and a submerged membrane
	David Peterman	Investigating pumping performance at intermediate Reynolds numbers with ctenophore-inspired magnetically actuated elastomers
	Jianfeng Yang	Light-Driven Dandelion-Inspired Polymer��
	Camille Aracheloff	Odonata flight: Mechanical study of the wings
	Ilambharathi Govindasamy	On the effect of flow separation in added mass and its relevance to flapping flight
	Dayo Jansen	Studying auditory-induced escape manoeuvres and flight activity of pest moths to improve bat-inspired drones hunting moths in greenhouses.
	Max Roccuzzo	New snake-like robot to explore the stability and instability of slender swimmers at the water's surface
19:30	DINNER	

## **Biocomotion @ Les Houches**

Breakfast: 7:45 am to 8:45 am ; Lunch: 12:30 am ; Dinner: 7:30 pm

<b>Time / period</b>	<b>Friday, 15-Sep-2023</b>	
<b>7:45</b>	<i>BREAKFAST</i>	
<b>8:30</b>		
	<i>Locomotion and flow at interfaces</i>	
<b>9:00</b>	<b>Sunghwan Jung</b>	<b>How a bat drinks on the wing</b>
<b>9:20</b>	Margaret Byron	Aquatic-aerial locomotion of freshwater insects
<b>9:35</b>	Ludovic Jami	Constraints Over Whirligig Beetle Body Size Due to Water-Air Interface Physics
<b>9:50</b>	Brooke Flammang	Flying fish: swimming, gliding, and aerial-aquatic transitions
<b>10:05</b>	Elizabeth Gregorio	How Olympic Divers Manipulate the Air Cavity during Entry
<b>10:20</b>	<i>COFFEE BREAK</i>	
<b>11:00</b>	<i>FREE TIME &amp; FINAL DISCUSSIONS</i>	
<b>12:30</b>	<i>LUNCH</i>	
<b>15:00</b>	<i>DEPARTURE</i>	