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Colloquium n. 654 - Bio-inspired Fluid-Structure Interaction

Dates and location

9 July — 11 July 2025, Vienna, Austria

Chairperson

Chandan Bose, Manuel Garcia-Villalba

Co-chairperson

Marco de Tullio, Oscar Flores, Ramiro Godoy-Diana

Conference fees

- Registration fee - early bird: **500.00 €**
- Registration Fee: **550.00 €**

What other funding was obtained?

None.

What were the participants offered?

The registration fee included:
Coffee breaks and lunches
Conference Dinner
Guided visit to Secession Museum

Applicants (members)

1. Marco Donato De Tullio
2. Manuel Garcia-Villalba
3. Manuel Garcia-Villalba
4. Ramiro Godoy-Diana
5. Christiana Mavroyiakoumou
6. Manuel Moriche
7. Karen Mulleners
8. Sandeep Saha
9. Sandeep Saha
10. Maximilian Schenk
11. Yvonne Stöcker

Applicants (non members)

1. Karim Ahmed
2. Alexander Alexeev
3. Samik Bhattacharya
4. Chandan Bose
5. Florian Bouard
6. Florian Bouard
7. Daehyun Choi
8. Anne Cros
9. Karthick Dhileep
10. Thomas Engels
11. Oscar Flores
12. Carlos García Baena
13. Ariane Gayout
14. Andres Goza
15. Alexander Hoover
16. Francisco Huera-Huarte
17. Makoto Iima
18. Justin Jaworski
19. Sunghwan Jung
20. Dmitry Kolomenskiy
21. Swathi Krishna

22. Melike Kurt
23. Gen Li
24. Liang Li
25. Juan Li
26. Manuel Lorite-Díez
27. Manuel Lorite-Díez
28. Abhinav Muta
29. Shuji Otomo
30. Somnath Roy
31. Lars-Uve Schrader
32. Sachin Shinde
33. Thomas Steinmann
34. Thomas Steinmann
35. Benjamin Thiria
36. Benjamin Thiria
37. John Young
38. Chengyao Zhang

Scientific report

The EUROMECH 654 Colloquium on "Bio-inspired Fluid Structure Interaction" was held from July 9-11, 2025, in Vienna, Austria, bringing together leading researchers from around the world to advance our understanding of how biological systems interact with fluid flows and inspire engineering solutions. The colloquium featured 38 presentations across 10 sessions, with participants from Europe, North and South America, Asia, and Australia. In addition to the regular talks two open discussion were held, discussing topics such as the benchmark of fluid-structure interaction solvers and data availability and dissemination.

The colloquium addressed a diverse range of research topics, demonstrating the interdisciplinary nature of bio-inspired fluid-structure interaction research. The presentations were organized into several key thematic areas:

Bio-inspired Engineering Applications dominated the program with 11 presentations, reflecting the field's strong focus on translating biological insights into practical engineering solutions. These studies explored applications ranging from Martian exploration aircraft to underwater robots, emphasizing the versatility of bio-inspired approaches.

Insect Flight and Wing Mechanics represented the second-largest theme with 9 presentations, covering topics from dragonfly wing resonance mechanisms to damaged wing aerodynamics. Notable contributions included the work on frequency matching in Odonata flight, which revealed a nonlinear resonance mechanism enabling energy-saving through dynamic wing softening.

Aquatic Locomotion featured 5 presentations examining various swimming mechanisms, from jellyfish propulsion to dolphin-inspired drag reduction. The research spanned from fundamental studies of shape-Reynolds number correlations in jellyfish to practical applications in underwater vehicle design.

Flexible Structures comprised 5 presentations focusing on the role of structural flexibility in fluid-structure interactions. These studies investigated how passive and active flexibility can be optimized for enhanced performance in both biological and engineered systems.

Turbulence and Flow Control included 4 presentations addressing the challenging interaction between bio-inspired systems and turbulent flows. Key findings included the discovery that turbulence can actually enhance bird tail aerodynamics and the development of dolphin-inspired skin microvibrations for significant drag reduction.

Energy Harvesting applications were represented by 2 presentations, exploring vortex-induced vibration harvesting and hydroelastic energy conversion.

Methodological Advances

The colloquium showcased significant advances in both experimental and computational methodologies. A balanced approach was evident, with studies employing experimental techniques, computational methods, and increasingly, combined experimental-computational approaches that leverage the strengths of both methodologies.

Computational Innovations were particularly prominent, featuring cutting-edge developments such as:

- GPU-accelerated fluid-structure interaction schemes
- Machine learning approaches using Fourier neural operators for design optimization
- Multi-fidelity Bayesian optimization processes

Experimental Techniques demonstrated sophistication, including:

- High-speed 3D wing deformation monitoring with simultaneous force measurement
- Advanced flow visualization using PIV, DIC, and event-based cameras
- Automated robotic experimentation for self-exploring scientific discovery
- Fringe projection profilometry for full-field deformation measurements

The integration of artificial intelligence and machine learning into bio-inspired FSI research emerged as a significant trend, with applications ranging from design optimization to flow control strategies.

Future Directions and Challenges

The colloquium identified several emerging research directions:

Multi-scale Integration: Increasing focus on connecting molecular-level biological mechanisms with macroscopic fluid dynamics performance.

Artificial Intelligence: Growing integration of machine learning and AI for both understanding biological systems and optimizing bio-inspired designs.

Extreme Environments: Expansion into challenging conditions such as Martian atmospheres, deep-sea environments, and highly turbulent flows.

Sustainable Technologies: Emphasis on bio-inspired solutions for environmental challenges, including energy harvesting and pollution remediation.

Number of participants from each country

| COUNTRY | PARTICIPANTS |
|----------------|--------------|
| France | 9 |
| United States | 8 |
| United Kingdom | 5 |
| Spain | 5 |
| Austria | 5 |
| India | 4 |
| Japan | 3 |
| Germany | 3 |
| Australia | 2 |
| Mexico | 1 |
| Italy | 1 |
| Netherlands | 1 |

| | |
|--------------------|-----------|
| Russian Federation | 1 |
| Switzerland | 1 |
| TOTAL | 49 |