Colloquium n. 656 – Data-driven mechanics and physics of materials

Dates and location
21 May — 23 May 2025, Gothenburg, Sweden

Chairperson
Mohsen Mirkhalaf

Co-chairperson
Iuri Rocha

Conference fees

- Student fee - early bird: **4000.00 €**
- Student fee: **5000.00 €**
- Delegates fee - early bird: **5000.00 €**
- Delegates fee: **6000.00 €**

What other funding was obtained?
Support for the conference venue

What were the participants offered?
Welcome gifts (umbrella, notebook ...), Coffee breaks, Lunches, and Banquet Dinner

Applicants (members)

1. Mahmoud Mousavi

Applicants (non members)

1. Tamadur Albaraghtheh
2. Tito Andriollo
3. Rui Barreira
4. Cemal Basaran
5. Antoine Benady
6. Magnus Ekh
7. Mohammed El Fallaki Idrissi
8. Mirja Granfors
9. Jacob Gunnarsson
10. Zhe Han
11. Fleur Hendriks
12. Nora Kovacs
13. Alex Lech
14. Runze Li
15. Marina Maia
16. Gagan Kaushik Manyam
17. Foudil Meraghni
18. Knut Andreas Meyer
19. Mohsen Mirkhalaf
20. Luca Patrignani
21. Ivan Ruiz Cozar
22. Ruben Schmeitz
23. Ronak Shoghi
24. Joep Storm
25. Nasrin Talebi
26. Petter Uvdal
27. Li Zheng
28. Li Zheng

Scientific report

Combining classical principles of mechanics and physics of solids with cutting-edge data science techniques has resulted in very accurate and efficient data-driven approaches. Data-driven models have a very high capacity to harness vast volumes of data generated in material science, engineering, and physics to uncover hidden patterns, relationships, and insights. During the last decade, the following have seen key developments, and further enhancements are ongoing:

1. **Efficient and accurate surrogate modelling:** By leveraging existing data and employing Machine Learning (ML), very accurate and remarkably efficient models have been developed. This is particularly important for micro-structurally heterogenous materials for which high-fidelity full-field micromechanical simulations are required for an accurate prediction.
2. **Accelerated material design:** The integration of data science techniques allows to identify optimal material properties for specific applications much more rapidly. This can lead to the development of innovative materials with enhanced performance, durability, and functionality.
3. **Discovery of constitutive laws:** Data-driven models have enabled discovery of constitutive laws from force and displacement information readily extractable from experiments. In comparison with classical approaches, this method dramatically reduces the required effort and time to derive constitutive laws.

Despite the great progress, challenges persist, including **(i)** the need for robust data sets, **(ii)** the interpretability of complex models, and **(iii)** the integration of physics-based constraints. Overcoming these challenges will pave the way for a deeper understanding of material behavior and the realization of more efficient and sustainable engineering solutions.

In this colloquium, we examined the developments and challenges outlined above by bringing together distinguished plenary and keynote presentations from leading scholars, who provided expert insights into the latest progress at the intersection of mechanics, physics, and data science. In addition to the invited lectures, the scientific program featured a series of thematically organized sessions that facilitated deeper engagement with focused topics, including:

- Probabilistic Machine Learning,
- Surrogate Modelling,
- Learning from Physics and Data,
- Image-Based Deep-Learning Models and Tools,
- Machine-Learning-Assisted Material Design and Manufacturing.

These sessions provided a platform for rigorous discussion of both foundational principles and cutting-edge techniques, enabling participants to explore how data-driven frameworks can harness datasets to uncover hidden patterns and relationships, enhance predictive capability, and accelerate innovation in material science and engineering.

Number of participants from each country

Country	Participants
Sweden	10
Netherlands	5
Switzerland	4
Germany	3
France	2
United Kingdom	2
Denmark	1

United States	1
Portugal	1
Total	**29**