Colloquium Final Report: N. 641- Euromech Colloquium on Non-Smooth Dynamical Systems (NSDS 2023)

Dates and location: 11/12/2023 – 13/12/2023, Dublin, Ireland

Chairperson
Dr Aasifa Rounak, University College Dublin, Ireland

Co-Chairpersons

- **Assoc. Prof. Vikram Pakrashi (Co-chair)**, University College Dublin, Ireland
- **Prof. Grzegorz Litak (Co-chair)**, Lublin University of Technology, Poland
- **Prof. Przemysław Perlikowski (Co-chair)**, Lodz University of Technology, Poland

The Local Organising Committee comprised **Rohit Chawla**, **Soumyajit Seth**, and **Meiyazhagan Jaganathan**(University College Dublin).

All presentations were held in **Room ENG 216**, with no parallel sessions, ensuring strong engagement and discussion. **Room ENG 224** was used for one-to-one and informal discussions, which were set up prior to the colloquium.

Conference fees:

- Regular registration fees 250 EUR
- Student registration fees 150 EUR

What other funding was obtained? We had received funding from:

Euromech	1000
UCD Foundation: Bertram Broberg Memorial Fund	2500
iForm	1000
NexSys: Next Generation Energy Systems	500
NUI Grant Scheme for Early Career Academics 2023	2000

What were the participants offered?

The registration fees included:

- A package with a folder, notebook, pen, lanyards
- 2 daily coffee breaks and 2 lunches
- A conference dinner and drinks at Farmer Browns, Clonskeagh
- Prizes for the best student presentations
- Tokens of appreciation for guest speakers

Number of members of Euromech (Reduced registration fee) **7**
Number of non-members of Euromech (Full registration fee) **13**

Keynote Speakers

Keynote talks were delivered by distinguished researchers, covering both foundational theory and emerging applications:

- **Prof. Marian Wiercigroch (University of Aberdeen)** discussed calibrated low-dimensional models in non-smooth dynamics, emphasising their role in engineering design and experimental validation.
- **Prof. Yang Liu (University of Exeter)** presented the development of vibro-impact capsules for biomedical applications, linking non-smooth dynamics to lower gastrointestinal endoscopy.
- **Prof. Rachel Kuske (Georgia Institute of Technology)** introduced computer-assisted methods for global analysis of vibro-impact systems via reduced smooth maps.
- **Prof. Soumitro Banerjee (IISER, India)** examined the nature of singularities and narrow-band chaos in impacting systems near grazing.
- **Prof. Piotr Brzeski (Lodz University of Technology)** explored hybrid modelling of church bell dynamics and associated structural loads.
- **Prof. Daniil Yurchenko (University of Southampton)** presented complex dynamics of vibro-impact energy harvesting systems.
- **Prof. Mike Jeffrey (University of Bristol)** discussed modern perspectives on singularities and bifurcations in high-dimensional and non-smooth systems.

These keynote lectures set the thematic direction of the colloquium and stimulated in-depth discussion throughout the event.

Applicants (Members)

- Marko Gavrilović
- Soumyajit Seth
- Lucio Demeio
- Natasa Trisovic
- Alicia Terrero-Gonzalez
- Máté Benjámin Vizi

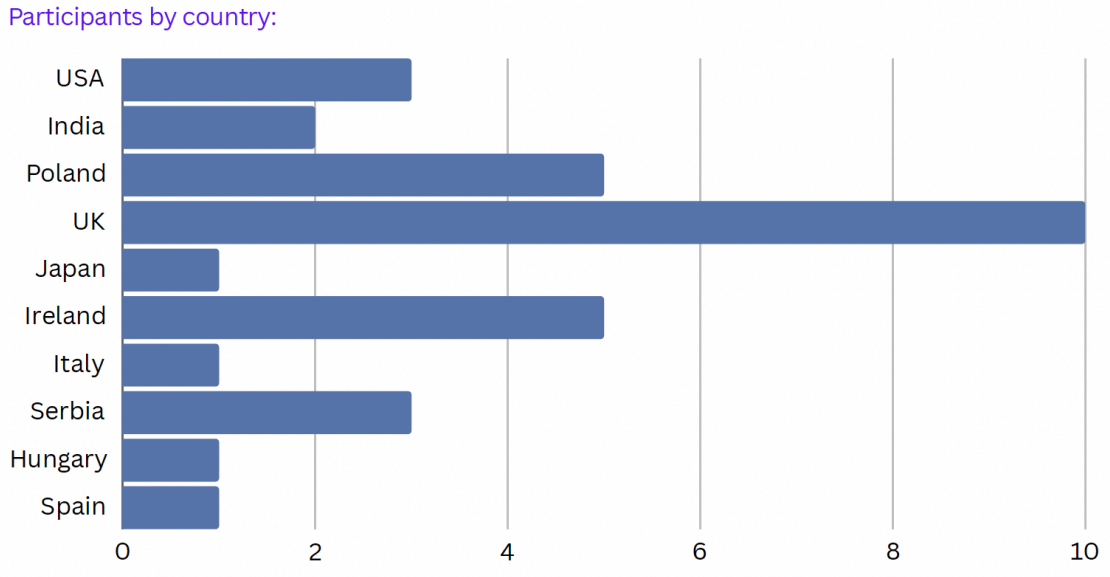
- Jerzy Warminski

Applicants (Non-Members)

- Salvador Catsis
- Rohit Chawla
- Meiyazhagan Jaganathan
- Dimitri Danulussi Alves Costa
- Ryo Kikuuwe
- Rahul Kumar
- Christina Athanasouli
- Mohsen Lalehparvar
- Idin Nazzari
- Peter Tang
- Majid Aleyaasin
- W. Chen
- Tomasz Burzyński

The colloquium attracted participants from a wide range of countries, including **Ireland, the United Kingdom, Poland, the United States, India, Japan, Italy, Serbia, Hungary, and Spain**. This diversity highlighted the global relevance of non-smooth dynamical systems and reinforced the international standing of the Euromech Colloquia.

The format, with a single-track programme, facilitated sustained interaction across disciplines and career stages.



1. Overview

The 641st Euromech Colloquium on **Non-Smooth Dynamical Systems (NSDS 2023)** was held from **11–13 December 2023** at **University College Dublin (UCD), Dublin, Ireland**. The colloquium brought together an international community of researchers working on

theoretical, computational, and experimental aspects of non-smooth dynamics, including systems with impacts, friction, switching, and discontinuities.

The event was hosted by the **Dynamical Systems and Risk Laboratory (DSRL)** and the **UCD Centre for Mechanics**, School of Mechanical and Materials Engineering, UCD. It formed part of the long-standing Euromech Colloquia series, which aims to promote high-level scientific exchange within the European mechanics community and beyond.

2. Objectives and Scope

The primary objective of NSDS 2023 was to provide a focused forum for discussing recent advances in non-smooth dynamical systems and their applications. The colloquium aimed to:

- Exchange state-of-the-art theoretical developments in non-smooth and hybrid dynamical systems;
- Showcase experimental and numerical methodologies for systems involving impacts, friction, delay, and switching;
- Foster interdisciplinary dialogue between mechanics, applied mathematics, control, and engineering applications;
- Strengthen international collaboration among early-career and senior researchers.

The scope covered a broad range of topics including vibro-impact systems, grazing and border-collision bifurcations, friction-induced vibrations, energy harvesting, drilling and cutting dynamics, hydraulic systems, control of non-smooth systems, and applications in biomechanics and infrastructure.

3. Scientific Report

Non-smooth dynamical systems arise naturally in mechanical, structural, control, and physical systems involving impacts, friction, switching, delays, and other forms of discontinuity. Such systems exhibit rich and often counter-intuitive phenomena including grazing and border-collision bifurcations, multistability, chatter, stick–slip motion, intermittency, and chaos. These behaviours are of fundamental scientific interest and of direct relevance to engineering applications.

The goal of the 641st Euromech Colloquium on Non-Smooth Dynamical Systems was to bring together a focused international group of researchers working on theoretical, computational, and experimental aspects of non-smooth dynamics. The colloquium aimed to strengthen the dialogue between mathematical foundations and real-world engineering applications, and to promote collaboration across mechanics, applied mathematics, and control. Specific topics addressed in the talks and discussions included:

• Vibro-impact systems and grazing dynamics
Several contributions focused on archetypal impact oscillators and vibro-impact systems, addressing grazing-induced bifurcations, co-existing attractors, narrow-band chaos, and

global dynamics. Both analytical and computer-assisted methods were presented, alongside experimental validation.

• Friction-induced and stick–slip dynamics
The modelling and analysis of frictional systems featured prominently, including anti stick–slip tools, metal cutting dynamics, inerter systems with friction, and dry-friction energy harvesters. Particular attention was given to non-smooth friction laws, stochastic effects, and their influence on stability and performance.

• Energy harvesting and applied non-smooth systems
Non-smooth dynamics in vibration energy harvesting systems were discussed in the context of vibro-impact harvesters and dielectric elastomer devices. Optimal operating regimes, multistability, and transitions between periodic and chaotic responses were analysed.

• Control of non-smooth and hybrid systems
Several presentations addressed control strategies for non-smooth systems, including sliding-mode and set-valued control approaches for hydraulic actuators, delay effects in controlled impact oscillators, and chaos control through stiffness and parameter tuning.

• Engineering and interdisciplinary applications
Applications ranged from drilling and jarring tools, church bell dynamics, and blast response of structures to biomedical devices such as vibro-impact capsules for gastrointestinal endoscopy. These studies highlighted the practical importance of non-smooth modelling in modern engineering design.

The colloquium demonstrated the range of the problems tackled by the non-smooth dynamics community and highlighted emerging directions where theory, computation, and experiment intersect. While classical concepts such as grazing bifurcations and impact maps remain central, there is a clear trend towards integrating non-smooth dynamics with stochastic modelling, control theory, experimental validation, and emerging applications. The colloquium reinforced the importance of Euromech meetings as a platform for deep scientific exchange and for shaping future research directions in non-smooth dynamical systems. The high scientific quality of the contributions and the interaction between participants leading to collaborative research initiatives underscored the success of the meeting.

4. Scientific Programme

The three-day programme consisted of keynote lectures by leading international experts and oral presentations selected from peer reviewed submitted abstracts. Oral contributions covered a wide range of topics, including:

- Multiple-impact and jarring tools in drilling systems;
- Anti stick–slip tools and friction modelling;
- Metal cutting dynamics with regenerative, frictional, and stochastic effects;
- Delay effects and Floquet analysis in impact oscillators;
- Non-smooth control of hydraulic actuators and excavators;
- Vibro-impact energy harvesting and nonlinear vibration mitigation;

- Structural and mechanical applications such as bells, shells, beams with cracks, and blast response.

The breadth and depth of the oral sessions demonstrated both mathematical advances and formalisms, methodological progress made in the field with strong links to real-world engineering problems.

5. Outcomes and Impact

NSDS 2023 successfully:

- Consolidated recent advances in non-smooth dynamical systems;
- Strengthened links between theory, computation, and experiment;
- Highlighted emerging applications in manufacturing, energy harvesting, biomechanics, and infrastructure;
- Fostered international collaboration across Europe, Asia, and North America.

The colloquium was featured on the **Euromech** and **SIAM Dynamical Systems** websites, increasing its visibility within the broader dynamics community.

Participants were invited to submit full-length papers for a **special volume in the *Journal of Physics: Conference Series***, subject to peer review, where 4 articles were published. More details here: https://iopscience.iop.org/article/10.1088/1742-6596/2983/1/011001/meta

The 641st Euromech Colloquium on Non-Smooth Dynamical Systems demonstrated the vitality and growing relevance of non-smooth dynamics in modern science and engineering. The high scientific quality, strong international participation, and focused single-track format made NSDS 2023 a highly successful event, reinforcing UCD's role as a hub for research in nonlinear and non-smooth dynamical systems. This also inspired the 657th Euromech Colloquium NSD2025 that was held in Exeter from 8-10 Dec, 2025. The organisers acknowledge the support of the Euromech Council, UCD, the non-smooth dynamical community, invited speakers, and all participants for their contributions to a stimulating and productive colloquium.