EUROPEAN MECHANICS SOCIETY

Colloquium n. 652 – Non-spherical particles in turbulence: recent advances in theory, simulation and experiments

Dates and location

16 July — 18 July 2025, Udine, Italy

Chairperson

Rene van Hout (Technion - Israel Institute of Technology, ISR)

Co-chairperson

Cristian Marchioli (University of Udine, ITA)

Conference fees

- Early-Bird: **400.00 €**
- Early-Bird (PhD students, postdocs): **300.00 €**
- Regular: **500.00 €**
- Regular (PhD students, postdocs): **400.00 €**
- Late/Onsite: **750.00 €**
- Late/Onsite (PhD students, postdocs): **600.00 €**
- Accompanying person: **100.00 €**

What other funding was obtained?

Funding (2,000 EUR) from the University of Udine to cover the conference material offered to the in-person participants and the printout of rollups and flyers.

What were the participants offered?

The services offered to speakers/attendees included: Printed version of the Scientific Program; stationery and other conference material; 5 Coffee & Tea Breaks, 3 lunches, a Welcome Cocktail, Pizza dinner and the Gala Dinner; 3-day access to a fully-equipped room, exclusively reserved for the Colloquium.

Online, the following services were offered: Electronic version of the Book of Abstract; electronic version of the Scientific Program.

Applicants (members)

1. Panagiotis Alexandrou
2. Luca Brandt
3. Christopher Brouzet
4. Salvatore Cito
5. Darish Jeswin Dahs
6. Alessandro Gambino
7. Cristian Marchioli
8. Manuel Moriche Guerrero
9. Federico Pizzi
10. Hugo Poncelet
11. Mona Rahmani
12. Alessio Roccon
13. Marco Eduardo Rosti
14. Francesco Serafini
15. Alfredo Soldati
16. Martin Sommerfeld
17. Defa Sun
18. Jiaxin Tan
19. Rene Van Hout

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21. Anthony Wachs

Applicants (non members)

1. Sourabh Apte
2. Patricia Ern
3. Piyush Garg
4. Susumu Goto
5. David Hasin
6. Dylan Letessier
7. Zhi Li
8. Qing Li
9. Haoran Luo
10. Ana Mucalica
11. Jingran Qiu
12. Hamood Ur Rahman
13. Anubhab Roy
14. Yi Hui Tee
15. Nicola Vanzetto
16. Ayal Yosef
17. Xudong Yuan
18. Domenico Zaza

Scientific report

Non-spherical particle-turbulence interactions are common in many environmental, technological and biological applications. In some cases these particles can be modeled as spherical ones, but in many other cases, e.g. microplastics dispersion, ice crystals in the atmosphere and composite material fabrication, the non-sphericity and associated alignment is governing the dispersion, light reflection or material strength. During the last two decades, much progress has been made in our understanding of the interaction of non-spherical particles in turbulence. However, due to the non-trivial interaction of these particles with turbulent flow structures that may be characterized by preferential sampling of flow regions (in the case of inertial particles) as well as preferential alignment with turbulent flow structures, still many questions remain unanswered, especially in non-homogeneous turbulent flows. Numerical simulations supported by theoretical and experimental results have been leading the way. However, recently both numerical and experimental methods have been advancing at a rapid pace and experiments are currently able to catch up with numerical simulations or even surpass them, especially at high Reynolds number applications. The aim of this colloquium was to convene a group of researchers that study non-spherical particle interactions with turbulent flows using theoretical, numerical, and experimental approaches. The participants were exposed to the different methodologies, their strengths and weaknesses, and as a result we achieved that the different groups have become more aware of the capabilities and limitations of the different approaches. The vision of the colloquium was that only by understanding the capabilities and shortcomings of the employed methodologies, synergy can be achieved between the different approaches allowing to further advance our understanding of the complex interaction of non-spherical particles with turbulent flows. The covered topics included the advances that were made during the last two decades in (1) the phenomenological description of non-spherical particle-turbulence interactions, and results on (2) the modeling and measurement of particle motion, (3) collisions and agglomeration and (4) flexible and deformable particle motion and interactions, (5) advances in numerical simulation techniques and measurement techniques and (6) possible exploitation of machine learning techniques.

In total 39 participants (37 speakers, 2 non-speakers) attended the Colloquium, which was held in-person only. The Colloquium was subdivided into 5 main blocks, each introduced by a keynote lecture, and the last day was concluded with a keynote lecture. A brief summary of the topics discussed during the event is given below:

DAY 1. The morning of Day 1 was dedicated to the motion of non-spherical rigid bodies in turbulent flows. Two keynote lectures were presented, one entitled "On the dynamics of flows laden with angular rigid bodies" by Prof. A. Wachs (University of British Columbia, Canada), who reported numerical research on the dynamics of flows laden with angular rigid bodies, and the second entitled "Preferential orientation and rotation of microfibers and their connection with small scale turbulence dynamics" by Prof. A. Soldati (Technische Universität Wien, Austria) who presented experimental research on the motion of microfibers and their connection with small-scale turbulence. In addition, three sessions of contributed talks were held that opened up the discussion on settling behavior of non-spherical particles in turbulent flows (Session #1), dynamics of long and curved fiber-like particles in turbulent flows both for drag reduction and as probes for dissipation rate estimation (session #2), and numerical and experimental studies on non-spherical particle motion in complex turbulent flows (Session #3).

DAY 2. The morning of Day 2 was mainly focused on flexible non-spherical particles in turbulence. The day opened with the Keynote lecture “Hydrodynamics of flexible aquatic plants” by Prof. M. Rosti (Okinawa Institute of Science and Technology) who linked freely moving fiber-like particles in turbulent flows to one-sided clamped flexible elements exposed to turbulent wall-bounded flows. This keynote lecture was followed by session #4 that was dedicated to flexible particle motion and dynamics in turbulent flows. This session was followed by session #5 that focused on the dispersion and settling behavior single non-spherical particles as well as on swarms and suspensions. A mix of experimental and numerical studies were presented. The 4th keynote lecture, entitled “Strategies for modelling non-spherical particle transport in the frame of an Euler/Lagrange approach” was presented by Prof. M. Sommerfeld (Otto von Guericke University, Germany) opening up the discussion on numerical methods. This keynote lecture was followed by session #6 that focused on numerical algorithms to be used to simulate non-spherical particle-laden flows. The day was closed by session #7 that started a discussion on non-spherical droplets and active particles such as zooplankton in turbulent flows.

DAY 3. The final day of the colloquium was limited to the morning (until 13:00). The day was opened by the keynote lecture entitled “Trapping of flexible discs by a vortex” by Prof. G. Verhille (IRPHE Marseille, France) who discussed the effect of flexibility on the aggregation of disk-like particles in vortices and showed detailed scaling laws. The following sessions #8 and #9 showed numerical results in a variety of topics and a combinations of analytical models and numerical results on active particles, suspensions and colliding rod-like particles. The day was closed by the keynote lecture entiled “Effects of gravitational settling on aggregation of microparticles in turbulent flows”, presented by Prof. M. Rahmani (University of British Columbia, Canada), who discussed the effects of gravitational micro-particle settling on aggregation in turbulent flows.

Overall, the scientific program of the Colloquium has allowed plenty of time for discussions both during the Q&A session after each presentation and during the 30-minute long coffee breaks, the nearly 2-hour long lunch breaks which were held close to the colloquium venue (being included in the registration fee, all participants attended the lunch), and also during the pizza and social dinners. Thanks to the contribution of all participants, and to the absence of online talks, discussions on the various aspects of non-spherical particles in turbulent flows were very lively and engaging. This has allowed not only a significant advancement in terms of general consensus on several of the crucial aspects tackled during the Colloquium, but also an increased awareness of the current limits and potentials of the various techniques employed in the simulation and measurement of non-spherical particles in turbulent flows. This has led to future research paths for this research community to embark on.

To conclude this report, a sincere thanks to Euromech for

making this meeting possible and for providing financial and organizational support is in order.

Number of participants from each country

Country	Participants
Italy	6
France	6
China	4
Canada	4
Japan	3
Israel	3
Austria	3
Spain	2
United Kingdom	1
United States	1
Switzerland	1
Sweden	1
India	1
Germany	1
Norway	1
Netherlands	1
Total	**39**