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Editorial

The multidisciplinary perspectives of cooperative phenomena in flows in the context of this Special Topical issue relate to liquid, particle/granular flow, flow in and of organic/living systems and turbulence. Special emphasis is placed on studies of fluid (gas, liquid) flow around and inside micro- and nanoscale systems. Since biological systems have evolved in water and are mostly composed of water, uncovering the secrets of biomolecular flows is crucial in understanding origins of life. Nanofluidics is a key technology for designing engineering devices for biological applications, such as biomedical devices and has over the past few years experienced a rapid development. They find applications in a range of areas such as microelectronics cooling, e-paper, micro-reaction devices, lab-on-a-chip systems etc. Among the challenges in nanofluidics are topics like: Fluid transport; hydrophobic/hydrophilic forces; diffusion; dispersion and sample mixing; particle and molecular transport; electroosmosis/electrophoresis ; adhesion; flow boundary conditions; and nanopumps. In order to solve these challenges both experimental and modelling/simulation approaches are needed. In particular, the reduced system dimensionality and the reduced number of degrees of freedom have to be handled properly. Breakthroughs in this field will have great impact in industrial fields such as: Pharmaceutics, biotech, medical diagnostics, health care, semiconductors, and chemicals processing.

The works included in this special issue are tutorial reviews, minireviews and original papers which treat different aspects of cooperative phenomena in flows.

The four introductory papers 1–4 discuss various aspects of granular flow and structures and flows in complex clay materials.

1. Granular material is a collection of macroscopic particles with a rheology quite different from that of molecular systems. The shear flow of dry and wet systems are discussed and compared.
2. The displacement of one fluid by another occurs in a range of natural and industrial settings. One example is oil recovery, where saline water replaces viscous oils extracted from the inter-particle space in porous reservoirs. Another application gaining considerable attention is the injection of CO_2 into suitable underground geological formations for mitigation of greenhouse gas emissions. The paper discusses the processes taking place when a compressible gas displaces a granular mixture in a quasi 2D space, and the friction causes stick slip motion.
3. In many natural and industrial situations, mixtures of granular materials and fluids are deformed. The paper discusses the case when submillimetric particles saturated with a fluid form a compact cluster on the top on a confined clear fluid of the same nature, they fall by detaching from the lower boundary of the cluster, and this separation front between particles and fluid is unstable. Particles detach and fall in the clear fluid region, giving rise to growing fingers of falling particles.
4. Clay materials are very complex systems and in order to understand and predict various macroscopic flow behaviors, it is crucial to know the underlying nanostructures in detail. The paper reviews recent advances in clay systems

from the geological example of quick clay flows and avalanches, to materials science and the stability, strength and flow of smart electrorheological clay structures.

The main focus of papers 5–8 is on flow aspects of biological systems ranging from flow of organisms in the oceans to flow inside cells and that of cells in confined regions.

5. Organisms often grow, migrate and compete in liquid environments, as well as on solid surfaces. However, relatively little is known about what happens when competing species are mixed and compressed by fluid turbulence. A review is given on the population dynamics and population genetics in compressible velocity fields of one and two dimensions.
6. The most important flow and transportation mechanism inside a living cell is diffusion. Various diffusion mechanisms are discussed.
7. Understanding how cells behave during flow and are distributed throughout the network of arteries, veins, and capillaries in the body has motivated numerous studies during the past decades. A review is given of the key developments in how flow in microfluidic devices are exploited to investigate the behavior of individual cells, from trapping and positioning single cells to probing cell deformability.
8. With the recent reports of global food shortages it is now more important than ever to have a clear understanding of processes that control crop growth. Cluster roots are thought to play an important role in mediating nutrient uptake by plants. The paper reviews a mathematical model for the transport and uptake of nutrients by a single root.

The last two papers review and discuss such widely aspects of flow as that of flow in flames and memory flows in cooperative phenomena.

9. The paper discusses how hydrodynamic flows are governed by complex nonlinear systems of equations and qualitative and quantitative characteristics of the flows depend on control parameters and boundary conditions. This process is illustrated using two spatio-temporal cellular states on a circular flame front.
10. The paper discusses key ideas that provide necessary insight for understanding Markov processes which is important in flow and cooperative phenomena.

This special issue on “Cooperative Phenomena in Flows: Multidisciplinary Perspectives” stems from a recent “Geilo School” (GS) [1], the twenty-first GS in a series held every two years since 1971 [2]. The objective of this GS was to bring together researchers with various interests and background including molecular biologists, theoretical physicists, soft condensed matter experimentalists, and social scientists to identify and discuss areas where synergism between modern physics, biology and social sciences may be most fruitfully applied to the study of various aspects of cooperative phenomena in flows involving many interdependent biological or inanimate components. Earlier GS have also discussed cooperative phenomena [3–8].

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References

1. Geilo, Norway, 4-14 April, 2011, A comprehensive list of lecturers, poster sessions and participants can be found in *Cooperative Phenomena in Flows - Geilo Advanced Study Institute* (2011) IFE Report IFE/KR/E-2011/002, `http://www.ife.no/publications/2011/fysikk`, ISBN: 978-82-7017-838-4 (electronic)
2. A list of previous Geilo schools may be found here: `http://www.ife.no/departments/physics/projects/geilo`
3. *Anharmonic Lattices, Structural Transitions and Melting*, edited by T. Riste (Noordhoff, Leiden, 1973)
4. *Fluctuations, Instabilities and Phase Transitions*, edited by T. Riste (Plenum, New York & London, 1975)
5. *Electron-Phonon Interactions and Phase Transitions*, edited by T. Riste (Plenum, New York & London, 1977)
6. *Nonlinear Phenomena at Phase Transitions and Instabilities*, edited by T. Riste (Plenum, New York & London, 1981)
7. *Multicritical Phenomena*, edited by R. Pynn, A.T. Skjeltorp (Plenum, New York & London, 1983)
8. *Phase Transitions and Relaxations in Systems with Competing Energy Scales*, edited by T. Riste, D. Sherrington (Kluwer, Dordrecht, 1993)