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Editorial: Editors' showcase 2023: granular matter

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Editorial on the Research Topic
Editors' showcase 2023: granular matter

Granular matter research spans a number of different techniques, measures, and approaches. On the theoretical front, there are (still) many questions regarding fundamental aspects such as packing and structure. Such considerations are commonly based on the discrete particle-scale approach, although significant inroads have also been reached in the development of continuum models. One obvious question is how to reach new insight allowing for bridging the scales from micro (particle) to macro (system) scale. Another set of questions involves various simplifications that are often considered and could be related to particle shape and interactions or the number of physical dimensions, among others. How useful are the results obtained using an idealized system to describe and understand physical experiments carried out in less ideal setups? On the experimental side, one could ask on one side what the best ways to incorporate theoretical findings are, and on the other one, how to upscale from the laboratory experiment scale to the one relevant to industrial-size applications.

The papers in this Research Topic touch on the number of questions listed above, illustrating the breadth of the field of granular matter research. They show both the progress made and the potential for further research.

The paper by Santos et al. focuses on one of the significant challenges in granular research: protocol dependence. The authors consider a seemingly very simple system of spherical granular particles exposed to various compression and relaxation protocols, motivated by the goal of understanding how and to which degree the considered protocols influence the results. An even more basic follow-up question involves the formulation of state variables: which and how many variables need to be specified to define precisely a granular system? While the answer to this question may depend on the specific system considered, the authors show that the question (and the answer) are not straightforward: even for the simple system considered, packing fraction and coordination (contact) number, for example, are shown not to be sufficient.

The paper by Carlevaro et al. follows further along the line of asking essential questions that may not be easy to answer. In this contribution, the authors consider one of the most common granular setups, a silo in a gravitational field with an opening at the bottom, and ask the following question: does the discharge rate depend on the size distribution of the particles? They consider mono- and bi-disperse distributions and measure the flow rate through the opening. The finding is that the particle size distribution does play a role, and even further, that the dependence on the parameter describing the deviation from mono-disperse distribution is nonmonotonous. Such a finding is not captured by the established Beverloo equation describing the flow and is also at odds with some of the more recent results in the literature. Once again, there is much more to be done!

The approach taken in the work by Arevalo attempts to bridge the gap from theory to applications by considering more involved mechanisms driving granular dynamics. The paper considers a mechanical stirrer that mixes the particles; the applications of interest are the systems where particles are used for temperature equilibration. The question is how to mix the particle efficiently, another question that has been around for a long time and has yet to receive a general answer. It is found in the paper, for example, that faster dynamics of the stirrer lead to faster mixing, which is not surprising. However, such dependence is discovered to be nonlinear, with unclear origins of nonlinearity. In any case, the paper provides precise predictions and will inspire experimental verifications that should explore the generality of the conclusions and explore another essential question related to upscaling.

The fourth contribution by Armanious et al. considers an application of granular matter: a granular-based filter, illustrating the ability of granular particles to serve as an absorbent of, in the considered case, airborne virus such as SARS-COV-2. The main finding is that granular matter (iron particles and protein nanofibrils are considered) provides high filtration efficiency. However, the price to pay is a large pressure drop across the filter and, therefore, a large energy expenditure. One hopes that simulations and theoretical approaches could be useful here to reduce the pressure drop but keep efficiency high. This paper clearly illustrates the significant potential of granular matter for developing useful devices, but also that much more needs to be learned about these systems.

The four papers in this Research Topic illustrate the significant progress of granular research and the number of unanswered questions in this exciting field of soft matter physics.

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