PARDIM10 – Scientific Report

Patrick Charbonneau,[1] Karen Daniels,[2] and Matthias Schröter[3]

[1] *Departments of Chemistry and Physics, Duke University, Durham, North Carolina, 27708, USA*
[2] *Department of Physics, North Carolina State University, Raleigh, North Carolina 27695, USA*
[3] *Max Planck Institute for Dynamics and Self-Organization, Bunsenstrasse 10, 37073 Göttingen, Germany*

(Dated: May 30–June 4, 2010)

From May 30-June 4, more than 60 chemists, engineers, mathematicians, and physicists from 5 continents gathered for a workshop at the Max Planck Institute for Complex Systems to address the question "Particulate Matter: Does Dimensionality Matter?" The main focus of the conference was to better understand industrially-important materials, such as sand, glasses, colloids, foams, and emulsions by comparing their behavior – and that of related models – in 2, 3, and more dimensions. Looking at the world from a dimensional lens helped 19th century *Flatland* readers grasp the metaphorical role of the fourth dimension; higher dimensions can also help scientists shine new light on our relatively low-dimensional world. A flat layer of coins pushed together on a tabletop and a pile of oranges on a grocer's stand have both similarities and differences. They are both the densest possible packing of spheres in their respective dimensions, but the way in which they form, support stress, and rearrange, are different. Computers allow us to contrast similar systems in even higher dimensions. The scientific discussion was lively: not all participants agreed about the role of disorder and randomness, or even the importance of the number of dimensions. Yet, certain lines of agreement have started to appear, as well as key regimes in which to conduct future investigations.

The original motivating scientific question was raised to a higher level than the organizers had anticipated. A new awareness of where to look for similarities and differences in dimensionality has arisen. For example, Corey O'Hern provided a provocative list of 16 dimension-independent properties of dense particulate matter. Friction, polydispersity, temperature, and particle shape are also important variables, but isolating the possible impact of dimensionality from these other factors is necessary if one hopes to make sense of the results.

A particular emphasis on the dynamics and structure of disordered systems was noted. On the one hand, the role of dimensionality in theories of jamming and the glass transition led to animated discussions about the physical basis and range of validity of the many analytical approaches explored by various groups. The state of the question and the nature of the challenges ahead have become clearer as a result. On the other hand, the description of order and geometry in disordered systems using local parameters that are accessible in both simulations and experiments – and a need to understand how these different measures differ from each other – allowed the identification of parallel challenges in separate scientific communities.

Several participating groups currently in a race to find the densest possible packing of tetrahedra were present. Record-holder Sharon Glotzer gave a lively presentation of the history of the race. Various novel techniques that this packing problem has spawned were also presented, which opened a line of conversation on combining analytical tools with computational methods in higher dimensions. Connections of packing problems to disordered biological systems were enlightening to many in the community, and will probably yield new research directions.

All postdocs and graduate students had posters and/or talks, and extensive lively discussions with senior participants during meals and breaks. Female graduate students and postdocs in particular were observed to network extensively with each other and with senior participants, which lays the groundwork for their future collaborations.

Overall, the week-long meeting allowed the researchers to spend a focused period of time discussing these issues, allowing them develop ideas for future research directions, and to capture the momentum created by these often independent developments taking place around the world.