Spring 2012 COLLOQUIUM SERIES

GRANULAR AND MULTIPHASE FLOWS

Sponsored by

The Granular Science Laboratory

Prof. Joe Goddard

Department of Mechanical and Aerospace Engineering

University of California, San Diego

Wednesday, March 28, 2012

2:30 – 4:00 p.m.

Guttenberg Information Technologies Center(GITC) room 3710

Playing in Sand for Science, Engineering and Amusement (or Life without kT)

The past forty years or so have seen a resurgence and continual growth of interest in the mechanics of granular materials, whose scientific origins go back at least to the 18th Century. The subject is relevant to a number of geotechnical and technological processes, such as stability of slopes and natural avalanches, mechanics of desert sands, and vibratory conveying and compaction. The challenge of understanding and mathematically modeling these materials and processes has attracted researchers from a wide array of disciplines, ranging from soil mechanics to theoretical physics, who often bring opposing scientific philosophies and methodologies to the subject.

In contrast to molecular solids and fluids, whose relatively small particles are governed by reversible (“frictionless") intermolecular forces and strong thermal motion (“kT"), the typical granular material consists of particles ranging in size from microns to meters, whose individual and collective motion is dominated by frictional contacts and external forces such as gravity. This rules out traditional molecular-kinetic theory and statistical mechanics, but the number of particles in such systems makes a brute-force numerical description impractical for most purposes. Hence, one important challenge is the development of continuum models of the kind that have proved indispensable for traditional solid and fluid mechanics.

This lecture provides a broad view of the field, starting with a review of several fascinating phenomena such as Reynolds dilatancy, Faraday patterns on vibrated layers, microscopic force chains, mechanical arching, and shear bands, with an attempt to relate these qualitatively to geotechnical and technological processes mentioned above. Finally, a discussion is given of continuum modeling and numerical simulation of granular materials in flow regimes that may be roughly characterized as solid, liquid and gas, and several outstanding theoretical problems are identified. A principal conclusion is that multiscale or “multipolar" continuum models involving additional kinematic degrees of freedom, such as “micromorphic" variables or higher gradients of strain and conjugate “hyperstresses", may be essential to the rheology of granular media, particularly the viscoplastic behavior. Because of the typical particle sizes, this becomes more compelling for granular media than for other complex solids and fluids.

Professor Goddard received his Ph.D. in chemical engineering from the University of California, Berkeley in 1962. He joined the chemical engineering faculty of the University of Michigan in 1963, and in 1976 he accepted the position of Fluor Professor and Chair in the Department of Chemical Engineering at the University of Southern California. He has been Professor of Applied Mechanics and Engineering Science at the University of California, San Diego, since 1991. He has published research in a wide number of fields, including the mechanics of complex fluids and solids, and the thermodynamics and transport properties of physical and biological systems. His professional distinctions include, NATO, NSF and Fulbright Postdoctoral and Senior Postdoctoral Fellowships, 1963-84. Fluor Professor of Chemical Engineering, USC, 1976-91. D.L. Katz Lecturer, University of Michigan, 1983, President of the U.S. Society of Rheology, 1991-93. He has served on the editorial boards of the AIChE Journal, The Journal of Non-Newtonian Fluid Mechanics, Continuum Mechanics and Thermodynamics, The Annual Review of Fluid Mechanics, and The International Journal of Engineering Science. He has also served on several U.S. national award and advisory committees, including the AIChE, the Fulbright Foundation, and the NASA Discipline Working Group for Fluid Physics. He has been visiting researcher or professor at several institutions, including the Department of Applied Mathematics and Theoretical Physics in the University of Cambridge, U.K., the Katholieke Universiteit Leuven, Belgium, the Kavli Institute of Theoretical Physics, University of California, Santa Barbara, the Isaac Newton Institute in the University of Cambridge, U.K., various CNRS laboratories in France, and in 2011, the Department of Mechanical Engineering in the Ben Gurion University of the Negev, Beer Sheva, Israel, the Department of Mechanics and Materials in the Aristotle University of Thessaloniki, and the Laboratoire d’Hydrodynamique in the École Polytechnique, France.

For further information, please contact Dr. A. Rosato, MIE Department (rosato@njit.edu; 973-596-5829)