JOHNS HOPKINS
WHITING SCHOOL
of ENGINEERING

Department of Civil Engineering and CISMMS

Center for Integrated Structure-Materials Modeling and Simulation

GRADUATE SEMINAR

Nonlinear Composites Materials

All materials exhibit nonlinear constitutive response (e.g., plasticity, magnetic saturation) at sufficiently large mechanical or other stimuli. Partly for tor this reason, it is necessary to develop general methods for estimating the macroscopic response of nonlinear composites, or heterogeneous materials with constituents exhibiting nonlinear response. For material systems with specific microstructures and types of nonlinearity, special "micromechanical" models have been developed, which often work very well for the special set of conditions for which they where developed, but which are difficult to generalize, or which don't work so well more generally. In this presentation, I will discuss a more general "homogenization" approach that is based on the notion of a "linear comparison composite" making use of appropriately designed variational principles. Such "variational linear comparison" methods provide optimal linearization schemes allowing the direct conversion of robust homogenization estimates for linear composites into corresponding estimates for nonlinear composites. We will consider several examples ranging from plasticity of composites and polycrystals to magneto- and electro-active composites to fluid suspensions of soft particles. The objective will be to show how these methods can be used to generate relatively simple (quasi-analytical) estimates for the macroscopic response---and field statistics---which can, in turn, be used to develop constitutive subroutines (UMATs) for use in standard finite element simulations at higher (structural) length scales. These homogenized models have the capability to account for coupled effects, microstructure evolution under finite strain conditions, as well as for the possible development of material instabilities.

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Pedro Ponte Castañeda is currently Raymond S. Markowitz Faculty Fellow and Professor in the Department of Mechanical Engineering and Applied Mechanics, and Member of the Graduate Group in Applied Mathematics and Computational Science at the University of Pennsylvania. He earned a B.S. in Mechanical Engineering and a B.A. in Mathematics from Lehigh University in 1982, and an S.M. in Engineering Sciences and a Ph.D. in Applied Mathematics from Harvard University in 1983 and 1986, respectively. Prior to joining Penn, he was Assistant Professor of Mechanical Engineering at the Johns Hopkins University (1987-90). He was also Professor of Mechanics at the École Polytechnique (2004-08; part time 2006-08). He is currently Associate Editor of the *Journal of Mechanics and Physics of Solids* and the *Journal of Elasticity*. He is an ASME Fellow and his honors include the ASME/AMD's Special Achievement Award for Young Investigators in Applied Mechanics (2000), the George H. Heilmeier Faculty Award for Excellence in Research from Penn's School of Engineering and Applied Science (2007), the Humboldt Senior Research Award (2013) and the ASME Warner T. Koiter Medal (2016).

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