LMS Seminars 2024 – 25

Continuum Modeling of Mechanical Feedback and Stress Relaxation in Growth-Elasticity: Theory and Applications

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Date and Time: May 15, 2025 (2 – 3 pm)
Venue: Amphi 104 (Pole Meca)

Abstract

Proliferating living tissues both generate and relax mechanical stresses—and, in turn, their growth responds to these stresses. Yet it remains unclear how complex patterns of tissue growth and flow emerge from these interactions. In this talk, I will present an Eulerian framework for chemo-mechanical regulation of growth, grounded in thermodynamic consistency within the theory of multiplicative growth-elasticity. Using an energy variational approach, we derive a novel formulation that couples elastic and chemical energies, where mechanical feedback on the volumetric growth rate arises from total energy dissipation during growth—converting chemical energy into mechanical energy—and deviatoric stress relaxes via isochoric rearrangement. We apply the model to explain quasi-circular flow modulation in in vitro partial EMT (epithelial–mesenchymal transition) tissues, where cells remain connected to their neighbors but mechanical interactions may be weaker than in fully epithelial states. In this case, stress relaxation is necessary for the proliferating tissue to close. Focusing on mechanical feedback, we also apply the model to reproduce growth curves of tumor spheroids in agarose gels (Helmlinger et al., 1998) and in semipermeable membrane environments (Montel et al., 2011). Finally, I will describe the numerical methods developed for both the Eulerian framework and its Lagrangian counterpart. (This work is joint with John Lowengrub, Nonthakorn Olaranont, and Chaozhen Wei. The experimental study of wound closure involves the lab of Yubing Sun at UMass Amherst and the lab of Qi Wen at WPI.)

About the speaker

Min Wu is an associate professor at the Department of Mathematical Sciences, Worcester Polytechnic Institute, and its Bioinformatics and Computational Biology program since 2023. She is interested in understanding growth-driven tissue morphogenesis, through modeling, computation, and data-theory integration approaches. She received her masters and PhD degrees from the University of California, Irvine, followed by a post-doctoral stint at the ENS Paris.

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