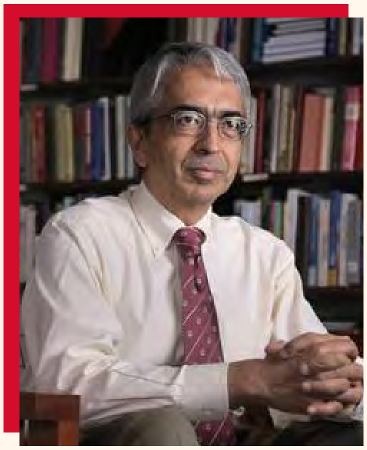
Oct 22, 2020

On the Mechanics of Surface Growth



Rohan Abeyaratne

Professor
Department of Mechanics,
Massachusetts Institute of Technology, Cambridge, MA

ABSTRACT:

Continuum mechanical modeling of surface growth requires some non-standard considerations. I will discuss some them in this talk including (a) the evolving nature of the reference configuration; (b) the nonstandard boundary conditions that couple diffusion to growth; (c) the driving force associated with surface growth; and (d) the phase transition that occurs in the interior of the growing body. I will illustrate the theory by briefly touching on a problem involving growth, either on the surface of a spherical bead or under spring loading conditions, where the build-up of stress at one surface slows down accretion, while the increase in strain energy at the other surface promotes ablation. Eventually, the system reaches a point where accretion is balanced by ablation, a regime referred to as "treadmilling". I will discuss the existence, uniqueness and stability of such configurations. This is joint work with Tal Cohen (MIT), Eric Puntel (University of Udine) and Giuseppe Tomassetti (University of Rome III). The rest of the talk will be devoted to joint work with Prashant Purohit (University of Pennsylvania) on modeling the intriguing experiments of Parekh et al. (2005) and Brangbour et. al. (2011) on growing dendritic actin filament networks. Parekh et al. polymerized dendritic actin between two AFM cantilevers and found that the elongation-rate was independent of the force over a range of force and this was followed by a convex curve in which polymerization stalled over a short range of force. They also demonstrated that the elongation-rate was loading history dependent and in particular that there could be two (or more) steady state elongation-rates at the same force. Some of these findings were confirmed in the later experiments of Brangbour et al. who used magnetic beads to control the force resisting polymerization. Both of these sets of experiments led to similar elongation rate-force relations that were strikingly different.

BIOGRAPHY:

Rohan Abeyaratne is the Quentin Berg Professor of Mechanics at MIT. From 2009-2013 he was the CEO & Director of the Singapore-MIT Alliance for Research and Technology (SMART), MIT's largest international program. Prior to this, Professor Abeyaratne was the Head of the Department of Mechanical Engineering at MIT from 2001-2008 and its Associate Department Head from 1996-2001. He has held visiting faculty positions at the California Institute of Technology, University of Cambridge, University of Minnesota, National University of Singapore and the Nanyang Technological University. Professor Abeyaratne is a Fellow of ASME and a Fellow of the American Academy of Mechanics. He is the recipient of ASME's 2010 Daniel Drucker Medal conferred in recognition of distinguished contributions in research and education to the field of Mechanical Engineering. He has served on the editorial boards of four international journals, is a member of the scientific advisory boards of several universities. Furthermore, he served a two-year term as President of the American Academy of Mechanics. Professor Abeyaratne's research interest is in the field of theoretical mechanics where he is particularly known for his work on the dynamics of phase transitions. He has published extensively, including three books, the "Evolution of Phase Transitions", "Mathematical Preliminaries: Volume I of the Mechanics of Elastic Solids" and "Continuum Mechanics: Volume II of the Mechanics of Elastic Solids". Professor Abeyaratne is the recipient of a MacVicar Fellowship, MIT's highest award for education. Professor Abeyaratne received his B.Sc. in Mechanical Engineering from the University of Ceylon (1975), and his M.Sc. (1976) as well as Ph.D (1979) degrees from the California Institute of Technology.