Models of legged locomotion, or How cockroaches run stably without thinking about it.

Philip J. Holmes
Princeton University, USA

I will discuss joint work with John Schmitt, Raffaele Ghigliazza, Justin Seipel, Raghavendra Kukillaya and Manoj Srivivasan, in which nonlinear mechanics and dynamical systems theory meet biology. Motivated by Robert Full's experimental studies of running insects at UC Berkeley, we propose a heirarchy of models for the dynamics of legged locomotion in the horizontal plane. We start with energetically-conservative bipedal models (each leg corresponding to the front/rear/opposite-middle tripod used by many insect species), and move on to describe a central pattern generator of bursting neurons linked via simplified muscles to more realistic hexapedal leg geometries. We show that piecewise-holonomic mechanics due to intermittent foot contacts can confer strong asymptotic stability. We stress the relevance of simple models, and show how phase reduction and averaging allow significant simplification of complex neuromechanical models.