Line Defect dynamics and solid mechanics

Continuum mechanics has been a successful model for studying macroscopic deformations and the forces causing them. The usual framework allows the study of continuous deformations giving way to surfaces of discontinuity, but does not provide an adequate framework for considering the dynamics of the terminating lines of surfaces of discontinuity, were such to occur. It turns out that such terminating lines of surfaces of discontinuity serve as a model of common line defects that arise in a host of materials; dislocations and grain/phase boundary junctions in crystalline and soft matter. I will describe a framework for considering line defect dynamics within continuum mechanics. I will show how the kinematics of line defect dynamics provides a unifying theme for describing the defects mentioned above, resulting in an augmentation of the classical balance laws of continuum mechanics with a microscopic conservation law for topological charge carried by these defect lines. The theory will be illustrated with examples related to dislocation dynamics with inertia, the computation of fields of interfacial defects like the star disclination and grain boundary disconnections, and a rationalization of the possible mobile defects in a metallic glass as 4-6 disclination pairs in a uniformly geometrically frustrated medium of static 5-fold disclination lines.

This is joint work with Chiqun Zhang, Xiaohan Zhang, and Michael Widom.