MATERIALS ENGINEERING SEMINAR

"The Statistical Foundations of Line Bundle Continuum Dislocation Dynamics"

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ABSTRACT

A first-principles theory of plasticity in metals currently does not exist. While many plasticity models make reference to rules based on heuristic arguments regarding dislocations (the fundamental mediators of plastic deformation in crystals), the scientific community still does not have a theory of dislocation dynamics which can recover even basic features of plasticity theory. Discrete dislocation dynamics, though a valuable tool for understanding fundamentals topics in dislocation plasticity, becomes unusable beyond ~1.5% strain due to the line length multiplication inherent in deformation. As a result, it is necessary to develop continuum theories of dislocation dynamics which treat dislocation densities rather than individual dislocations. This thesis examines the foundations of one such continuum theory: line bundle continuum dislocation dynamics, which assumes that dislocations are roughly parallel at every point. First, this assumption is given definite meaning and it is shown from discrete dislocation dynamics data that to be appropriate when modelling dislocation densities on fine length scales (resolving densities on lengths less than 100 nm). Second, it is found that an additional driving force, the correlation stress, emerges from coarse-graining the line bundle dynamics. This correction to the dislocation interactions is dependent on tensorial dislocation correlation functions describing the short-range errors in the products of dislocation densities lying on two slip systems. The full set of these dislocation correlation functions are evaluated from discrete density data with the aid of a novel left-and-right handed classification of slip system interactions in FCC crystals. Lastly, a study of the correlation stress in a representative dislocation system suggests that these stresses are roughly one tenth the magnitude of the mean-field dislocation interaction stress. Taken together, this thesis bridges discrete and continuum models of dislocation dynamics and provides a foundation for future work on a first-principles theory of metal plasticity.

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Place: ARMS 1021 or via the link: https://purdue.webex.com/join/aelazab

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