THE MODERN FRAMEWORK OF ANISOTROPIC LINEAR ELASTIC DISLOCATION THEORY AND ITS INCORPORATION INTO NUMERICAL MODELING AND SIMULATION

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This keynote address will focus on (a) the current state of the theory of dislocations in anisotropic linear elastic solids and (b) the ongoing incorporation of this framework into numerical modeling and simulation of non-elastic deformation in solids. We regard the deforming body as elastic, with the non-elastic (plastic) deformation arising from the motion of dislocation lines (loops) in the solid according to an appropriate empirical Peach-Koehler Force - dislocation velocity law for the medium considered. To this end, computer simulation of the interactions and behavior of a very large number of curvilinear dislocations requires the ability to accurately and efficiently compute (and to re-compute) dislocation stress fields at many material points in an efficient way.

The theory for determining the elastic field of a single dislocation loop in an unbounded linear elastic medium of arbitrary anisotropy is quite complete, but is not particularly well-known outside a small number of researchers. We begin by motivating the necessity for anisotropic computations and by reviewing the current state of the theory. This will be followed by a description of the framework for curvilinear dislocations in a half-space, including situations in which dislocations pierce the half-space boundary.

For two-dimensional modeling involving only infinitely long straight dislocations, a Fast Multipole Method (FFM) as suggested by Greengard and Rokhlin and introduced in isotropic dislocation computations by LeSar and Wang can be profitably extended to the general anisotropic case to study dislocation motion under externally imposed stresses. Although Rodin has shown how the FFM can me used in modeling 3-dimensional dislocation loop interactions in isotropic media, the method has yet to be extended to general anisotropy, essentially because a scheme to separate source and field points in a re-usable way as required by the FMM has not been advanced for anisotropic solids.

Finally, time-permitting, other topical issues (including self-forces on dislocations) will be discussed from both a theoretical and computational viewpoint.