New Methodologies for Calculating Polycrystalline Materials: Cyclic Plasticity and Reduced Order Modeling

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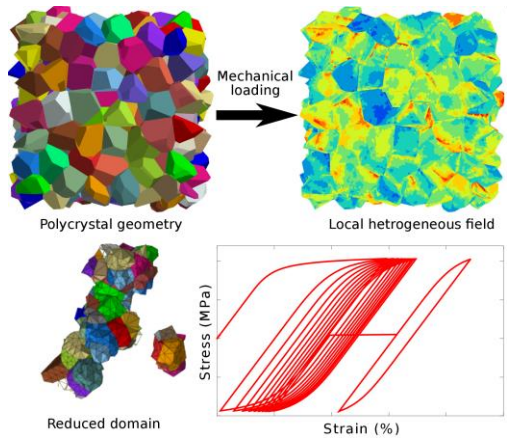

- The development of plasticity in polycrystalline materials over large numbers of simulated cycles is a pending issue.
- Mean stress relaxation and ratcheting under asymmetric cyclic loadings to be simulated.
- Need of data science approaches for crystal plasticity simulations: Reduced Order Models

Abstract:

We know that the local mechanical behavior in metallic materials is anisotropic and complex laws are needed for its modeling. More importantly, engineering components can be designed to meet specific needs if we can successfully relate these local properties to the actual response of a structure. In this thesis a new way of simulating the cyclic behavior of polycrystalline materials, which aims to link their micro and macromechanical properties is presented. Two different routes, mean field and finite element models, are taken to estimate the cyclic response of metallic materials. Finite element computations on polycrystal aggregates give a detailed response of all the local interactions but in the process they makes us pay a large computational cost. To date, little progress has been made to classify the complex behavior of evolving stresses and strains at a larger number of simulated cycles. We use model reduction techniques to focus on particular clusters of grains which help in quantifying the nonlinear evolution of plastic strains at the local level. As we focus on the microstructural level, the number of parameters effecting a polycrystal's mechanical response increase. Given that we are able to simulate high numbers of cycles, the nonlinear effect of these parameters is also quantified. In particular focus are the phenomena of ratcheting and mean stress relaxation which require large numbers of simulated cycles to reach their asymptotic values. Low cycle fatigue in a nickel iron based superalloy (Inconel 718) will be used as a test case.