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Orowan Looping with Platelet-like Precipitates in Overaged Aluminum-Copper Alloys

Ryan B. Sills[a,b] and Wei Cai[b]

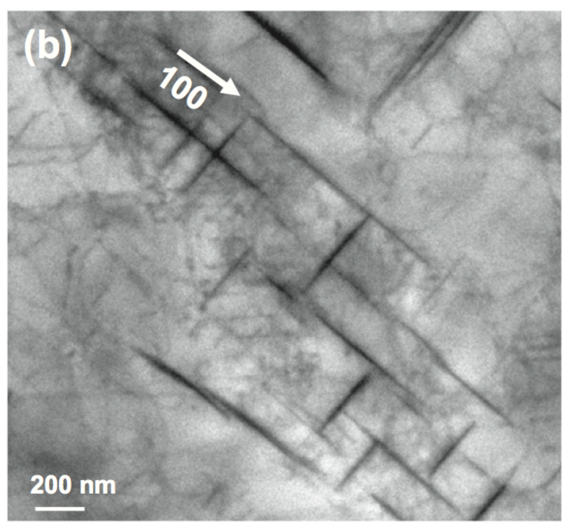
[a] Sandia National Laboratories, Livermore, CA 94551, USA

[b] Department of Mechanical Engineering, Stanford University, CA 94305, USA

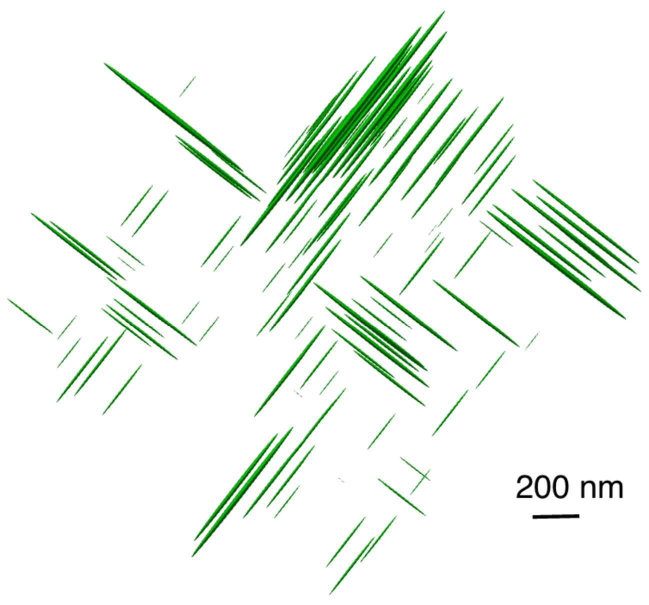
Introduction

Aluminum-copper alloys can exhibit four types of platelet-shaped precipitates, depending on copper content and aging treatment. Arguably, most important are so-called ***θ***′ precipitates which have:

- Average diameter ≈ 400 nm
- Semi-coherent misfit at perimeter



TEM of ***θ***′ precipitates[1]

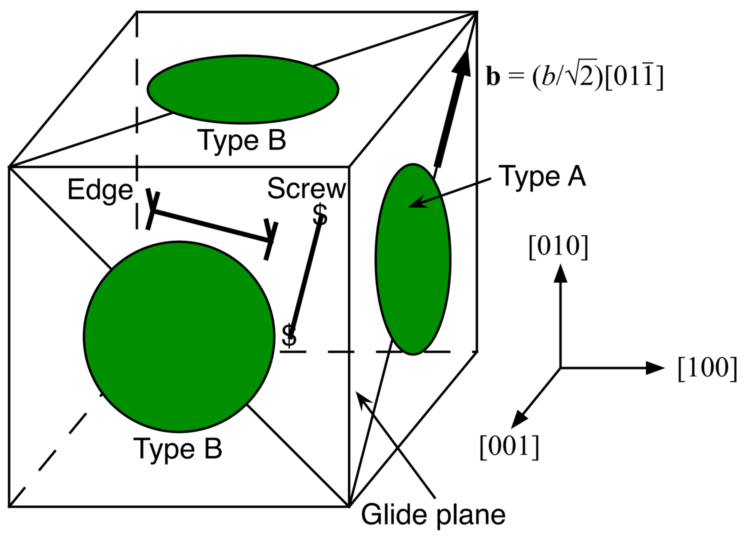


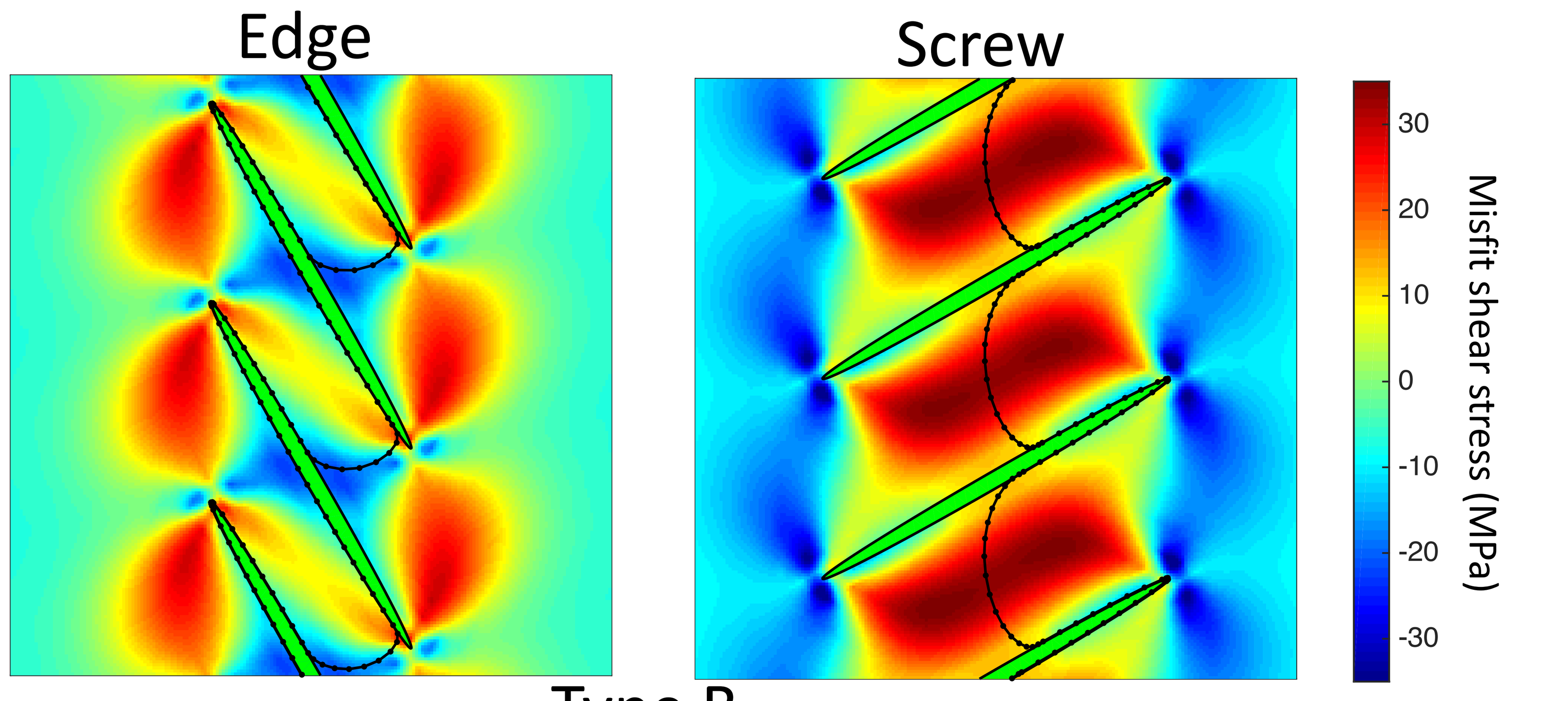
Research Questions

- How does platelet shape affect Orowan looping?
- How significant is misfit strengthening?
- Optimal precipitate microstructure for strength?

Simulation Geometry

- {001} habit planes
- Two "types" of precipitates
- Intersect glide planes obliquely





Type B

Methods

New DD algorithms developed and implemented in ParaDiS[2] for ellipsoidal precipitates:

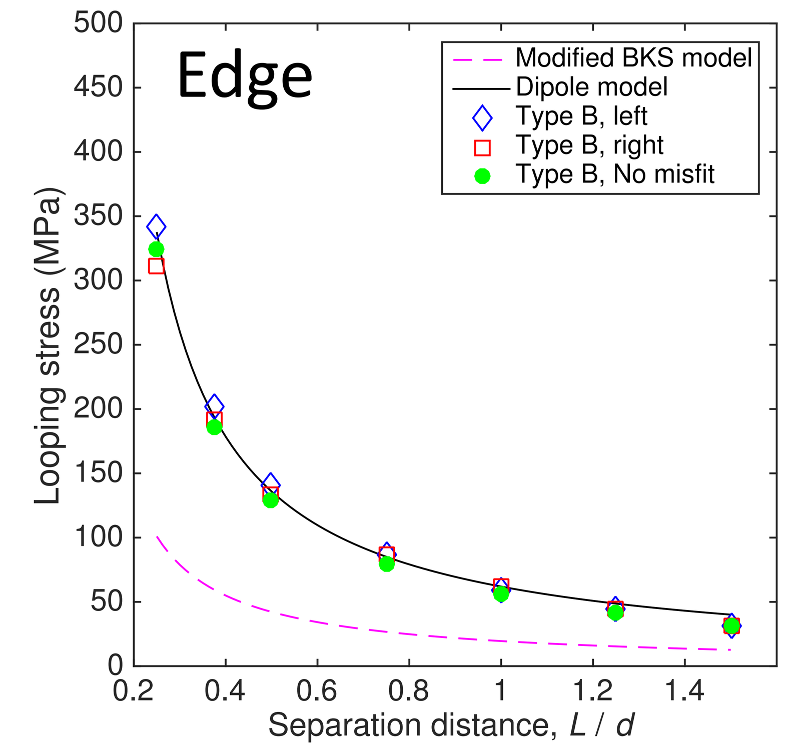
- Segment-precipitate collisions
- Remeshing at precipitate surface
- Misfit force for arbitrary eigenstrain

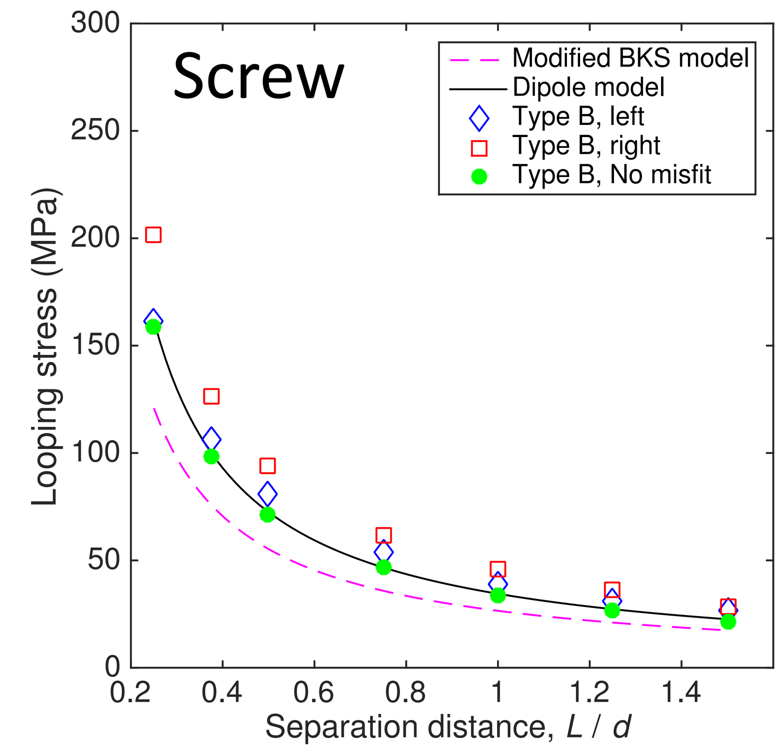
Results

Looping stress increases with reduced separation, but does not obey Bacon-Kocks-Scattergood[3] relation:

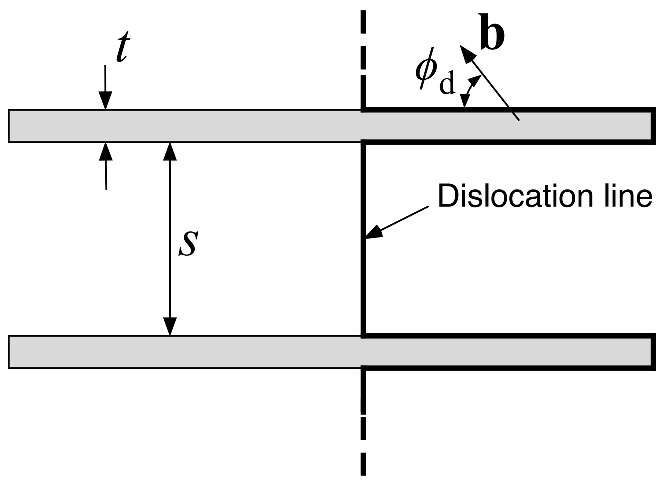
$$\tau_{BKS} = A\left(\frac{\mu b}{L-d}\right)\left[\ln\left(\frac{X}{r_c}\right) + B\right]$$

$$X = \left[(L-d)^{-1} + d^{-1}\right]^{-1}$$





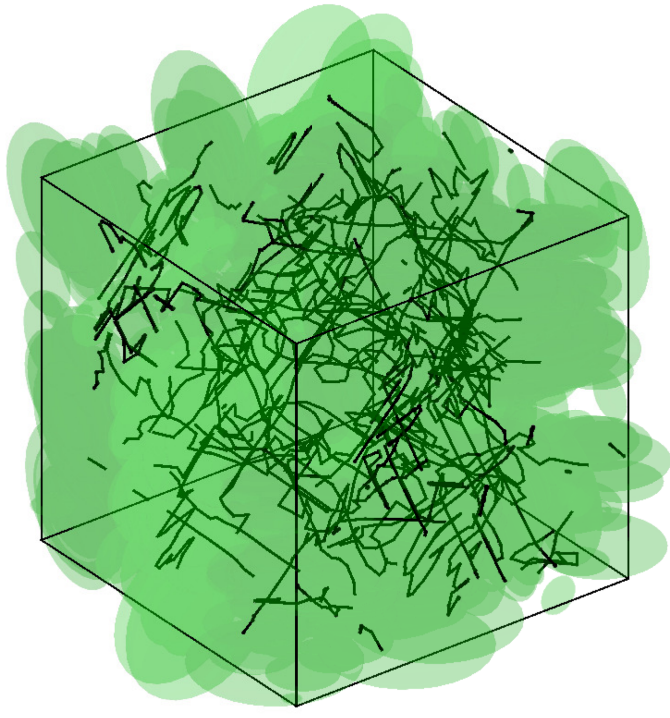
Constructed new Orowan looping model based on energy necessary to form dipoles across precipitates:



$$\tau_{dipole} = A\left(\frac{\mu b}{s}\right)\left[\ln\left(\frac{t}{r_c}\right) + B\right]$$

Future Work

- Large-scale simulations with realistic microstructures
- Precipitate cutting model development



References

[1]A. Biswas, D. J. Siegel, C. Wolverton, and D. N. Seidman. Acta Mater. 59 (2011).
[2]A. Arsenlis *et al*. Modell. Mater. Sci. Eng. 15 (2007).
[3]D. J. Bacon, U. F. Kocks, and R. O. Scattergood. Phil. Mag. 28 (1973).

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