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# ANALYSIS OF KINK DEFORMATION USING DISCLINATION MODEL

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## 1 Introduction

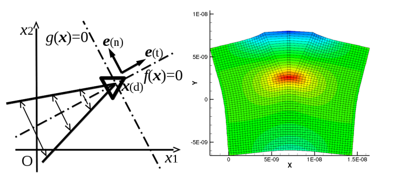
The realization of a specific array of lattice defects due to their cooperative motion is important for formation of kink band in long period stacking ordered structure(LPSO). In this work, we mainly discuss wedge disclinations to understand the essence of the deformation, mechanical phenomena.

## 2 Lattice defect model

To solve the boundary value problem including dislocations and disclinations, discrete dislocation plasticity based on analytical solution[1, 2] is applicable. There are some other effective approaches which can deal with the discontinuity of displacement with lattice defect such as the extended finite element method (XFEM)[3]. We introduce the following equation to take into account an wedge disclination with Frank vector $\omega$ as shown in Fig. 1(a).

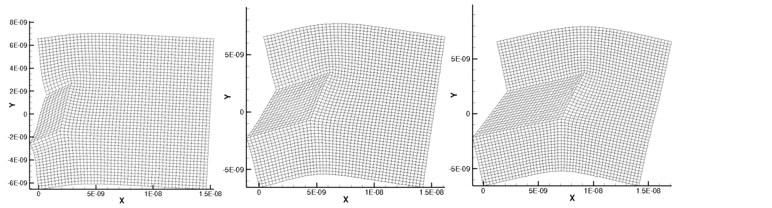
$$\boldsymbol{u}(\boldsymbol{x}) = \sum_I N_I(\boldsymbol{x})\boldsymbol{d}_I + \sum_J N_J(\boldsymbol{x})\boldsymbol{\Gamma}(\boldsymbol{x}), \quad \boldsymbol{\Gamma}(\boldsymbol{x}) = 2g(x)\tan\frac{\omega}{2}\Phi(f(\boldsymbol{x}))\Psi(g(\boldsymbol{x}))\boldsymbol{e}^{(n)} \quad (1)$$

where $\boldsymbol{u}(\boldsymbol{x})$ is displacement at position $\boldsymbol{x}$, $\boldsymbol{d}_I$ is displacement of node, $N_I$, $N_J$ are interpolation function of entire node and of enrich node, respectively. $\boldsymbol{\Gamma}$ is the function related to jump of degree of freedom added for discontinuity. We can find appropriate solution of opening type discontinuity of displacement field by using a generalization of this procedure. A calculated result of distribution of stress on deformed mesh are shown in Fig. 1(b).



(a) Model (b) Stress $\sigma_{xx}$

**Figure 1**: Model and result of analysis for wedge disclination



(a) $w/l = 1/6$ (b) $w/l = 1/3$ (c) $w/l = 1/2$

**Figure 2**: Kink deformation described by disclination quadrupole

## 3 Kink model of disclination quadrupole

The disclination dipole consisting of positive and negative disclinations corresponds to edge dislocation arrangement within limited segment[4]. We set up kink model of LPSO alloy by using disclination quadrupole. Figure 2 shows the changed shape of analysis results of boundary value problems with internal eigen strain, where $w$ and $l$ are representative dimensions of kink region and specimen, respectively. According to combination with calculation of the configurational force due to external force, it is possible to obtain the growth process of kink deformation with temporal evolution.

## 4 Conclusions

We proposed new analysis idea of kink deformation with LPSO structure based on the solving lattice defect with XFEM and disclinations quadrupole.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## REFERENCES


[1] E. Van der Giessen and A. Needleman. Discrete dislocation plasticity: A simple planar model, *Model. Simul. Mater. Sci. Eng.*, Vol. **3**, 689-735, 1995.

[2] A. Nakatani, H. Kitagawa, M. Sugizaki. Discrete dislocation dynamics study of fracture mechanism and dislocation structures formed in mesoscopic field near crack tip under cyclic loading, *JSME Int. J., A.*, Vol. **42**, 463-471, 1999.

[3] R. Gracie, G. Ventura, and T. Belytschko. A new fast method for dislocations based on interior discontinuities, *Int. J. Num. Meth. Engng.*, Vol. **69**, 423-441, 2007.

[4] A. E. Romanov and V. I. Vladimirov. Disclinations in crystalline solids, in F. R. N. Nabarro (eds.), *Dislocation in Solids*, Vol. **9**, 191-402, North Holland, 1992.