where K_{ic}^0 is the fracture toughness in linear elastic case ($= \sqrt{EG_{ic}^0}$ or $\sqrt{2\gamma_s E}$); r_i^*, the plastic zone size; and $E_0 \propto E^{-1}$. The E_0 in Eq. (1.2.6) is proportional to the inverse of the elastic modulus of materials, and $F_i(\theta)$, the angular dependent function respectively. θ_0 is the direction of $r_{\max}^*$ of the plastic zone.

Comparing Eqs. (1.2.6) with (1.2.5), the two approaches lead to the same conclusion that γ_s plays the role of a multiplying factor in the expression of critical crack extension forces. For a multiplying factor,

$$\frac{\Delta(\gamma_s f)}{(\gamma_s f)} = \frac{\Delta\gamma_s}{\gamma_s} + \frac{\Delta f}{f}\,. \tag{1.2.6$'$}$$

The relative change of γ_s is as important as that of f. If we consider the underlying role of atomic forces in the structure of dislocation core and dynamics, the role of interatomic forces is not only in the surface energy term but also in the dislocation core structure.

1.3. *Peierls Stress and Barrier*

A dislocation experiences an oscillating potential energy as it glides in a crystal. In the Peierls model (Peierls, 1940), the bonds across the glide plane were considered to interact via an interatomic potential, while the remainder of the lattice was linearly elastic. Nabarro (1957) gave an analytical expression for the dislocation core model. One can approximately estimate the ideal lattice resistance to dislocation motion by means of the Peierls model. The resolved applied stress necessary to move the dislocation over the Peierls barrier is called the Peierls stress, σ_p. The Peierls stress comes from the expression for the Peierls energy which changes for a translation of the dislocation by a distance smaller than the Burgers vector.

Figure 1.1, reproduced from Nabarro (1967), shows the Peierls model of a dislocation. The material above A and below B is regarded as forming an elastic continuum. The force between the rows A and B is a periodic function of the displacement.

As the dislocation moves through the lattice, it passes through an unsymmetrical configuration to a different symmetrical configuration in which one half plane of atoms on the expanded side of the glide plane lies midway between two half planes on the compressed side. Further motion passes through unsymmetrical configurations back to a state equivalent to the original. The dislocation moves if a finite force acts on it. The critical stress is the Peierls stress. After a lengthy calculation, the approximate energy of misfit

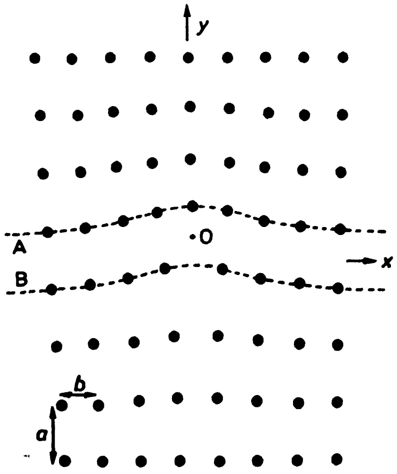

Fig. 1.1. Peierls's model of a dislocation. The material above A and below B is regarded as forming an elastic continuum. The force between the rows A and B is a periodic function of the displacement.

is given by (Nabarro, 1967)

$$E = \left[\frac{b^2\mu}{4\pi(1-\nu)}\right]\left\{1 + 2\cos 4\pi\alpha \exp\left(\frac{-4\pi\zeta}{b}\right)\right\}. \tag{1.3.1}$$

The force acting on unit length of the edge dislocation is,

$$F = -\left(\frac{1}{b}\right)\frac{dE}{d\alpha} = \frac{2b\mu}{(1-\nu)}\sin 4\pi\alpha \exp\left(\frac{-4\pi\zeta}{b}\right) \tag{1.3.2}$$

where $\zeta = \frac{a}{2(1-\nu)}$ is a parameter measuring the width of dislocation, αb, the displacement of the centre of the dislocation from the original equilibrium position, μ, the shear modulus and ν Poisson's ratio.

The maximum value of Eq. (1.3.2) is the critical shear strength; the Peierls stress is given by

$$\sigma_p = \frac{2\mu}{4\pi(1-\nu)}\exp\left(\frac{-4\pi\zeta}{b}\right). \tag{1.3.3}$$

Considering the spirit of this model, and extending the displacement of the centre of the dislocation to include the thermal vibration amplitude, the temperature dependence of the crss can be obtained (see Lung *et al.*, 1966; or later Sec. 10.3).