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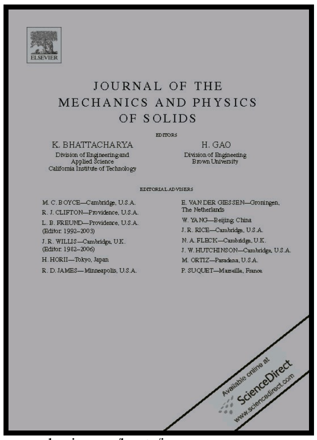

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A Newtonian interpretation of configurational forces on dislocations and cracks

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ABSTRACT

Configurational forces are fundamental concepts in the description of the motion of dislocations, cracks and other defects that introduce singularities within the solid state. They are defined by considering variations in energies associated with the movement of such defects, and are therefore different from the classical forces that enter the balance laws of classical Newtonian mechanics. Here, it is demonstrated how a configurational force can be viewed as the resultant of the (Newtonian) contact forces acting on the perturbed shape of an object of substance equivalent to the defect, and evaluated in the limit of the shape being restored to the primitive configuration. The expressions for the configurational forces on the paradigmatic examples of cracks and dislocations are in agreement with those determined using classical variational arguments. This finding opens a new prospective in the use of configurational forces by permitting their physical and intuitive visualization.

Keywords: Configurational forces; Eshelbian forces; Newtonian mechanics; dislocations; cracks; perturbative methods; J-integral

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1 INTRODUCTION

The states of stress and strain and their associated strain energy within an elastic body free of external actions is a subject that has been studied for more than one century. Such a condition may be produced, for example, by removing or adding a thin slice of material bounded by two planes and then rejoining the resulting material surfaces. The general theory of *dislocations* developed by Vito Volterra , relying upon fundamental work of Ernesto Cesàro, permits the description of elastic states of this kind using a very limited number of variables including the elastic constants and the thickness and location of the geometric construct. In the atomistic physical theory of the solid state, the term “defect” more generally applies to different types of imperfections of the crystal lattice, which can develop and propagate as a consequence of the re-arrangement of the interatomic distances. The movement of imperfections is regulated by the neighboring environment, which may involve the presence of solute atoms in the crystalline lattice or the interaction with other defects, in such a way that the ensemble naturally evolves towards a minimum energy configuration.

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