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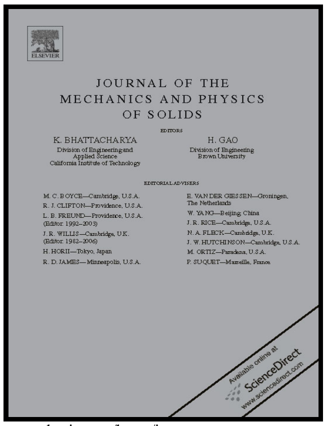
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Stress channelling in extreme couple-stress materials Part I: Strong ellipticity, wave propagation, ellipticity, and discontinuity relations

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Abstract. Materials with extreme mechanical anisotropy are designed to work near a material instability threshold where they display stress channelling and strain localization, effects that can be exploited in several technologies. Extreme couple stress solids are introduced and for the first time systematically analyzed in terms of several material instability criteria: positive-definiteness of the strain energy (implying uniqueness of the mixed b.v.p.), strong ellipticity (implying uniqueness of the b.v.p. with prescribed kinematics on the whole boundary), plane wave propagation, ellipticity, and the emergence of discontinuity surfaces. Several new and unexpected features are highlighted: (i.) Ellipticity is mainly dictated by the 'Cosserat part' of the elasticity and (ii.) its failure is shown to be related to the emergence of discontinuity surfaces; (iii.) Ellipticity and wave propagation are not interdependent conditions (so that it is possible for waves not to propagate when the material is still in the elliptic range and, in very special cases, for waves to propagate when ellipticity does not hold). The proof that loss of ellipticity induces stress channelling, folding and faulting of an elastic Cosserat continuum (and the related derivation of the infinite-body Green's function under antiplane strain conditions) is deferred to Part II of this study.

Keywords: Cosserat elasticity; strain localization; folding; faulting; anisotropy

1. Introduction

A so-called 'extreme material' possesses mechanical properties (typically an extreme degree of anisotropy) designed in such a way as to keep the material in a state close to an instability threshold (for instance failure of ellipticity), so that ultimate mechanical effects are

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