Fundamental Deformations in Asymmetric Continuum: Motions and Fracturing

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ABSTRACT

The problem of rotation waves becomes again actual due to the recent observations based on very precise intruments able to measure very small rotation time rates and due to development and new approaches to the continuum theories.

We start our consideration recalling that between serious defaults of the classical approach, like the known problem how to include into continuum theory the angular motions and related moments, there is a necessity to include the constitutive laws to account for response to the applied moments and angular motions in continuum.

The independent rotation field and related constitutive law joining the antisymmetric stresses and rotations, e.g., rotations related to grains (the points of continuum), have been introduced by Shimbo (1975; 1995) in his considerations on the friction and fracturing processes. In this way, there arose an idea to construct the theory of continuum with the asymmetric stresses, that is with the additionally introduced antisymmetric stresses. The two independent motions, displacements and rotations, are interrelated and combined in the asymmetric theory. The question related to existence of independent rotations appears as irrelevant; there only remains to solve problems related to the origin of the displacements and rotations generated in a source and their scales and, finally, effects produced.

These problems lead us to consideration on the basic motions and deformations. Among them we define the twist motion as directly related to shear stresses, it means, to the rotational oscillations of their orientations and to changes of their amplitudes.

We present the direct differential relations between any density of defects, dislocations and disclinations, and the asymmetic stresses; these relations permit to study the defect interactions and elastodynamic solutions describing a slip propagation along a fault including friction effects and related seismic radiation. We continue our considerations analyzing the thermodynamical conditions related to seismic energy release and we consider the rotation counterpart in the fracturing processes.

The rotation processes of different nature and scale participate in the extremely complicated fracture phenomena, in which the dynamic processes proceed together with the simultanuous changes of material properties. We remind a special role of rotations in the energy release effectiveness under different load conditions, and further on, we include the rotation impact on the granulation processes accompanying the material crushing, which leads to the formation of mylonite zones adjacent to fracture planes. A counterpart and co-action of slip-fracturings and rotations in an earthquake source help to explain the fragmentation and spalling processes and permit to estimate the efficiency of different fracture modes. The rotation signals spread over the source zone and synchronize the progress, and in the case of compression conditions, even the sense of slip and rotation included in fracture processes. The rotational processes at the source zones help us to understand the geometry of fracturing and fragmentation and to understand the precursory and fracture rebound processes. Further, we underline that the considered conditions in the mylonite zone can serve us as the basis to formulate the asymmetric fluid theory with the extreme motion phenomena.

We demonstrate that the spin and twist motions form the rotational wave field and we end our considerations showing that the relations governing the rotation wave propagation are in almost exact analogy to the electromagnetic theory.