Physics of Rotation Motions: Spin and Twist

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ABSTRACT

The problem of seismic rotation waves was apparently closed after the Gutenberg statement (1926) that such waves cannot propagate as, even generated at source, become immediately attenuated.

Two group of achievements shall be mentioned from the contemporary point of view:
- development of the continuum theories
- development of the precise instruments to measure very small rotation time rates.

The continuum elastic theory from its origin bears the following serious defaults:
- the angular motions and related moments are not included
- there are no constitutive laws for the angular motion response on the applied moments.

We recall that the independent rotation field, e.g., rotation related to grains or points of continuum, has been introduced by Shimbo, (1975; 1995), in his considerations on the friction and fracturing process; the constitutive law introduced joins the antisymmetric stresses and rotations.

The twist motion is introduced as the equivalent of the pure shear deformation; its definition is based on the rotational oscillations of the shear main axes. We derive the equations of motion for the rotation field: the spin and twist.

We present the co-action of the displacements and rotations fields and we formulate possibility of the related dual approach; we show how these motions are combined in the asymmetric theory of continuum. The defects defined in the standard asymmetric continuum theory are not the material defects, but only those related to the structural deformations. We derive the differential relation between the dislocation density and the asymmetric stress field.

We supplement our considerations with the thermodynamical conditions related to seismic energy release and, then further, we consider the rotation counterpart in the fracturing. We discuss the different nature and scale of rotation processes taking part in the extremely complicated fracture phenomena in which the dynamic processes proceed together with the simultaneous 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. The constitutive laws undergo simultaneously the considerable changes, from the rigid elastic to plastic and, further, to mylonite-type material. We consider the conditions in the narrow zones adjacent to fracturing, where the shear stresses break the molecular bonds and crash the rock material; we consider the release of stresses and a rapid increase of the stress rates. The fracturing transport process, as well as the bond breaking and granulation processes force us to include, in the fracturing description, the hypothesis that the twist-shear deformations leading to the bond breaking precede in phase the rebound rotation motion.
We indicate 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 and dynamic defect objects.

We demonstrate that the spin and twist motions form the rotational wave field and we demonstrate its almost exact analogy to the electromagnetic theory and , finally, we mention some aspects of the relativistic problems entering into the continuum mechanics, as some deformations can lead us from the Euclidean space to the Riemannian one.