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Rotational waves in geodynamics

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The rotation model of a geoblock with intrinsic momentum was constructed by A.V. Vikulin and A.G. Ivanchin [9, 10] to describe seismicity within the Pacific Ocean margin. It is based on the idea of a rotational motion of geoblocks as the parts of the rotating body of the Earth that generates rotary deformation waves. The law of the block motion was derived in the form of the sine-Gordon equation (SG) [5, 9]; the dimensionless form of the equation is:

$$\frac{\partial^2\theta}{\partial\xi^2} - \frac{\partial^2\theta}{\partial\eta^2} = \sin\theta, \tag{1}$$

where $\theta = \beta/2$, $\xi = k_0 z$ and $\eta = v_0 k_0 t$ are dimensionless coordinates, z – length of the chain of masses (blocks), t – time, β – turn angle, ν_0 – representative velocity of the process, k_0 – wave number.

Another case analyzed was a chain of nonuniformly rotating blocks, with deviation of force moments from equilibrium positions μ, considering friction forces α along boundaries, which better matched a real-life seismic process. As a result, the authors obtained the law of motion for a block in a chain in the form of the modified SG equation [8]:

$$\frac{\partial^2\theta}{\partial\xi^2} - \frac{\partial^2\theta}{\partial\eta^2} = \sin\theta + \alpha\frac{\partial\theta}{\partial\eta} + \mu\delta(\xi)\sin\theta \tag{2}$$

that was solved using McLaughlin and Scott perturbation method. Here, δ is Dirac function. According to the analysis, for the slow seismic process when interaction between the blocks–sources of earthquake is contributed to by slow motion — creep, asymptotic velocity of translation of rotation deformations is $c_0 \approx 1 - 10$ cm/s [8].

An SG-equation can have many solutions. Modeling of motion in long molecular chains [12] showed that wave motion in those chains could be described by a soliton or an exciton solutions. Such solutions have typical “limit” velocities matching the maximum excitation energies $E_{\max}$: V_{01} and V_{02}. The following conditions are valid: $0 \le E \le E_{\max}$, $0 \le V \le V_{01}$ for soliton and $0 \le E_0 \le E \le E_{\max}$, $V_{01} \le V \le V_{02}$ for exciton solutions; $E_{\max}$ — maximum excitation energy that corresponds to highest earthquake magnitudes; E_0 — excitation energy of the entire chain of molecules (earthquake sources in a seismic belt) when $V = 0$.

According to the data on migration velocities of the Pacific zone earthquakes with less than 100 km hypocenter depths [1, 4-6], the global (along the whole seismic belt) and the local (inside of strong earthquake sources) migration relations, the maximum velocities and the related maximum magnitudes are:

$M_1 \approx 2\lg V_1$, $\quad V_{1,\max} \approx 1 - 10$ cm/s, $M_{1,\max} = 8.5 - 9$, (3)

$M_2 \approx \lg V_2$, $\quad V_{2,\max} \approx 4$ km/s, $M_{2,\max} = 8.3$. (4)

The model relations for molecular chains and experimental relations for chains of earthquake sources qualitatively agree [2], which allows interpreting migration relations (3) and (4) as soliton and exciton solutions of the SG-equation with intrinsic limit velocities $V_{01} = V_{1,\max}$ and $V_{02} = V_{2,\max}$. The maximum velocity of global migration $V_{1,\max} \approx 1 - 10$ cm/s matches the intrinsic velocity c_0 within the rotation model of a nonlinear block-structure geomedium, which permits interpretation of the latter as the limit velocity V_{01} of the soliton SG-equation solution.

The SG-equation soliton solutions are known to have properties relating the properties of the real elementary particles [11], and excitons are the perturbances that are transformed into regular waves on a linear approximation [12], the $P-$and $S-$waves (seismic waves, V^s) in the case discussed. Consequently, the soliton and exciton solutions with the limit intrinsic velocities $V_{1,max} \approx V_{01} \approx c_0, V_{2,max} \approx V_{02} \approx V^s$, in the framework of the rotation model may be a new type of elastic waves in solids — rotational waves [3, 7], solitary waves which are polarized perpendicularly to a spreading direction [8]. They are responsible for particle-and-wave interactions of geoblocks in rotation geomedia.

REFERENCES

1. Bykov, V.G., Strain waves in the Earth: theory, field data and models. *Russian geology and geophysics*, 2005, vol. 46, no. 11.

2. Vikulin, A.V., Acoustics of the Earth. *The «Planet Earth» system: XX anniversary of «The "Planet Earth" system» seminar*, Moscow: LENAND, 2014. 608 p.

3. Vikulin, A.V., New Type of Elastic Rotation Waves in Geomedia and the Vortex Geodynamics, *Geodinam. Tektonofiz.*, 2010, vol. 1, no. 2.

4. Vikulin, A.V., *Seismichnost'. Vulkanizm. Geodinamika: sb. tr.* (Seismicity. Volcanicity. Geodynamics: Collected Works), Petropavlovsk-Kamchatski: KamGU, 2011.

5. Vikulin, A.V., Physics of wave seismic process. Petropavlovsk-Kamchatsky: KGPI, 2003. 150 p.

6. Vikulin, A.V., *Fizika Zemli i geodinamika: ucheb. posobie* (Physics of Earth and Geodynamics: Educational Aid), Petropavlovsk-Kamchatski: KamGU, 2008.

7. Vikulin, A.V., Energy and Force Moment of Elastic Rotation Field in Geophysical Medium, *Geolog. Geofiz.*, 2008, vol. 49, no. 6.

8. Vikulin, A.V., Bykov, V.G. and Luneva, M.N., Nonlinear Strain Waves in the Rotation Model of Seismic Process, *Vychislit. Tekhnol.*, 2000, vol. 5, no. 1.

9. Vikulin, A.V. and Ivanchin, A.G., Model of a Seismic Process, *Vychislit. Tekhnol.*, 1997, vol. 2, no. 2.

10. Vikulin, A.V. and Ivanchin, A.G., Rotation Model of a Seismic Process, *Tikhookean. Geolog.*, 1998, vol. 17, no. 6.

11. Gaponov-Grekhov, A.V. and Rabinovich, M.I., Mandel'shtam and Modern Theory of Nonlinear Vibrations and Waves, *Usp. Fiz. Nauk*, 1979, vol. 128, no. 4.

12. Davydov, A.S., Solitons in Quasi-Unidimensional Molecular Structures, *Usp. Fiz. Nauk*, 1982, vol. 138, no. 4.