

Artificial Intelligence-Assisted Exploratory Modeling of Planetary Distance Patterns: A Standing-Wave Grid Analysis of the Solar System

Andrey Shcherbakov^{1,2,3,4}

¹World Academy of Artificial Consciousness (WAAC), correspondent academician, Paris, France

²Scientific Director of the Center for Advanced Fundamental Research, 3268112 Haifa, Israel

³Leading Researcher at the State University of Management, 109542 Moscow

⁴Editor-in-Chief of the journal Bulletin of Modern Digital Technologies Moscow

ABSTRACT

This study investigates the use of artificial intelligence-assisted exploratory modeling for the analysis of radial regularities in planetary distances within the Solar System. The proposed approach combines hypothesis generation and structural interpretation supported by artificial intelligence with numerical fitting of a standing-wave grid model and comparative evaluation against the classical Titius-Bode rule. The model represents planetary orbits as approximate positions of minima in a linear radial grid defined by a constant step and a fixed phase shift. Using the observed heliocentric distances of the eight major planets, the study estimates the grid parameters, assigns each planet to the nearest node, and evaluates model performance by means of absolute and relative error metrics. For the selected configuration, the fitted model with $\Delta = 0.2845$ AU and $\varphi = 0.5$ yields lower average approximation errors for the eight-planet sample than the classical Titius-Bode relation. However, this result is interpreted as evidence of numerical fit only and does not by itself establish the physical validity of a wave-based mechanism for planetary orbital architecture. The fitted grid formally corresponds to a wavelength of 0.569 AU and an associated frequency of approximately 3.52 mHz, which is numerically close to the range of observed solar five-minute oscillations. This proximity is treated as a heuristic observation relevant to model development rather than as confirmation of a causal connection between solar oscillatory phenomena and planetary distances. An extended two-resonator version of the scheme is also examined for selected trans-Neptunian objects, several of which show close numerical alignment with the calculated grid nodes in the outer region of the model. At the same time, the approach remains limited by the presence of numerous unoccupied nodes, sensitivity to boundary assumptions, and the absence of an independently verified physical mechanism. The results indicate that artificial intelligence can serve as a useful research-support instrument for hypothesis formulation, parameter exploration, structured model comparison, and pattern-oriented analysis in astronomy. In this context, the standing-wave grid is best regarded as a heuristic computational framework that warrants further statistical testing and critical physical assessment rather than as an established theory of Solar System structure.

*Corresponding author

Andrey Shcherbakov, 1World Academy of Artificial Consciousness (WAAC), correspondent academician, Paris, France and Scientific Director of the Center for Advanced Fundamental Research, 3268112 Haifa, Israel and Leading Researcher at the State University of Management, 109542 Moscow and Editor-in-Chief of the journal Bulletin of Modern Digital Technologies Moscow.

Received: September 21, 2026; **Accepted:** September 28, 2026; **Published:** October 08, 2026

Keywords: Artificial Intelligence-Assisted Research, Exploratory Modeling, Planetary Distances, Solar System, Standing-Wave Grid, Titius-Bode Rule; Numerical Fitting, Pattern Analysis

Introduction

The emergence of large language models and related artificial intelligence tools has provided researchers in the natural sciences with powerful instruments for generating, reformulating, and testing scientific hypotheses. Even when such systems are used only as auxiliary instruments, they may alter the research workflow by accelerating the construction of alternative conceptual schemes, formalizing assumptions, and organizing observational material into testable structures. In this sense, artificial intelligence does not replace physical reasoning but can support an exploratory mode of inquiry in which candidate models are rapidly articulated and then subjected to explicit numerical verification.

This article applies such an AI-assisted exploratory strategy to a long-standing astronomical question: whether the heliocentric distances of planets exhibit a nontrivial structural regularity that can be represented

in a compact mathematical form. Historically, the best-known empirical expression of such regularity is the Titius-Bode rule, which offered a simple numerical approximation for planetary distances from Mercury to Uranus and played a role in motivating the search for bodies in the asteroid belt. At the same time, alternative heuristic interpretations have been proposed in terms of resonance, wave-like ordering, or discrete orbital grids.

The present study examines a standing-wave grid model in which planetary orbits are treated as approximate positions of minima in a radial wave-like structure centered on the Sun. Within this framework, the model is not presented as an established physical theory of Solar System architecture. Rather, it is considered a heuristic research construct that may help organize orbital data, reveal hidden regularities, and identify node positions near which the search for additional bodies could be conceptually motivated.

A central methodological point of the article is that the scientific value of a model is not exhausted by the question of its final ontological truth.

A model may also be valuable because of its heuristic and operational productivity: if it provides a structured ordering of orbital nodes, approximates known bodies with nontrivial accuracy, and suggests additional directions for investigation, it can function as a meaningful exploratory device even before its physical interpretation is resolved. This perspective is especially relevant in AI-assisted research, where computational systems can help formulate and compare candidate structures more quickly than in traditional fully manual workflows.

In this study, the language model was used not merely as a writing aid but as an exploratory research instrument. It supported the generation of alternative hypotheses, the reformulation of assumptions into explicit mathematical expressions, the comparison of competing conceptual schemes, and the identification of potential weaknesses in the proposed model. In this sense, the model functioned as a cognitive intermediary between an intuitive scientific idea and its formally testable representation, accelerating the transition from heuristic insight to structured analysis while leaving physical validation to independent numerical and theoretical scrutiny. The specific version studied here uses a linear radial grid with constant spacing between successive minima. Once the spacing is estimated from the orbital radii of the eight major planets, the resulting structure formally implies a wavelength of 0.569 AU and a corresponding frequency near 3.52 mHz. This value is numerically close to the observed range of solar five-minute oscillations; more importantly, the article is situated against the background of historical attempts to express planetary-distance regularities, above all the Titius-Bode rule, and only then compares the derived frequency with solar oscillation data [1-6]. The article therefore explores both the numerical performance of the fitted grid and the methodological implications of this coincidence, while maintaining a clear distinction between numerical proximity and physical explanation.

The article is organized as follows. First, the Titius-Bode rule and the standing-wave hypothesis are introduced conceptually. Next, the materials and methods section describes the radial grid formalism, the fitting logic, and the error metrics used for comparison. The results section presents the fitted parameters, the comparison with the Titius-Bode rule for the eight major planets, the analysis of node-number structure, the discussion of the frequency scale, and the extended two-resonator application to selected trans-Neptunian objects. The discussion then addresses the methodological significance and physical limitations of the proposed model.

Materials and Methods

The empirical benchmark for the present analysis is the classical Titius-Bode rule, an historically important numerical relation for mean heliocentric distances [1,2]. In its standard form, the rule is commonly written as $r_n = 0.4 + 0.3 \cdot 2^n$, where r_n is the mean heliocentric distance in astronomical units and the index n is assigned the sequence $-\infty, 0, 1, 2, 3, 4, 5, 6, 7, 8$, corresponding to Mercury, Venus, Earth, Mars, the asteroid belt, Jupiter, Saturn, Uranus, Neptune, and Pluto. The rule approximates the distances from Mercury to Uranus reasonably well but becomes substantially less accurate for Neptune and Pluto; accordingly, it is treated here as an empirical approximation rather than a universal physical law [1,2].

The standing-wave grid model considered in this article was originally proposed by the author in 1988 as a heuristic principle [7]. The idea is to suppose that the Sun acts as the source of a certain oscillatory process and that reflection from one or more distant resonators generates a radial pattern of minima in which planetary orbits are located. In speculative interpretations these oscillations may be described as gravitational waves or as oscillations in a hypothetical elastic cosmic medium. However, within modern physics, gravitational waves in general relativity arise from systems with time-varying quadrupole moments rather than from quasi-static radial layers; consequently, any literal physical interpretation of the standing-wave grid would require additional assumptions about source periodicity, reflection, and boundary stability.

For numerical testing, the model uses a radial grid of minima of the form $r_n = (n + \phi)\Delta$, where Δ is the constant step between neighboring

minima, ϕ is a phase shift, and n is an integer node number. In the basic version of the model, $\phi = 0.5$, which gives the specific form $r_n = (n + 1/2)\Delta$. This expression is equivalent to assuming a regular linear radial lattice. If the grid is formally interpreted as a standing wave, then the wavelength is $\lambda = 2\Delta$, and if one additionally assumes propagation at the speed of light, the associated frequency is $f = c/\lambda$.

The step Δ was selected by compromise fitting to the heliocentric distances of the eight major planets. For each planet, the continuous node index was calculated as $n_{\text{cont}} = a/\Delta - \phi$, where a is the observed semimajor axis in astronomical units [8,9]. The nearest integer node was then selected by comparing the floor, round, and ceiling candidates and choosing the one with the smallest absolute radial error. After node assignment, the absolute and relative errors were calculated for the standing-wave grid and compared with the errors obtained from the Titius-Bode rule. Model performance was summarized with mean absolute error (MAE), root mean square error (RMSE), mean absolute percentage error (MAPE), and the number of planets for which each model yielded the smaller absolute deviation. In addition to the eight-planet test, an extended two-resonator version of the scheme was explored for selected trans-Neptunian objects using the same radial step. The two resonator boundaries were set at $L1 = 30.157$ AU and $L2 = 89.902$ AU. Finally, the sequence of node numbers assigned to the eight planets was examined by fitting simple one-formula approximations in order to clarify whether the index structure contained an additional regularity beyond the geometry of the radial transformation.

Model performance was summarized with mean absolute error (MAE), root mean square error (RMSE), mean absolute percentage error (MAPE), and the number of planets for which each model yielded the smaller absolute deviation. In addition to the eight-planet test, an extended two-resonator version of the scheme was explored for selected trans-Neptunian objects using the same radial step. The two resonator boundaries were set at $L1 = 30.157$ AU and $L2 = 89.902$ AU. Finally, the sequence of node numbers assigned to the eight planets was examined by fitting simple one-formula approximations in order to clarify whether the index structure contained an additional regularity beyond the geometry of the radial transformation.

Results

For the fitted standing-wave grid, the parameter values are summarized in Table 1. The selected step is $\Delta = 0.2845$ AU, corresponding to a wavelength of 0.5690 AU. Under the formal propagation assumption $f = c/\lambda$, this spacing implies a characteristic frequency of approximately 3.5 mHz [3- 6]. The phase shift is fixed at $\phi = 0.5$, and the reflective boundary in the one-resonator version is placed at 30.157 AU, slightly beyond Neptune [9]. The resulting node density is about 3.51 nodes per astronomical unit.

Table 1: Main Parameters of the Standing-Wave Model (AU = Astronomical Units)

Parameter	Value	Comment
Step between minima, Δ	0.2845 AU	Compromise fit to 8 planets
Wavelength, λ	0.5690 AU	$\lambda = 2\Delta$
Frequency, f	≈ 3.5 mHz	If $f = c/\lambda$ is assumed formally
Phase shift, ϕ	0.5	Form $r_n = (n + 1/2)\Delta$ was used
Position of reflecting boundary, L Linear node density	30.157 AU ≈ 3.51 nodes/AU	$L = 106\Delta$, slightly beyond Neptune $1/\Delta$

With these parameters, the standing-wave grid reproduces the orbital distances of most outer planets with comparatively small errors, although Mercury is described much less accurately. A notable structural property of the model is the large number of unoccupied nodes between observed planetary orbits. Table 2 presents the detailed comparison between the standing-wave model and the Titius-Bode rule for the eight major planets.

Table 2: Comparison of the Standing-Wave Model and the Titius-Bode Rule for Eight Planets

Planet	Observed orbit, AU	Wave model, AU	Node number	Wave error, AU	Wave error, %	Titius-Bode, AU	TB error, AU	TB error, %	Closer model
Mercury	0.387	0.42675	1	0.03975	10.27	0.4	0.013	3.36	TB
Venus	0.723	0.71125	2	-0.01175	-1.63	0.7	-0.023	-3.18	Wave
Earth	1.000	0.99575	3	-0.00425	-0.42	1.0	0.0	0.0	TB
Mars	1.524	1.56475	5	0.04075	2.67	1.6	0.076	4.99	Wave
Jupiter	5.203	5.26325	18	0.06025	1.16	5.2	-0.003	-0.06	TB
Saturn	9.537	9.53075	33	-0.00625	-0.07	10.0	0.463	4.85	Wave
Uranus	19.19	19.20375	67	0.01375	0.07	19.6	0.41	2.14	Wave
Neptune	30.07	30.01475	105	-0.05525	-0.18	38.8	8.73	29.03	Wave

The summary accuracy metrics are given in Table 3. Formally, the standing-wave model yields lower MAE, RMSE, and MAPE values than the classical Titius-Bode rule for the eight-planet sample, and it is closer for five of the eight planets. This result demonstrates a stronger numerical approximation in the chosen configuration, but it remains a result about fit quality rather than proof of physical validity.

Table 3: Summary Comparison of Model Accuracy

Metric	Standing-wave model	Titius-Bode rule
MAE, AU	0.029	1.21475
RMSE, AU	0.03589	3.09439
MAPE, %	2.06	5.95
Number of planets where the model is more accurate	5.0	3.0

The sequence of node numbers assigned to the eight planets is 1, 2, 3, 5, 18, 33, 67, and 105. This sequence does not form a simple arithmetic or geometric progression. Among smooth one-formula approximations, however, it is described best by an exponential form, while a piecewise linear fit achieves still smaller residuals. The results are shown in Table 4.

Table 4: Best Approximations of the Node-Number Sequence

Model	Formula	MAE	RMSE
Piecewise linear, break after k = 5	$k \leq 6: n = -10.667 + 6.000k; k \geq 6: n = -183.667 + 36.000k$	2.875	3.956
Exponential $A \cdot B^k$	$n = 0.445 \times 2.009^k$	3.963	5.843

The near-exponential increase of the node numbers arises naturally when a geometrically increasing sequence of orbits is mapped onto a linear grid with constant radial spacing. For this reason, the fitted dependence should be interpreted primarily as a consequence of the chosen transformation geometry rather than as an independent physical law.

A further numerical observation concerns the characteristic frequency formally implied by the fitted spacing. In the Solar System, the nearest natural candidate to this frequency scale is provided by solar oscillations, especially the five-minute acoustic p-modes [3-6]. Helioseismology shows that solar p-modes occupy roughly the 1-5 mHz range, with particularly strong power in the interval from 2 to 4 mHz [3-6]. A frequency near 3.5 mHz therefore falls inside the observed band of solar five-minute oscillations [3-6]. Nevertheless, this order-of-magnitude agreement does not establish that solar oscillations generate planetary orbits or produce a radial standing grid on the scale of the Solar System.

The article therefore formulates a speculative working hypothesis according to which the observed acoustic oscillations of the Sun may represent a secondary resonant manifestation of a deeper oscillatory process associated with propagation in a special elastic cosmic medium at a speed close to that of light [7]. In this interpretation, the solar plasma acts as a resonator that transforms hidden fast dynamics into the observable p-mode spectrum. From the standpoint of modern physics, however, this interpretation remains speculative and requires independent experimental

verification, since standard helioseismology explains solar modes as acoustic oscillations of matter [3-6].

If such a speculative hypothesis were true, several testable consequences could be expected. These might include phase correlations between distant solar regions not fully explained by standard acoustic models, additional stable spectral series, or systematic deviations from conventional helioseismic calculations [4,5]. Another possible consequence would be a relation between oscillation parameters and the geometry of the circumsolar medium on scales larger than the solar radius. Conversely, if all observed properties of solar modes are fully explained by plasma and hydrodynamic theory, then the introduction of a new medium becomes unnecessary [3-6]. In the absence of an independent detection of such a medium, the hypothesis remains interpretive rather than physically established.

The two-resonator version of the model extends the same radial grid beyond Neptune. In this variant, the first boundary is taken immediately beyond Neptune at $L1 = 30.157$ AU and the second much farther away at $L2 = 89.902$ AU. Under this assumption, many known Solar System bodies lie close to nodes of the same radial grid [9]. The internal resonator includes the planets from Mercury to Neptune together with Ceres, whereas the second resonator contains several major trans-Neptunian objects. The alignment is especially strong for Pluto, Orcus, Haumea, Quaoar, Makemake, and Eris [10].

Table 5: Objects and their Correspondence to the Nearest Nodes

Object	Semimajor axis, AU	Nearest node n	Node radius, AU	Error, %	In resonator 1 to 30.157 AU	In resonator 2 30.157-89.902 AU	Beyond two resonators
Mercury	0.387	1	0.427	10.27	yes	no	no
Venus	0.723	2	0.711	-1.63	yes	no	no
Earth	1.0	3	0.996	-0.43	yes	no	no
Mars	1.524	5	1.565	2.67	yes	no	no
Ceres	2.7653	9	2.703	-2.26	yes	no	no
Jupiter	5.203	18	5.263	1.16	yes	no	no
Saturn	9.537	33	9.531	-0.07	yes	no	no
Uranus	19.19	67	19.204	0.07	yes	no	no
Neptune	30.07	105	30.015	-0.18	yes	no	no
Pluto	39.482	138	39.403	-0.2	no	yes	no
Orcus	39.173	137	39.119	-0.14	no	yes	no
Haumea	43.218	151	43.102	-0.27	no	yes	no
Quaoar	43.316	152	43.386	0.16	no	yes	no
Makemake	45.436	159	45.378	-0.13	no	yes	no
Eris	67.668	237	67.569	-0.15	no	yes	no
Sedna	518.57	1822	518.501	-0.01	no	no	yes

The outer resonator is therefore the most numerically striking part of the scheme. At the same time, these matches cannot be treated as decisive evidence for real physical resonators. When a constant step is used over large distances, relative error tends to decrease automatically with scale; therefore, part of the apparent precision for outer objects may arise from the metric itself rather than from a deep dynamical law. Sedna, moreover, lies far beyond the second resonator boundary and thus does not support the finite two-resonator interpretation.

Discussion

From a methodological point of view, the comparison between the two models highlights the difference between a good fit and a good explanation. The standing-wave grid can produce small errors for a number of orbits, but it does so at the cost of introducing additional assumptions, hidden degrees of freedom, and entities not established by current physical theory. The Titius-Bode rule is much simpler and historically more transparent, yet it performs worse for some distant bodies, especially Neptune [1,2,9]. Therefore, the preferred model depends on the evaluation criterion: compactness favors the empirical rule, while eight-planet approximation quality favors the fitted standing-wave grid in the chosen configuration.

In physical terms, however, modern celestial mechanics and theories of planetary system formation explain Solar System architecture primarily through the evolution of the protoplanetary disk, accretion, migration, and orbital resonances rather than through minima of standing gravitational or other waves. The present model does not replace these frameworks. Its relevance lies mainly in exploratory numerical analysis and in the possibility of using AI-assisted tools to formalize, compare, and critically inspect unconventional hypotheses. Within this role, artificial intelligence supports research design and structured comparison, but it does not eliminate the need for physical interpretation, statistical controls, or independent observational tests.

The educational and methodological value of the article is also noteworthy. The case illustrates how a speculative but explicit model can be translated into formulas, fitted to observations, and evaluated against a historical benchmark. It also demonstrates why apparent numerical success must be distinguished from explanatory adequacy. In this respect, AI-assisted exploratory modeling can be productive precisely when it remains disciplined by transparent assumptions, reproducible calculations, and critical discussion of limitations.

Conclusions

The analysis shows that a standing-wave grid model can be constructed as a comparatively accurate numerical approximation to planetary orbital distances when a regular linear lattice of minima with step 0.2845 AU, phase shift 0.5, and a reflecting boundary near 30.157 AU is adopted. In the chosen configuration, the model yields smaller average errors for the eight major planets than the classical Titius-Bode rule [1,2].

At the same time, the improved numerical fit is obtained at the cost of many unoccupied nodes, freedom in boundary selection, and the absence of a physically verified mechanism capable of generating such a large-scale standing structure in the Solar System. The numerical proximity of the derived frequency to solar five-minute oscillations is intriguing but should be treated as heuristic rather than confirmatory [3-6].

Accordingly, the Titius-Bode rule remains an historically important empirical approximation, whereas the standing-wave grid is best regarded as a heuristic computational construct. Its main significance lies in exploratory pattern analysis, in the structured comparison of alternative models, and in its potential use within AI-assisted research workflows aimed at hypothesis generation and numerical testing rather than as an established theory of Solar System structure.

Appendix: Node Selection Procedure and Frequency Estimation
In this model, a linear radial grid of minima is first specified in the form $r_n = (n + \varphi)\Delta$, where Δ is the step between neighboring minima and φ is the phase shift. In the version used here, $\varphi = 0.5$, so the nodes are located at $r_n = (n + 1/2)\Delta$. For each planet, a continuous node index is computed as $n_{cont} = a/\Delta - \varphi$, where a is the observed semimajor axis [8,9]. The three nearest integer candidates, $\text{floor}(n_{cont})$, $\text{round}(n_{cont})$, and $\text{ceil}(n_{cont})$, are then compared, and the node yielding the smallest absolute radial error is selected. After the step Δ has been chosen, the grid is interpreted formally as a standing wave with wavelength $\lambda = 2\Delta$. The wavelength is then converted to meters and the frequency is calculated from $f = c/\lambda$. In this sense, the frequency is not an independently fitted input parameter but a derived quantity determined by the already selected radial step.

Appendix Table 1: Summary of the Parameters and Formulas Used

Element	Value
Rule for node selection	$n = \text{round}(a/\Delta - \varphi)$
Phase used	0.5
Step Δ used	0.2845
Interpretation of frequency	formal: $f = c/(2\Delta)$
Derived frequency	$3.521949\text{e-}03 \text{ Hz} = 3.5219 \text{ mHz}$
Derived period	$283.93 \text{ s} = 4.73 \text{ min}$

Appendix Table 2: Node-Selection Procedure for Each of the Eight Planets

Planet	Observed a, AU	Continuous index $n =$ $a/\Delta - \varphi$	floor(n)	round(n)	ceil(n)	Candidates	Selected node n	Model radius, AU = $(n + \varphi)\Delta$	Error, AU	Error, %
Mercury	0.387	0.860281	0	1	1	n=0: $r=0.14225$ AU, $\text{err}=-0.24475$ AU (-63.24%); n=1: $r=0.42675$ AU, $\text{err}=+0.03975$ AU (+10.27%)	1	0.42675	0.03975	10.2713
Venus	0.723	2.041301	2	2	3	n=2: $r=0.71125$ AU, $\text{err}=-0.01175$ AU (-1.63%); n=3: $r=0.99575$ AU, $\text{err}=+0.27275$ AU (+37.72%)	2	0.71125	-0.01175	-1.6252
Earth	1.0	3.014938	3	3	4	n=3: $r=0.99575$ AU, $\text{err}=-0.00425$ AU (-0.43%); n=4: $r=1.28025$ AU, $\text{err}=+0.28025$ AU (+28.02%)	3	0.99575	-0.00425	-0.425
Mars	1.524	4.856766	4	5	5	n=4: $r=1.28025$ AU, $\text{err}=-0.24375$ AU (-15.99%); n=5: $r=1.56475$ AU, $\text{err}=+0.04075$ AU (+2.67%)	5	1.56475	0.04075	2.6739
Jupiter	5.203	17.788225	17	18	18	n=17: $r=4.97875$ AU, $\text{err}=-0.22425$ AU (-4.31%); n=18: $r=5.26325$ AU, $\text{err}=+0.06025$ AU (+1.16%)	18	5.26325	0.06025	1.158
Saturn	9.537	33.021968	33	33	34	n=33: $r=9.53075$ AU, $\text{err}=-0.00625$ AU (-0.07%); n=34: $r=9.81525$ AU, $\text{err}=+0.27825$ AU (+2.92%)	33	9.53075	-0.00625	-0.0655
Uranus	19.19	66.95167	66	67	67	n=66: $r=18.91925$ AU, $\text{err}=-0.27075$ AU (-1.41%); n=67: $r=19.20375$ AU, $\text{err}=+0.01375$ AU (+0.07%)	67	19.20375	0.01375	0.0717
Neptune	30.07	105.1942	105	105	106	n=105: $r=30.01475$ AU, $\text{err}=-0.05525$ AU (-0.18%); n=106: $r=30.29925$ AU, $\text{err}=+0.22925$ AU (+0.76%)	105	30.01475	-0.05525	-0.1837

Appendix Table 3: Step-By-Step Derivation of Frequency from Wavelength (Millihertz)

Step	Formula	Value	Units
Selected grid step Δ	$\Delta = 0.2845 \text{ AU}$	0.2845	AU
Standing-wave wavelength	$\lambda = 2\Delta$	0.569	AU
Conversion to meters	$\lambda = 0.5690 \times 149597870700$	85121188428.29999	m
Frequency	$f = c/\lambda$	0.0035219486891036	Hz
Frequency in mHz	$f(\text{mHz}) = 1000 \cdot f(\text{Hz})$	3.5219486891036977	mHz
Period	$T = 1/f$	283.933722002773	s

References

1. Titius-Bode rule (2026) Great Russian Encyclopedia [website]. 2015. Available at: <https://old.bigenc.ru/physics/text/4194136>.

2. Bode's law (2026) Encyclopaedia Britannica [website]. 2025. Available at: <https://www.britannica.com/science/Bodes-law>.

3. (2026) Helioseismology. Great Russian Encyclopedia <https://old.bigenc.ru/physics/text/2348773>.

4. Christensen-Dalsgaard J (2026) Helioseismology. Reviews of Modern Physics 2002 DOI: 10.1103/RevModPhys.74.1073.

5. (2026) Helioseismology. National Solar Observatory <https://nso.edu/research/helioseismology/>.

6. Hill F, Harvey JW, Hubbard RP, Kennedy JR, Leibacher JW, et al. (1996) The Global Oscillation Network Group (GONG) Project. Science 272: 1284-1286.

7. Fizika Zemli (2021) <https://sciencejournals.ru/view-article/?j=fizzemli&y=2021&v=0&n=4&a=FizZemli2104005Gulelmi>.

8. (2026) Planetary Fact Sheets | NASA GSFC [website]. 2023. Available at: <https://science.gsfc.nasa.gov/earth/projects/629/>.

9. (2026) Neptune: Facts. NASA <https://science.nasa.gov/neptune/neptune-facts/>.

10. (2026) Pluto: Facts. NASA <https://science.nasa.gov/dwarf-planets/pluto/facts/>.

Copyright: ©2026 Andrey Shcherbakov. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.