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Wavelet Analysis of a Number of Prime Numbers

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Abstract We adhere to the concepts of Descartes, the need to apply algebraic equations directly as a final decision. The concept of wavelet signal allows to abstract from an unknown number of primes of a physical quantity. Any number of primes can be decomposed into a finite set of asymmetric wavelets with variable amplitude and frequency. For example, taken a number of A000040. The first term of the total number of model A000040 according to the law of exponential growth is the contribution of the absolute error 97,53 %. The first member of the general model of a number of A000040 on the law of exponential growth is the contribution of the absolute error 97,53 %. The remaining 35 wavelets amount to a total of 2.47 %. But their influence on the number of primes very significant. It is proved that any type of fnite-dimensional number of primes can be decomposed into a fnite-dimensional set of asymmetric wavelets with variable amplitude and frequency of oscillatory perturbations.

Keywords: *prime numbers, the family of wavelets, fractal levels*

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1. Introduction

It is necessary to identify a stable law of distribution of prime numbers, by analogy with the methodology, we have shown the growth of the relative atomic mass of 109 chemical elements according to atomic number in the Periodic Table D.I. Mendeleev [1]. For example, take a series of prime numbers 11 $a(n)=\{2,3,5,7,11.13.17,...\}$ at 22 $n=\{1,2,3,...\}$ and 33 $1\le n\le 58$ for an array A000040. The article shows the physical and mathematical approach to the analysis.

2. Wavelet (Splash) - A Mathematical Function

The word «wavelet» means "small wave". Wavelets - a family of functions, "the waves coming one after another." According to [2] the term "wavelet" refers to some soliton-like function.

The abscissa axis can be not only time but also any other value. Wavelet has a clear amplitude-frequency characteristic of prime numbers in order (conditional time). If $n=\{1,2,3,...\}$ - the abscissa, then the y-axis will share $a(n)=\{2,3,5,7,11,13,17,...\}$.

In [3] graphics, similar to the wavelet, called a smooth oscillating function. Therefore, a smooth function of the type $a(n)=f(n)$ require continuous wavelet transform in real numbers. It is known that wavelets with continuous analysis are subject to Heisenberg's uncertainty principle and, consequently, the basis of the wavelet is also not initially determined with respect to the x-axis plots. These sites appear in the identification process.

3. The Properties of the Wavelet

The main features of the wavelet the following:

1. Amplitude-frequency localization of the axes of rectangular coordinates (x , y);
2. Self-similarity (fractal) of the wavelet as quantitative mapping process;
3. Removal of the uncertainty principle for the sequence of appearance of wavelets;
4. Independence of the wavelet function from the object of mathematical analysis;
5. Invariance of the wavelet shift the origin of coordinates on the x-axis;
6. Integral of the wavelet, i.e. the footprint of the schedule, shall be equal to or close to zero.

On these grounds the wavelet analysis is often compared to a "mathematical microscope", revealing internal structure of heterogeneous objects, phenomena and processes.

4. Asymmetrical Wavelet

We adhere to the concepts of Descartes, the need to apply algebraic equations directly as final solutions without the use themselves primitives (differential and / or integral equations).

Asymmetrical wavelet function of the form completely satisfies the six conditions

$$y = \sum_{i=1}^{m} y_i,$$
$$y_i = a_{1i} x^{a_{2i}} \exp(-a_{3i} x^{a_{4i}}) \quad (1)$$
$$\times \cos(\pi x / (a_{5i} + a_{6i} x^{a_{7i}} \exp(-a_{8i} x^{a_{9i}}) - a_{10i})$$

where y - the index (dependent factor), i - the number of component (1), m - the number of components, x - the explanatory variable (influencing factor), $a_1 ... a_{10}$ - parameters (1), taking the numerical values in the process of structural-parametric identification of model (1).

In most cases, to identify patterns apply wavelet type

$$y = \sum_{i=1}^{m} y_i,$$
$$y_i = a_{1i} x^{a_{2i}} \exp(-a_{3i} x^{a_{4i}}) \quad (1a)$$
$$\times \cos(\pi x / (a_{5i} + a_{6i} x^{a_{7i}}) - a_{8i})$$

5. A Number of Prime Numbers as a Series of Signals

Physical and mathematical approach involves understanding a number of prime numbers as a reflection of a composite process of reality.

Signal - a material carrier of information. And the information we have understood as a measure of interaction. The signal can be generated, but the reception is not mandatory. For example, the number of primes known for thousands of years, but its essence is a set of signals has not yet been disclosed. The signal can be any physical process, but it features a number of prime numbers is not yet clear. It turns out that changing the set of unknown signals has long been known through a series of prime numbers. So take a number of prime numbers for the fractal set of analog signals that vary continuously in a certain time in order. n

Then each term of equation (1a) can be written as a kind of harmonic wavelet

$$y = A_{0.5} \cos(\pi x / p_{0.5} - a_8),$$
$$A_{0.5} = a_1 x^{a_2} \exp(-a_3 x^{a_4}), \quad , \quad (2)$$
$$p_{0.5} = a_5 + a_6 x^{a_7}$$

where $A_{0.5}$ - the amplitude (half) of the wavelet (axis y), $p_{0.5}$ - half-period fluctuations (axis x).

By (2) with two fundamental constants e and π (irrational numbers), formed inside the quantized wavelet signal in the proportion of 0.5 (real number) or 1/2 (rational number), and quantization step 1/2 fits under the Riemann hypothesis.

Further record 0.5 in indexes it is lowered.

The concept of wavelet signal allows to abstract from an unknown number of primes of a physical quantity. We are confident that, as the signals in biology, identified patterns of primes as sums of wavelets - will be an important event. As in living cells: a signal - this is an event of regulatory importance for the functioning of cells. There is an analogy with the signals in a series of prime numbers, which must first be identified as wavelets.

6. Table A000040

Table 1 shows baseline data for wavelet analysis. Schedule A000040, or "the ladder of the Gauss-Riemann" are listed in the Internet. Computational experiments have shown that for $n > 500$ need a supercomputer petaflop class.

Table 1. Finite-dimensional range of primes A000040:n - the order of a prime number; a (n) - prime

n	a(n)	n	a(n)	n	a(n)	n	a(n)	n	a(n)	n	a(n)
1	2	11	31	21	73	31	127	41	179	51	233
2	3	12	37	22	79	32	131	42	181	52	239
3	5	13	41	23	83	33	137	43	191	53	241
4	7	14	43	24	89	34	139	44	193	54	251
5	11	15	47	25	97	35	149	45	197	55	257
6	13	16	53	26	101	36	151	46	199	56	263
7	17	17	59	27	103	37	157	47	211	57	269
8	19	18	61	28	107	38	163	48	223	58	271
9	23	19	67	29	109	39	167	49	227		
10	29	20	71	30	113	40	173	50	229		

7. The First Wavelet

Trend (Figure 1) after 90000 steps is calculated in the software environment CurveExpert-1.38 was the law of exponential growth by the formula

$$a(n) = 6.57251 \cdot 10^{-83} \exp(189,7135 n^{0,0065804}) \quad (3)$$

The residue of the first order of prime numbers is equal to 0.38096. But simple numbers begin with $n = 1$, and the ordinate is equal $a(n) = 2$. In a number zero values are absent. The remainder of the deterministic model (3) in the form of the law of exponential growth was obtained by the wavelet of the form (1a) in the formula (Figure 2)

$$a_2(n) = A_1 \cos(\pi n / p_1 + 1,41491) \quad (4)$$

$$A_1 = 16,40912 n^{-1,81310} \exp(+0,40441 n^{0,63429}),$$
$$p_1 = 92,03817 - 68,33022 n^{0,050053}$$

The graph in Figure 2 is similar to graph the Riemann zeta function. The difference is that instead of the complex domain (4) is located in the positive quadrant of real numbers.

The amplitude of the formula (4) changes in the anomalous biotech law, when the signs of the second and third parameters of bio-law change. In contrast to the zeta

function of half-cycle fluctuations in (4) is reduced, and is not constant, the oscillation frequency increases with the growth of a prime number. In $n=0$ the period of oscillation is $2\times 92.03817 \approx 184$. It's more of the series $1\le n\le 58$.

The second wave of disturbance (Figure 3) gets the function of asymmetric wavelet type

$$a_3(n) = A_2\cos(\pi n / p_2 - 1,33556), \quad (5)$$

$$A_2 = -0,00011633n^{4,01562}\exp(-0,49274n^{0,62216}),$$

$$p_2 = 4,78606 - 0,00034507n^{1,88011}$$

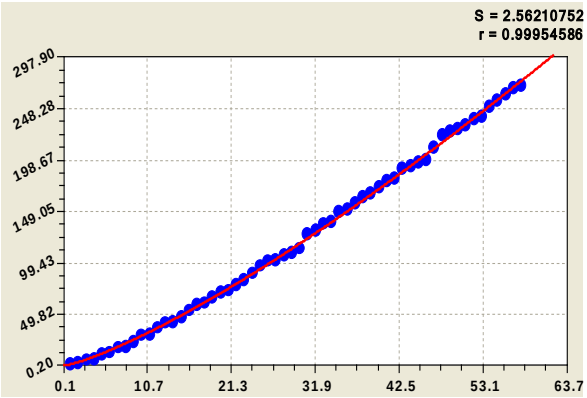

Figure 1. Graph the trend (3) of the set A000040 of prime numbers: S - Dispersion; r -correlation coefficient

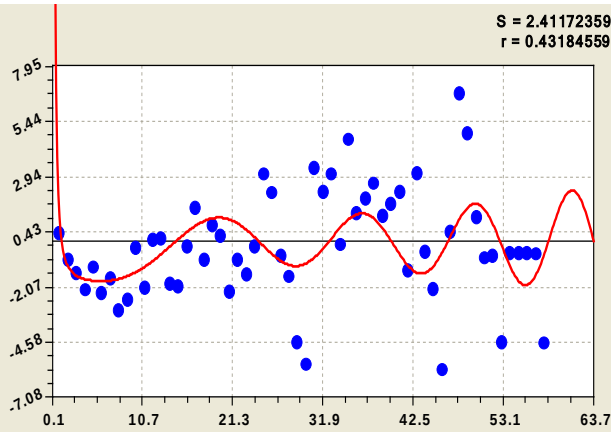

Figure 2. Schedule of the first wave oscillatory perturbations

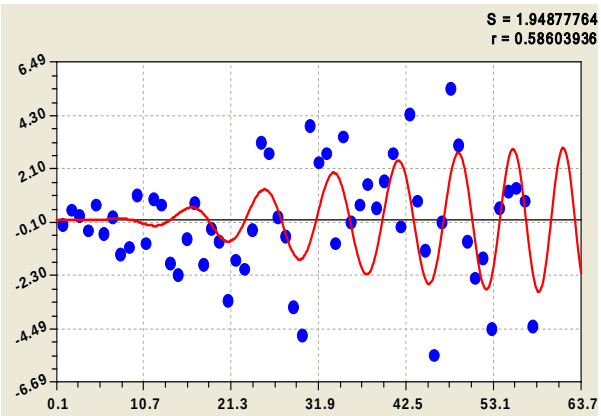

Figure 3. The graph of the second wave of the oscillatory perturbations

Amplitude has a negative sign, i.e. perturbation series of prime numbers is a crisis. In model (4) is the shift of the wave is equal to 1.41941 order to the right of $n=0$, and in the (5) shift is equal to 1.33556. Solitary wave ends after $n=58$. A left boundary to the left of zero order. Significant interval of the soliton starts around with $n=8$ or $a(n)=19$.

8. Combining Wavelets

Features CurveExpert (19 parameters) are small, so can "shake" together for more dense packing of wavelets, only three components (Figure 4) and obtain a general model of the form

$$a(n) = a_1(n) + a_2(n) + a_3(n) \quad (7)$$

$$a_1(n) = 5.82517\cdot 10^{-83}\exp(189,83601n^{0,0065753}),$$

$$a_2(n) = A_1\cos(\pi n / p_1 + 1,41453),$$

$$A_1 = 19,39898n^{-1,73234}\exp(+0,23129n^{0,76261}),$$

$$p_1 = 93,75309 - 70,10898n^{0,048713},$$

$$a_3(n) = A_2\cos(\pi n / p_2 - 1,44553),$$

$$p_2 = 4,74039 - 0,00027372n^{1,92343}$$

Two waves give rise to a correlation coefficient with 0.999546 in trend (Figure 1) to 0.999763 in the model (7). But such small increments give the opportunity to the decomposition of a series of prime numbers on wavelets $a(n) = f(n)$.

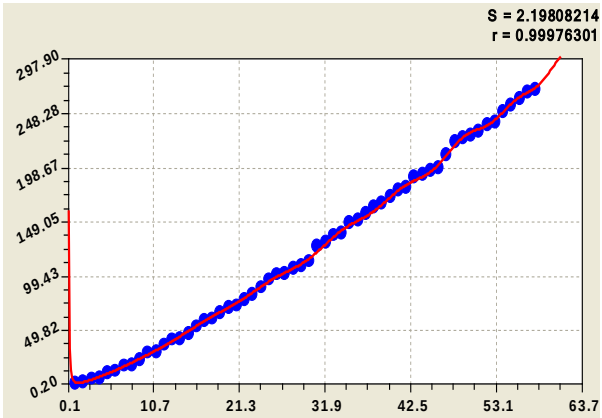

Figure 4. Chart sum of three wavelets growth of the number of primes

9. Compact Recording Wavelets

The parameters of the model can be written in the form of a matrix (Table 2). The trend is a solitary wave with a half-period, which considerably exceeds the interval of the order of prime number.

Need a special software environment to "shake" together the full sum of wavelets.

10. Fractal Groups of Wavelets

All were identified 36 wavelets on seven groups of the components of the general model. In this anomalous wave of the second component was repeated on the 36th member of the set. The grouping is made on the jumps decrease in balances of the module, as shown in Table 3.

Graphs of groups of wavelets are shown in Figure 5-Figure 8.

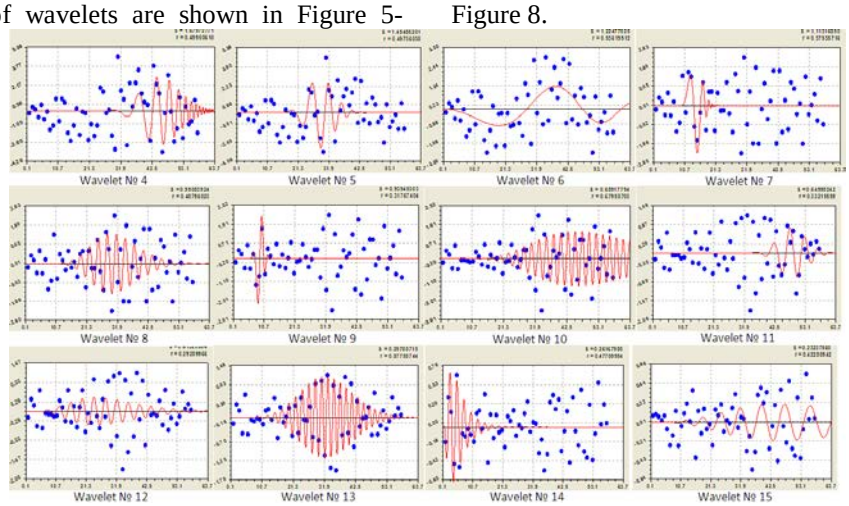

Figure 5. Graphics wavelets of the second and third groups (Table. 3) the distribution of the primes A000040

Wavelet number 14 is closer to the left side of the number of primes, but the computer gave the sequence, which is consistently identified by the software environment CurveExpert. A series of signals from the expansion of a number of prime numbers does not coincide with the number of wavelet. But this series should be specified only after the procedure package of all 36 components of the general model of the type (1a), but this requires a software package that allows you to simultaneously take into account the tens of wavelets with several hundreds of model parameters.

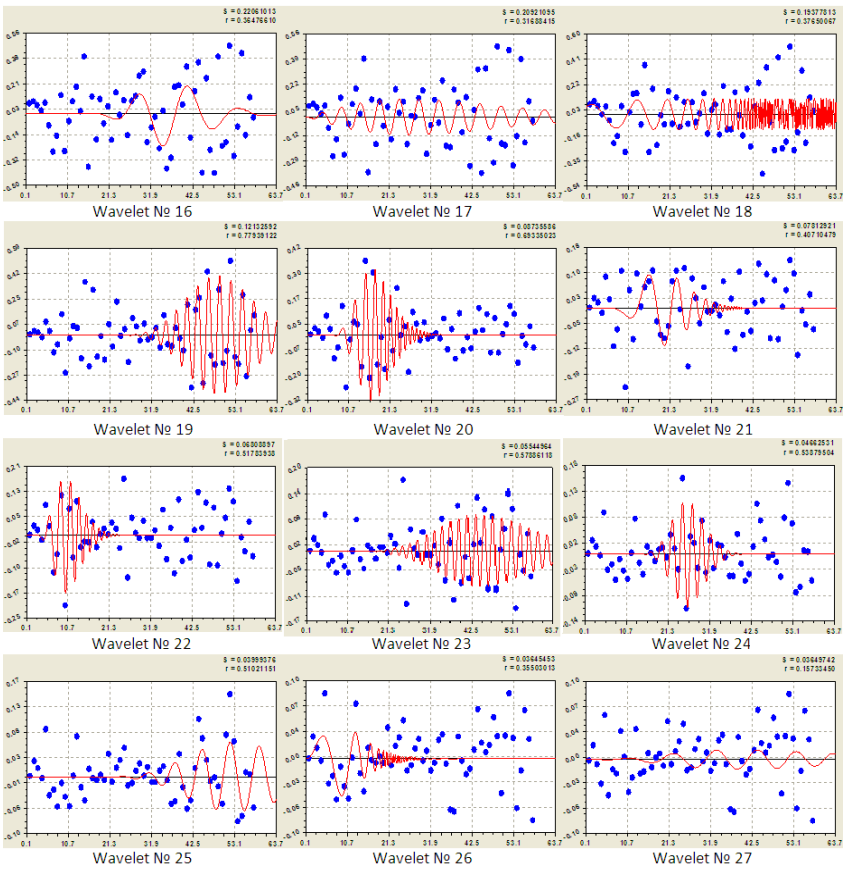

Figure 6. Graphs of wavelets fourth and fifth groups of the distribution of prime numbers A000040

11. Analysis of the Fractal Sum of Wavelets

Different signals in the form of a self-similar, i.e. fractal through a common model of the type (1a). It is known, that fractals like the through the law of Mandelbrot $y = a_1 \exp(-a_2 x)$. For the fractal model of the sum of wavelets indicator has a maximum absolute error (residue) $|\varepsilon_{\max}|$. According to Table 3 of the received formula:

$$\begin{aligned} |\varepsilon_{\max}| &= 271\exp(-6,95984i) \\ &+2,66495\cdot 10^9 i^{2,99207}\exp(-19,84166i^{0,15133} \\ &+473460,03i^{2,18365}\exp(-13,64245i^{0,13941}) \\ &\times\cos(\pi i/(0,72506+0,056028i^{1,22448})+0,69650) \end{aligned} \quad (8)$$

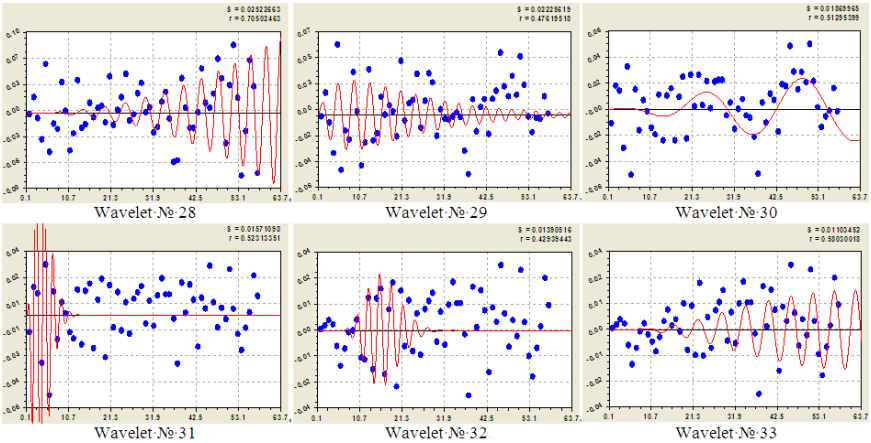

Figure 7. Graphics wavelets of the sixth group of distribution of prime numbers A000040

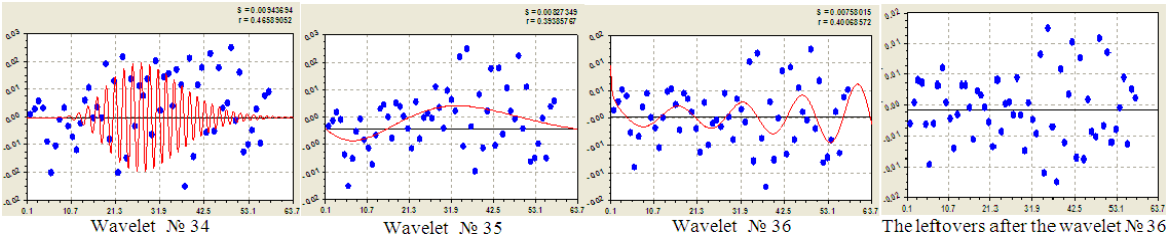

Figure 8. Graphics wavelets seventh group

Table 2. Parameters of the general equation of growth of number of primes of set A000040

Number i	Wavelet $y_i = a_{1i}x^{a_{2i}}\exp(-a_{3i}x^{a_{4i}})\cos(\pi x/(a_{5i}+a_{6i}x^{a_{7i}})-a_{8i})$								Correlation coefficient r
	amplitude (half) the fluctuations				half-period			shift	
	a_{1i}	a_{2i}	a_{3i}	a_{4i}	a_{5i}	a_{6i}	a_{7i}	a_{8i}	
1	5,82517e-83	0	-189,83601	0,0065753	0	0	0	0	
2	19,39898	-1,73234	-0,23129	0,76261	93,75309	-70,10898	0,048713	-1,41453	0,9998
3	-0,00011171	4,00261	0,49079	0,61786	4,74039	-0,00027372	1,92343	1,44553	
4	1,24610e-43	31,64837	0,060802	1,53064	16,36546	-0,19364	1,03795	-4,00668	0,499
5	5,56081e-23	17,97705	0,0043979	2,23659	16,94340	-3,48197	0,36080	-4,50713	0,497
6	0,021536	1,41090	0,00077267	1,97238	54,23757	-3,77334	0,53026	-1,91737	0,536
7	1,04309e-86	50,52931	3,54300	1	16,80229	-0,70449	1	-1,82130	0,375
8	1,70137e-15	14,37566	0,47611	1,00424	1,40716	0,033313	0,34232	2,31806	0,488
9	-4,06038e-35	66,89465	7,47700	0,99717	4,45330	-0,20420	1,01131	-2,82198	0,318
10	-2,02068e-12	14,10056	3,53171	0,52917	1,84833	-0,14689	0,32830	-3,55583	0,680
11	8,92820e-80	54,00030	0,014702	1,84395	4,37877	-0,00081240	1,75655	-3,02207	0,332
12	1,18070e-5	4,78940	0,19683	1	2,07024	-0,00027510	1,34578	-1,12678	0,293
13	-3,38101e-8	5,76583	0,0012728	2,20188	2,18782	-0,43852	0,22272	-0,69168	0,8776
14	-521,1866	4,37952	7,50836	0,38100	1,45463	-0,16507	0,091410	2,86731	0,477
15	2,54885e-6	4,01934	0,088735	1	2,40526	0,016938	1	2,36226	0,423
16	1,09156e-22	19,19700	0,61836	0,96619	6,08203	0,00035135	1,66701	-4,41882	0,365
17	-0,0059078	1,18206	0,0085163	1,40727	2,41174	0,00019104	1,62562	2,35497	0,317
18	-0,083202	0,18659	0,064990	0,45064	8,27728	-0,15579	0,99938	-2,96093	0,377
19	-1,68978e-36	26,46217	0,16725	1,24814	1,83808	0,0011193	1,19831	0,092090	0,7794
20	-2,36039e-13	16,30454	1,36566	0,91503	2,73707	-0,071939	0,92727	-2,97519	0,693
21	2,93607e-10	10,25109	0,54899	1	11,61479	-0,25836	1	0,23163	0,407
22	-1,89540e-6	8,85309	0,90538	0,99540	2,13247	-0,048777	0,99977	0,31235	0,518
23	-6,94085e-18	13,23390	0,29628	0,99986	0,83762	0,0028770	0,99853	0,80734	0,579
24	1,43427e-38	35,77440	0,79521	1,13034	1,84401	-0,013419	0,98188	-5,53047	0,539
25	1,06010e-22	15,41216	0,13593	1,15576	3,16118	0,00027502	1,63773	4,84800	0,510
26	-0,0036569	2,47324	0,31615	1	11,32210	-0,45103	1	-2,21077	0,355
27	7,58224e-7	3,62252	0,083916	1,02103	6,43220	-0,016110	0,99970	-1,10336	0,157
28	-1,52119e-5	2,09124	0	1	3,13542	-0,011853	0,99928	-0,85981	0,7050
29	0,012398	1,01396	0,25956	0,75747	2,03834	-0,00052756	1,52643	1,56442	0,476
30	4,34226e-5	2,04230	0,033661	1,00138	10,68980	0,021455	1,01024	0,47087	0,513
31	-0,093145	3,23242	1,04851	0,99848	1,07959	-0,0013151	1,17492	4,12146	0,523
32	1,93548e-13	14,59147	0,91161	1,00513	1,25837	0,0043789	1,05760	5,23704	0,429
33	4,05962e-7	3,42328	0,054790	0,99867	3,32185	-0,0047885	1,04828	-3,09568	0,580
34	-1,18100e-12	10,26508	0,42189	0,97466	1,18580	-0,00091799	1,33998	-0,93562	0,466
35	-0,0010015	1,16087	0,062654	0,99977	46,92809	0,072304	0,61386	-0,53443	0,394
36	-0,0049178	-0,43329	-0,035896	1,01859	8,80314	-0,020204	1,00481	-3,33438	0,401

Table 3. Fractal reduction of balances (by module) after the components of the statistical model (1a)

1 group		2 group		3 group		4 group		5 group		6 group		7 group	
i	$.\lvert\varepsilon_{\max}\rvert$	i	$.\lvert\varepsilon_{\max}\rvert$	i	$.\lvert\varepsilon_{\max}\rvert$	i	$.\lvert\varepsilon_{\max}\rvert$	i	$.\lvert\varepsilon_{\max}\rvert$	i	$.\lvert\varepsilon_{\max}\rvert$	i	$.\lvert\varepsilon_{\max}\rvert$
0	271	4	4.591	10	1.764	16	0.473	22	0.167	28	0.059	34	0.021
1	6.696	5	2.995	11	1.764	17	0.508	23	0.158	29	0.050	35	0.018
2	5.592	6	2.365	12	1.522	18	0.503	24	0.148	30	0.050	36	0.017
3	4.575	7	2.365	13	0.643	19	0.361	25	0.086	31	0.031		
		8	2.461	14	0.548	20	0.231	26	0.086	32	0.031		
		9	2.461	15	0.472	21	0.209	27	0.081	33	0.021		

The main three members of the formula (7) give the contribution to the reduction of residues 100(271-4,575)/271 = 98.32 %. In this case the first term under the law of exponential growth is the contribution of the absolute error of 100(271-6.696) /271 = 97.53 %. The remaining 35 wavelets give just 2.47%. However, their impact on a number $a(n) = \{2, 3, 5, ..., 271\}$ of very significant.

12. Conclusion

Any type of a number of primes can be decomposed into a finite-dimensional set of asymmetric wavelets with variable amplitude and frequency of vibration disturbance.

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