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The Rules for the Arrangement of Quatrains in the "Prophecies" of Nostradamus: The "Scytale" Cipher and the Principle of Alliteration

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Abstract: In recent publications, the author has demonstrated the presence of two types of steganography in Nostradamus's Prophecies. First, the order of the quatrains and the dates corresponding to them can presumably be reconstructed using simple ciphers similar to the well-known "scytale" cipher. Second, a graphic cipher is embedded in the Prophecies, possibly carrying illustrations for the predictive text. Fitting the text to the image parameters could be one of the reasons for its fogginess. This work continues the author's previous research concerning the algorithms for arranging quatrains. The author has developed a computer program for text analysis, which has revealed the chains of words "Provence" and "Concorde" placed in quatrains with equidistant numbers. The distance between the corresponding quatrains determines the keys for a cipher similar to a simple scytale, which allows arranging the fourth part of the quatrains without repetitions. The criterion for the correct arrangement is the presence of identical rare words in adjacent quatrains of the calculated chain, which was called by the author the "principle of alliteration." In addition, it turns out that the principle of alliteration is also applicable to the arrangement of quatrains in accordance with the previously formulated hypothesis concerning the counting of the letter combination "an." Thus, some specific algorithms for arranging quatrains have been discovered, which can be called the "branches" of the cipher. At the same time, the rules for assigning specific dates to quatrains remain less clear, which requires further research. It can be concluded that Nostradamus's Prophecies are not only a collection of predictive quatrains but also a kind of textbook of medieval steganography using several codes.

Keywords:

Nostradamus, prophecies, quatrains, centuries, chronologies, ciphers, scytale, steganography, cryptography, alliteration

1. Introduction.

Nostradamus' *Prophecies* have been exciting the minds of humankind for almost 500 years, giving rise to many popular interpretations [1]. However, the scientific study of the life and work of the French fortune teller only began relatively recently [2–4]. Historical and philological commentaries on the quatrains [5–14] were compiled, clarifying the meaning of several astrological passages and making it possible to establish the end date of the *Prophecies* (2240–2242), close to the end of the 6,000 years of the Jewish calendar. A very informative review of sources and historiography on the topic is presented in A. Penzensky's dissertation [11]. At the conclusion of this work, it was noted that *"the prophecies of Nostradamus are just beginning to be studied,"* so researchers still have a lot to learn and rethink. The prerequisites for the possible existence of hidden rules (cipher) for the arrangement of quatrains can be seen in A.A. Sapelkin's dissertation [12], according to Sapelkin, Nostradamus was not a magician and sorcerer but a "research *scientist, thoughtful historian, and subtle analyst"* of his era; therefore, *"it is highly likely that the idea of the cyclical development of world history prompted Nostradamus to engage in forecasting the future, whereas the form of traditional prophecies is secondary, and was chosen to draw attention to his predictions. [...] Nostradamus, who was the first to attempt to model the future, is, in fact, the forerunner of futurology."* In the same work, it was shown that many quatrains have an accurate historical basis in the events preceding their publication. This means that the predictor believes in the repetition of such events in the future. However, Sapelkin simultaneously suggests that Nostradamus did not have a specific futurological theory, or he would not have made it public. Therefore, the proposed concept seems internally contradictory. Indeed, if the prophecies are not only the result of poetic inspiration but were consistent with ideas about historical cycles, then it is logical to assume that the predictor still put specific dates by the quatrains but, for some reason, did not publicly announce them.

On the other hand, in popular literature based on the explicit and indirect signs of the presence of a cipher in the *Prophecies*, various variants of "decryptions" have long been proposed (R. Frontenac, D. Ruzo, D. and N. Zima, etc.). The main reason for the failure of these searches (at best, they can be viewed in a mystical but not scientific way) turned out to be a misunderstanding by commentators of the special terms, toponyms, and medieval astrological concepts attracted by the predictor. For example, E. Leoni, the author of one of the most authoritative and informative popular books, *Nostradamus: Life and Literature* (1961) [15], which is often referred to as scientific literature, comments on a large fragment of text with astronomical information preceding the second chronology in the preface to the *Prophecies* addressed to King Henry II with the irritated remark: *"This astrological nonsense seems to defy interpretation."* From here, it is clear that this fragment remained completely unclear to researchers even in the second half of the twentieth century. Meanwhile, he only described the features of planetary movements in 1606, and after the publication of Professor Brind'Amour [5,6], it is, by far, perhaps the most understandable place in the *Prophecies*. At the same time, according to the author's recently published hypothesis [16], the year 1606 indicated in this text fragment is used by the predictor as a reference point for the organization of the cipher.

In recent publications by the author [16–19], it was shown that the *Prophecies* of Nostradamus contain two types of cipher. Firstly, the biblical chronologies given in the prosaic preface to the *Prophecies* addressed to King Henry II of France should apparently be used to arrange quatrains and assign them real-time dates. It was shown that this assumption is in agreement with the existing historiography and also fully corresponds to the statement of the soothsayer himself before the second chronology: *"I calculated and calculated the real prophecies entirely according to the order in [this] chain, which contains its cycle, all through astronomical teaching and my natural gift."* However, the specific algorithms for restoring the order of quatrains remained unclear. Secondly, there is a large graphic cipher in the *Prophecies*, possibly transmitting illustrations to the predictive text. However, the quality of the restored images does not allow the characters to be identified at the moment. Fitting words to image parameters could be one of the reasons for the vagueness of the content of the text, which acts as a container for a hidden message.

In this paper, the previously formulated ideas [16] concerning the arrangement of quatrains are developed. The program developed by the author for computer analysis of the digitized text of the *Prophecies* made it possible to detect the placement rule for the fourth part of the quatrains, similar to the cipher of a simple scytale, and to estimate the probability of a random realization of the resulting sequence (no higher than a fraction of a percent). At the same time, the neighboring quatrains of the resulting series turned out to be connected not by meaning but by repeating the same rare words or letter combinations, which was called by the author the "principle of alliteration" of quatrains.

Another computer program was written to determine the numbers of quatrains corresponding to the calculation of the letter combinations "an" according to the chronologies from the epistle to King Henry II, within the framework of the modified scytale algorithm, according to the previously proposed hypothesis [16]. It turned out that the principle of alliteration also applies to the resulting chains of quatrains. The probability of a random implementation for the first steps of this algorithm is estimated analytically through the frequency of repeated words. It does not exceed a hundredth of a percent, which proves the validity of the previously formulated hypothesis. The problem remains the variety of parameters used (two types of cipher for the arrangement of quatrains, two chronologies, three reference quatrains with mention of 1607), which suggests the presence of currently unknown rules of interaction between different branches of the cipher.

Plunging into the search for a cipher for the arrangement of quatrains, we must imagine the expected final result. It is unlikely that he will predict the future based on the calculations of a medieval mystic scientist. Nostradamus's ideas about the future do not have to coincide with reality. At the same time, such a result

should increase the level of objective knowledge about the goals and methods of the predictor and his beliefs and reduce the space for arbitrary interpretations of quatrains considered out of the system.

The result achieved so far contains a significant increase in Nostradamian knowledge. He shows that the quatrains were not the result of poetic inspiration and prophetic ecstasy alone, as was believed in the work [11]. There is some consistency in them, the concealment of which required detailed calculations from the predictor. The ideas formulated in [12] about Nostradamus as a mystical scientist, the forerunner of futurology, may turn out to be much closer to reality, provided that the quatrains are still evidence-based on specific dates. However, this task requires further research.

2. A simple scytale for quatrains numbers: keys "Provence" and "Concord."

The widely known "scytale" cipher is one of the oldest ways to conceal information. In this method, tape is wound onto a cylinder, after which the text is written on the tape along the axis. After removing the cylinder, a sequence of letters remains on the tape, which looks chaotic. The decryption of the message is carried out by re-winding the tape on a cylinder of the correct radius. To apply a cipher of this kind to the numbers of quatrains, it is enough to close 1,000 quatrains in a circle (i.e., use periodic boundary conditions), determine the starting number of the quatrain K_1 and the key period P. Then the encrypted sequence of numbers will be determined by the formula:

$$K_i=[K_1+P*(i-1)] \bmod 1000 \qquad (1)$$

where the index i takes the values i=1,2,3... etc., the "mod" operation means taking the remainder of the integer division. Given that each century contains 100 quatrains, the ordinal number of the quatrain in the general list is associated with the number of the century N_c and the number of the quatrain in the century N_k by the formula $K_i=(N_c-1)*100+N_k$. When using such a cipher, the criteria for its detection should also be embedded in the text of the *Prophecies*; that is, the "correct" sequence of quatrains should differ from the random sequence by some signs.

The author of this article has written a computer program to search for periodically repeated words in a closed set of numbers of quatrains. As a result, two keywords were found: "Provence" and "Concorde". Each of these words occurs in the *Prophecies* only three times: the word "Provence" in quatrains 9–75, 2–59, 5–43 and the word "Concorde" in quatrains 3–39, 6–03, 8–67. It is easy to verify that the ordinal numbers of these quatrains are at the same distance from each other (taking into account periodic boundary conditions), P=284 for the sequence "Provence" and P=264 for "Concorde," that is, both elementary sequences satisfy formula (1). It should be emphasized that the computer check was performed for all the words in the *Prophecies*; other elementary sequences satisfying formula (1) were not found. When analyzing the work of the program, the features of Middle French spelling were also taken into account, such as the interchangeability of the letters “u” and “v,” “i” and “y,” the final “s” and “z” [20], as well as numerous typos, especially in toponyms, due, as it is believed, to the practice of typographical typesetters, when one employee read the text aloud. The other typed it by ear [11].

The word "Provence" is particularly well suited as a "key" to a cipher. Nostradamus was born and spent his childhood in this region of France. In 1546, he returned to fight the plague epidemic, got a new family, and wrote his almanacs and Prophecies here. The use of the key "Provence" characterizes Nostradamus as a patriot of his small homeland.

The found periods P=284 and P=264 and the corresponding starting sequence numbers of the quatrains K_1 =875 and K_1=239 allow us to calculate by formula (1) the continuation of the sequences, which, for simplicity, we will call the series "Provence" and "Concorde," in accordance with the keywords. As a result, it turns out that the calculated sequences of quatrain numbers have interesting properties. The sequence "Provence" contains 250 quatrains, a fourth of their nominal number; at the 251st step, there is a return to the starting quatrain 9–75. The Concorde sequence contains 125 quatrains, and at first

glance, it seems independent. However, a closer analysis shows that all the quatrains of the "Concorde" sequence are present under even numbers *i* in the "Provence" sequence, although in a completely different sequence order. On the contrary, not a single quatrain present in the sequence "Provence" under the odd number *i* is contained in the sequence "Concorde."

The first calculated quatrain in the sequence "Provence," following immediately after the three starting quatrains 9–75, 2–59, 5–43, has the form:

8-27 (i_P=4)

Aurelian road, one arch on the other,

Except for the grits and gorse of the Le Muy desert,

The Scripture of the Phoenix Emperor,

Noticed by someone who is not anyone else.

As Penzensky notes in historical and philological comments on the quatrains [9], the Aurelian Road connects Arles (a city in Provence) with Rome through the Maritime Alps. It passes first through the territory of Provence and then along the western coast of the Apennine Peninsula. The mentioned "Le Muy desert" is located in Provence, west of Frejus. "One arch on another" is presumably an aqueduct near the city of Frejus. Aqueducts were often built as a two-level system of arches.

If we consider quatrain 8–27 as a metaphor, it fits nicely into the context of the cipher. The "Aurelian Road" coming from Provence is associated with the sequence calculation, starting with quatrains 9–75, 2–59, and 5–43, in which the keyword "Provence" is present. The discovery of the mysterious "Emperor's writings" is associated with deciphering *Prophecies*. And finally, "one arch on the other" is related to the presence of two sequences, "Provence" and "Concorde," of which the second is strangely contained in the first.

The next after 8-27 (i_P=4) in the sequence "Provence" quatrain 1-11 (i_P=5) noticeably "echoes" the preceding one, 5-43 (i_P=3):

5-43 (i_P=3)

La grande ruine des sacrez ne s'esloigne,
Provence, Naples, Sicille, Seez & Ponce,
En Germanie, au Rhin & la Cologne,
Vexez a` mort par tous ceux de Magonce.

1-11 (i_P=5)

Le mouvement de sens, cueur, pied, & mains
Seront d'accord Naples, Leon, Sicille,
Glaisues, feus, eaux puis aux nobles Romains,
Plonges, tues, mors par cerveau debile.

In the second line of each of these quatrains, there are the words "Naples" and "Sicille" ("Sicily"), which occur together only in four quatrains; in the last line, there are the phrases "mort par" and "mors par," which differ in a single letter and occur in this form also only in four quatrains. The joint implementation of these repetitions is realized only in this pair of quatrains. Such repetition of words or letter combinations in neighboring quatrains of the calculated series would be called alliteration, understanding the term "alliteration" known from poetry in a generalized sense.

The given quatrains 5–43 (i_P=3) and 1-11 (i_P=5) belong to the odd row of the sequence "Provence," while the quatrain 8-27 (i_P=4) considered before them belongs to the even row, which means, as noted above, it is present in the sequence "Concorde." At the same time, there is no alliteration of quatrain 8–27 with quatrains 5–43 and 1–11. This suggests that the odd and even series of the sequence "Provence" (let's call them "Provence I" and "Provence II") can, in some sense, be considered separately. In this case, cross-alliteration is immediately detected between the first quatrains of the series "Provence II" and "Concorde" (see Table 1). In quatrain 8-27 (i_P=4), there is the word "Empereur" ("Emperor"), and in quatrain 6-03 (i_C=2), there is the word "Empire." In addition, the rare words "l'escript" ("scripture") and "le sceptre" ("scepter") in these quatrains are very consonant. In quatrains 3-95 (i_P=6) and 8-67 (i_C=3), in almost the same position (the beginning of the second line), there are the speech phrases "apres une autre" ("after one another") and "ne l'un ne l'autre" ("neither one nor the other") accordingly. The frequency of occurrence of these words in quatrains is relatively low, which suggests a non-random nature of alliteration. This may mean that both series, "Provence II" and "Concorde," are involved in the cipher, differing only in the order of the quatrains, which is somewhat unexpected. According to the author, any quatrains still should not be present twice in the combined sequence. Therefore, the following quatrain should not be included in the combined series if it was already *included in at least one of the rows earlier (with lower values of* I_P, I_C). However, we do not have enough arguments to substantiate such a hypothesis.

«Provence II»	«Concorde»
8-27 (i_P=4) La voye auxelle l'une sur l'autre fornix Du muy deser hor mis braue & genest, **L'escript**(4) d'**Empereur**(4) le fenix Veu a` celuy ce qu'a` nul autre n'est.	6-03 (i_C=2) Fleuue qu'esprouue le nouueau nay de Celtique Sera en grande de l'**Empire**(32) discordes Le ieune prince par gent ecclesiastique, Ostera **le sceptre**(10) coronal de concorde
3-95 (i_P=6) La loy Moricque on verra defaillir: Apres **une autre**(30) beaucoup plus seductive, Boristhenes premier viendra faillir: Pardons & langue une plus attractive.	8-67 (i_C=3) PAR. CAR. NERSAF, a` ruine grand discorde, Ne **l'un ne l'autre**(30) n'aura election, Nersaf du peuple aura amour & concorde, Ferrare, Collonne grande protection.

Table 1. Cross-alliteration between quatrains at the beginning of the series "Provence II" and "Concorde." The numbers in parentheses indicate the frequency of occurrence of highlighted repetitive or consonant words.

Further analysis shows that direct and cross-alliteration are preserved along the entire length of the calculated series, although they become weaker. Table 2 shows some examples of alliteration in the sequence "Provence I." The frequency of occurrence (*F*) of words in quatrains is indicated in parentheses next to the highlighted words. Special attention is paid to situations for which the possibility of accidental implementation of repetitions is reduced due to additional features. So, in quatrains 5-19 (i_P=17) and 10-87 (i_P=19), the repeated words “grand roy” (*F*=14) are located in the same position—at the very beginning of the quatrain. In quatrains 3-75 (i_P=101) and 9-43 (i_P=103), the word "proche" (*F*=52) is located at the beginning of the last and first lines, respectively. In quatrains 1-51 (i_P=65), 7-19 (i_P=67), 2-87 (i_P=69), the word "temps" (*F*=59) is present in three quatrains of the chain at once, and quatrains 1-51 and 7-19 are additionally connected by the word "long" (*F*=36); as a result, the highlighted words represent a symmetrical shape.

5-19 (i_P =17) Le grand Roy(14)al d'or, d'airain augmente', Rompu la pache, par ieune ouuerte guerre: Peuple afflige' par vn chef lamente', De sang barbare sera couuerte terre.	1-51 (i_P =65) Chef d'Aries,Juppiter & Saturne, Dieu eternel quelles mutations ! Puis par long siecle son maling temps retourne, Gaule & Italie quelles esmotions !
10-87 (i_P =19) Grand Roy(14) viendra prendre port pres de Nisse, Le grand empire de la mort si en fera Aux Antipolles(1), posera son genisse, Par mer la Pille tout esuanouyra.	7-19 (i_P =67) Le fort Nicene ne sera combatu: Vaincu sera par rutilant metal. Son faict sera vn long(36) temps(59) debatu, Aux citadins estrange espouuental.
6-55 (i_P =21) Au chalme' Duc en arrachant l'esponce, Voile Arabesque voir, subit descouuerte: Tripolis(1), Chio, & ceux de Trapesconce, Duc prins, Marnegro & la cite' deserte'	2-87 (i_P =69) Apres viendra des extremes contrees Prince Germain sus le throsne dore: La servitude & eaux rencontrees La dame serve,son temps(59) plus n'adore

1-99 (i_P =37) Le grand monarque que fera compaignie Auecq deux roys unis par amitie: O quel souspir fera la grande mesnie: Enfant(19)s Narbon a l'entour quel pitie !	6-95 (i_P =81) Par detracteur calomnie a` puis nay, Quand istront faicts enormes & martiaux: La moindre(5) part dubieuse a` l'aisnay, Et tost au regne seront faicts partiaux.
3-35 (i_P =41) Du plus profond de l'Occident d'Europe, De pauures gens vn ieune enfant(19) naistra(22), Qui par sa langue seduira grande troupe, Sont bruit au regne d'Orient plus croistra.	2-63 (i_P =83) Gaulois, Ausone bien peu subjuguera. Po,Marne,& Seine fera Perme l'vrie Qui le grand mur contre eux dressera Du moindre(5) au mur le grand perdra(8) la vie.
9-03 (i_P =43) La magna vaqua a` Rauenne grand trouble, Conduicts par quinze enserrez a` Fornase: A Rome naistra(22) deux monstres a testes double Sang, feu, deluge, les plus grands a` l'espase.	8-31 (i_P =85) Premier grand fruict le Prince de Pesquiere: Mais puis viendra bien & cruel malin, Dedans Venise perdra(8) sa gloire fiere, Et mis a` mal par plus ioyue Celin.

4-71 (i_P =45) En lieu d'espouse les filles(1) trucidees, Meurtre a` grand faute ne fera superstile: Dedans se puys vestu les inondees, L'espouse estainte par haute d'Aconile.	8-07 (i_P =99) Ver(10)ceil, Milan donra intelligence Dedans Tycin sera faicte la playe, Courir par Saine eau, sang(114) feu par Florence, Vnique cheoir d'haut en bas faisant maye
10-39 (i_P =47) Premier fils(31) vefue malheureux mariage, Sans nuls enfans deux Isle(34)s en discord: Auant dixhuict incompetant eage, De l'autre pres plus bas sera l'accord.	3-75 (i_P =101) P.A.V. Ver(10)onne,Vicence,Sarragousse De glaisves loings terroirs se sang(114) humides: Peste si grande viendra a la grand gousse Proche(52)s secours,& bien loing les remedes.
6-07 (i_P =49) Norneigre Dace, & l'Isle(34) Britannique, Par les vnis freres seront vexees: Le chef Romain issu de sang Gallique Et les copies aux forests repoussees.	9-43 (i_P =103) Proche(52) a` descendre l'armee Crucigere, Sera guettee par les Ismaelites, De tous costez batus par nef Rauiere, Prompt assaillis de dix galeres eslites.

Table 2. Examples of alliteration in the "Provence I" series. The numbers in parentheses indicate the frequency of occurrence of highlighted words or letter combinations.

A discussion of the alliteration of quatrains in the series under consideration would be incomplete and insufficiently convincing without more rigorous statistical estimates. The author has written a computer

program for the statistical evaluation of alliteration in the series "Provence" and "Concorde" (see Appendix). As a result, the probabilities of a random realization of P=0.002 and P=0.008 were obtained for the series "Provence I" and "Concorde," respectively. This means that with a probability of 99.8% and 99.2%, alliteration in these rows cannot result from random coincidences. At the same time, alliteration in the series "Provence II" was not found in these calculations, and cross-alliteration between the series "Provence I" and "Concorde" turned out to be relatively weak (P=0.04). As discussed in the appendix, the estimates obtained are conservative as the program did not take into account a number of significant features of the order.

Let's discuss how quatrains in the ranks of "Provence" and "Concorde" can be assigned real-time dates. There are only two quatrains in the ranks with openly named dates. Quatrain 10–91, which mentions the year 1609, is present both in the series "Concorde" (with the serial number I_C = 19) and in the series "Provence" (with the number I_P= 100). Quatrain 8–71, which mentions the year 1607, is present only in the series "Provence" (under the number I_P=145). Notably, both quatrains point to almost the same date, which we previously discussed as a reference point for the proposed cipher [16]. In addition, for several quatrains, the estimated date can be set for reasons of common sense or from an analysis of the planetary configurations given in them, but such exercises will already have the character of interpretation. Therefore, according to the author, the search for a date encryption method should start with the justification of the openly named dates in quatrains 10–91 and 8–71:

10–91

The Roman clergy, in the year 1609,

At the beginning of the year, you will hold elections

A specific gray and black, a native of the Campaign,

Who has never been so angry.

8–71

The number of astronomers will increase so much

Exiled, exiled, and renounced books

In the year 1607, that [even eating prosphora],

No one will be safe with the holy gifts.

The simplest assumption that the key numbers 264 and 284 are used not only to arrange quatrains but also at the same time to assign them some dates immediately leads to an exciting result.

We believe it is reliably established that the prophecies were calculated for the time interval 1555–2242, that is, for 687 years [16]. Using the scytale cipher on a given time interval mathematically means finding the remainder of the integer division (operation "mod") of the accumulated sum of years by the value of the interval, after which the resulting remainder is either added to the initial year or subtracted from the final year of the interval. By linking the first quatrain in each of the "Concorde" and "Provence" sequences with the starting point, we obtain remarkable equalities for the openly dated quatrain 10–91:

$$2242-[(i_C-1)*264] \bmod 687 = 1612 \quad (2)$$

$$2242-[(i_P-1)*284] \bmod 687 = 1606 \quad (3)$$

where i_C=19 and i_P=100 are the ordinal numbers of the quatrain 10–91 in the rows "Concorde" and "Provence" respectively. It can be seen that the date openly named in the quatrain, 1609, is exactly in the

middle, between two dates obtained within the framework of the alleged cipher. This coincidence does not look accidental and suggests that we have established some correspondence between the ordinal numbers of the quatrains in the "Concorde" and "Provence" sequences and the real-time dates to which these quatrains are dedicated.

Unfortunately, however, this observation is insufficient to understand the cipher fully. Firstly, quatrain 8–71 cannot be connected with 1607 using formulas (2) and (3). Secondly, quatrain 10–91 is the only one for which the calculated dates in the series "Concorde" and "Provence" approximately coincide. This means, at a minimum, that only one of the formulas can be used for the other quatrains, but not both simultaneously. It follows from this that our knowledge is incomplete, i.e., we are dealing with only some part of the cipher.

3. The modified "scytale": biblical chronologies as keys to the cipher.

In the preface to the *Prophecies* addressed to King Henry II, almost without connection with the context, two biblical chronologies do not agree on dates (see Table 3). The first chronology is organized so that 7,000 years from the world's creation expire in 2242 AD. After the second chronology, the predictor explicitly states that the order of quatrains is calculated based on this cyclically repeating sequence: *"I have calculated and calculated the real prophecies entirely according to the order in [this] chain, which contains its cycle, all through astronomical teaching and my natural gift."* He further explains that the starting point for the calculation is the date determined by a set of planetary movements and configurations (borrowed from the ephemerides of Leowitz and unambiguously indicating the year 1606, as shown by Professor Brind'Amour [5,6]). Thus, the presence of this cipher in the *Prophecies* is more noticeable compared with the cipher of a simple scytale discussed above, but at the same time, the cipher itself turns out to be more complex.

										The amount (fact.)	The amount (named)
I chr.	Noah 1242		Abraham 1080				Moses 516	David 570	Jesus 1350	4758	
II chr.	Noah 1506	Flood 600	Abraham 296	Isaac 100	Jacob 60	Egypt 130	Issue 430	Temple 480	Jesus 490	4092 and 2 months	4173 and 8 months

Table 3. Chronologies of biblical events (intervals between events, with a starting point from the world's creation) are given by Nostradamus in the preface addressed to King Henry II.

A recent paper by the author [16] proposed a reasoned hypothesis regarding the algorithm for arranging quatrains based on chronologies. This hypothesis is based on an observation [21], from which it follows that Nostradamus counted some words and letter combinations in his texts, in particular, the letter combination "an" ("year," translated from French). It was shown in [16] that, due to typos by publishers, the results of such calculations depend on the edition. However, the most plausible calculation performed from facsimiles of the first editions leads to several remarkable coincidences, clearly indicating the key to the arrangement of quatrains. In particular, in 353 quatrains of the incomplete first edition (1555), there are 777 letter combinations "an" in the first four centuries—888 "an," in five centuries—1,111 "an." Apparently, Nostradamus uses "recognizable" numbers to signal the cipher and confirm the correctness of the calculation. The total number of letter combinations "an" in the quatrains turned out to be 2,087, exactly equal to half of the length of the II chronology named by Nostradamus: 2,087*2=4,174. This corresponds to the mental image that the chronology is counted from the beginning of the quatrains to the end and then returns to the beginning ("contains its own cycle," as the predictor himself notes in its description). In other words, the enumeration of quatrains is carried out using an algorithm similar to the

modified scytale, in which the biblical chronology acts as a key sequence (unlike a simple scytale, where a single key number is used). Next, we propose the development of this hypothesis.

The quatrains contain only a few openly named dates, a special place among which is occupied by the year 1607, mentioned three times (quatrains 3–56, 6–54, 8–71). Considering the mention of the year 1606 close to it after the second chronology in the epistle to King Henry II, it is logical to assume that these three quatrains act as reference points in calculations according to chronologies. In each case, it is necessary to determine which of the two chronologies is used and in which direction the counting starts (decreasing or increasing the number of quatrains).

In all cases, when calculating the letter combination "an," we use mirror boundary conditions. This means that when the limit quatrains 1–1 or 10–100 are reached, the direction of movement along the quatrains in the counting process changes to the opposite. Note that such a counting scheme allows for a simple physical implementation (Fig.1). Let's mark up the letter combinations "an" (and their corresponding quatrains) from the outside of the disk and mark up the chronology numbers from its inside. For example, we will combine the position of the chronology "Creation of the World" with the quatrain 1–01 and turn the disk, alternately combining the positions of the chronology with this starting point. In this case, the arrow corresponding to the "Creation of the World" in the chronology will alternately indicate the number "an" corresponding to the accumulated sum of years in the chronology. When the last digit of the chronology is reached ("Jesus"), it is enough to take the current position of the arrow as a new reference point and repeat the cycle, alternately combining the chronology positions with the reference point. Nostradamus likely used this simple method instead of manually counting for a large number of cycles. In turn, the author's research implements a computer model of this process. The marking of the letter combinations "an" by quatrains is performed manually once, after which a specially written computer program implements the calculation, determining the number of the quatrain corresponding to the accumulated sum of the letter combinations "an."

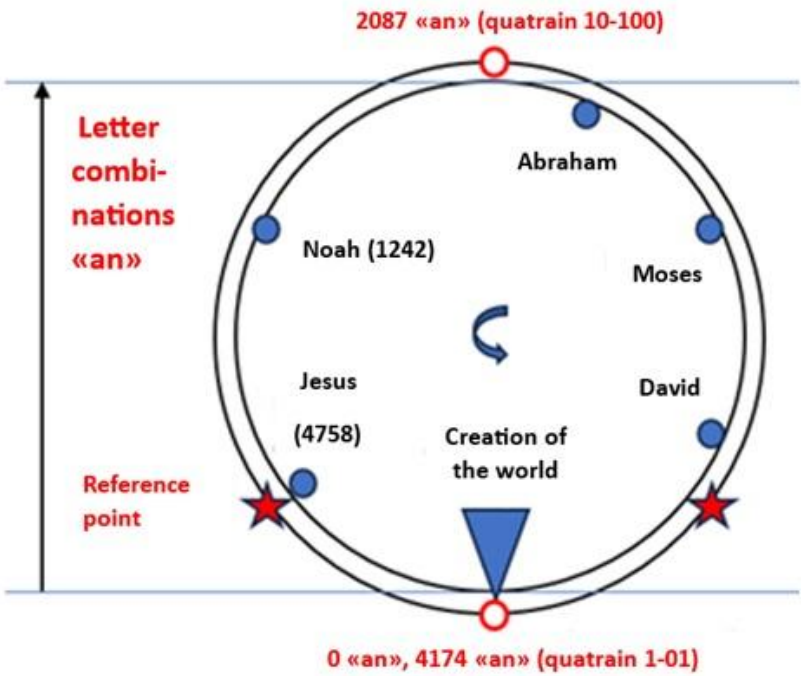

Fig.1. Schematic representation of a simple device that allows you to automate the process of arranging quatrains in accordance with a cyclically repeating chronology.

In this work, we will limit ourselves to considering only quatrain 3–56 as a starting point (the first quatrain, in which 1607 is openly mentioned). It turns out that it exactly corresponds to (!) 4,758 letter combinations

"an" (the length of the I chronology from "Creation of the world" to "Jesus"), counted from the first quatrain 1–1. Hence, it is logical to assume that quatrain 1–1 is put in accordance with the "Creation of the world" from the I chronology (as shown in Fig.1), then quatrain 3–56 corresponds to "Jesus," after which the chronology is cyclically repeated. Table 4 shows the calculated arrangement of quatrains near quatrain 3–56 based on the I chronology (the line corresponding to quatrain 3–56 is shaded in gray). Here and further, we assume that due to various kinds of errors (for example, possible typos in the texts or inaccurate markup of the intended computing disk), the calculated quatrain number may differ by one or two from the actual one.

It can be seen that the two quatrains of the chain following 3–56 (the upper part of Table 4) turned out to be tightly connected thematically ("naval victory achieved by deception"), but above all, by repeating the vocabulary used (the principle of alliteration). In particular, the words with the root "fraud" ("deception") occur in the *Prophecies* only 8 times, *F*("fraud") = 8. Therefore, the probability of repeating such a word in a randomly taken position (with an acceptable error in calculating the quatrain number + -1) does not exceed 0.025. However, we find words with this root in each of the three quatrains preceding 3–56 (upper part of Table 4); the probability of double repetition of the selected word is estimated at ~6E-04. Moreover, quatrains 4-42 and 6-77, although not thematically related, both contain the root "fraud" as part of the rare word "fraudulente" ("deceptive"), which is not found anywhere in the *Prophecies* except for these quatrains (!), which additionally reduces the probability of accidental realization (by about an order of magnitude). The words *chef* and *classe* are often found by themselves, but their joint appearance is realized only in seven quatrains, from where the probability of their repetition in a random quatrain is about 0.02, and we observe exactly such a case in quatrains 9–79, 6–77.

Similarly, a statistically rare situation is observed in two quatrains of the chain (4–49 and 7–5) preceding 3–56 (lower part of Table 4), in each of which the phrase *sera respandu* ("it will be poured") is present at the end of the first line, which is not found in the *Prophecies* anywhere other than these quatrains (in 4–49 it is spilled blood (*sang*), at 7–5, wine [*vin*]).

Finally, alliteration is found between the quatrains of the upper and lower parts of Table 4. The words *Langres*, *Dole* (*F*=2) and the root of the word "fraud" (*F*=8) are present both in quatrains 4–42 (the third step after 3–56) and in quatrains 7–3, 7–4 (the second step before quatrain 3–56). Note that the word "Dole" is rare in itself (*F*=3) and, in conjunction with the word *Langres*, is not used anywhere except for the specified quatrains 4–42 and 7–4. Moreover, in quatrain 4–42, there is also the word *dole* ("plan, trick"), which attracts additional attention to the name of the settlement of the same name, *Dole*. Further observations led the author to the conclusion that the technique of repeating some words in one quatrain is often used by Nostradamus as an index, indicating that these words alliterate with other quatrains. Special attention should be paid to the fact that in quatrain 7–3, there is a word with the root "fraud" (*F*=8), as in the previously considered quatrains 4–42, 6–77, 9–79. Given that we have considered only six positions in the table, with an acceptable error in calculating the quatrain number + -1, the probability of a triple random repetition of such a word is estimated by Bernoulli as 3E-04.

Calculation of the quatrain number (from 1-1)	Tha actual quatrain	Frequencies of characteristic words and letter combinations
(4758+ 1242+ 1080+ 516) «an»→ **4-43 «Moses»**	**4-42** Geneve & ***Langres*** par ceux de Chartres & ***Dole*** Et par Grenoble captif au Montlimard Seysset, Losanne par **fraudulente** ***dole***, Les trahiront par or soyxante marc.	F(«fraudulente»)=2 F(«fraud»)=8 F(«Langres»+ «Dole»)=2
(4758+1242+ 1080) «an» → **6-76 «Abraham»**	**6-77** **Par** la victoire du deceu **fraudulente**, **De**ux **classe**s vne, la reuolte Germanie, **Le chef** meurtry & son fils dans la tente, Florence, Imole pourchassez dans Romaine.	F(«fraud»)=8 F(«chef»+«class»)=7
(4758+ 1242) «an» → **9-79 «Noah»**	**9-79** **Le chef de classe par fraud**e stratageme, Fera timides sortir de leurs galees, Sortis meurtris **chef**s renieux de cresme, Puis par l'embusche luy rendront le saleres.	F(«fraud»)=8 F(«chef»+«class»)=7
4758 «an» **3-56 «Jesus» (I chr.)**	**3-56** Montauban, Nismes, Avignon, & Besier, Peste, tonnerre & gresle a fin de Mars: De Paris pont, Lyon mur, Montpellier, Depuis **six cent & sept** XXIII.pars.	
(4758-1350) «an» → **4-49 «David»**	**4-49** Devant le peuple **sang sera respandu** Que du haut ciel ne viendra eslogner: Mais d'un longtemps ne sera entendu L'esprit d'un seul le viendra tesmoigner.	F(«sera respandu»)=2 F(«sang»+ «espand»)=9
(4758-1350-570) «an» → **7-4 «Moses»**	**7-3** [...] Ceux de Ptolon au ***fraud*** seront consens. **7-4** Le Duc de ***Langres*** assiege' dedans ***Dole*** [...] **7-5** Vin sur la table en **sera respandu** [...] **7-8** [...] **Sang espandu**, les plus grands prins a` main [...]	F(«sera respandu»)=2 F(«sang»+ «espand»)=9 F(«fraud»)=8 F(«Langres»+ «Dole»)=2

Table 4. The arrangement of quatrains in the vicinity of the selected quatrain 3-56 in accordance with the I chronology, provided that the counting of letter combinations "an" is conducted from the quatrain 1-1.

Further, it is found that if, at the start of the same quatrain 3–56, you change the direction of counting the letter combinations "an" to the opposite, another series of quatrains arises, interconnected with the first row through alliteration. This is especially evident when comparing the first quatrains in two rows (see Table 5), 9–79 and 3–90. The phrase "Le chef de classe" ("Head of the fleet"), from which the quatrain 9–79 begins, is not found anywhere except in these two quatrains. In Table 6, the quatrains of these rows are compared in four steps, and repeated words are written out. In this table, direct alliteration (words in red italics) is observed only for the first row (columns 1 and 3). However, the cross-alliteration of the rows can hardly be questioned. The alliteration between the 1st and 4th columns of Table 6 in the first two steps is worth noting. In quatrains 9–80 and 10–36 (the first step) there is a rare word "tyrannie" (*F*=3), and in quatrains 6–76 and 9–5, there is a rare word "tyran" (*F*=9). These words are also consonant with the toponym "Tyrren"(*F*=4) from quatrain 3–90 (second column). The author suggests that Nostradamus deliberately created an excessive order to attract the attention of researchers to his cipher. This means that some of the "directions" of the cipher may be "false" or meaningless.

From 3-56 forward, 1242 «an»	From 3-56 backward, 1242 «an»
9-79 **Le chef de classe** (2) par fraude stratageme, Fera timides sortir de leurs galees, Sortis meurtris chefs renieux de cresme, Puis par l'embusche luy rendront le saleres. **The fleet leader** will use a deceptive strategy To force the timid to leave the galleys. Those who leave are killed, the leader will renounce the cross, And then he will be repaid with a trap.	**3-90** Le grand Satyre & Tigre de Hyrcanie, Don presente a ceux de l'Ocean: **Le chef de classe** (2) istra de Carmanie Qui prendra terre au Tyrren Phocean. The Great Satyr and the Tiger of Hyrcania, A gift presented to the inhabitants of the Ocean: **The fleet leader** will leave Carmania And land in Tyrrhenus Phoceanus.

Table 5. Quatrains calculated at the first step according to the I chronology, forward and backward from the starting quatrain 3-56.

От 3-56	+1242+1080…	-1242-1080-…	-1350-570-…	+1350+570+…
0			***3-56*** **3-55,56,57 *regner+ peste+sept+sang***	
1	***9-80*** **9-79 *fraud* (8)** **9-79 *chef meurtry* (4)** 9-79 Le chef de classe (2) **9-80 tyrannie (3)**	***3-90*** 3-90 Le chef de classe (2) 3-91 longtemps+viendra (3) **3-90 Tyrren (4)**	***4-49*** **4-48,49,50 *regner+ peste+sept+sang*** 4-48 ronge (6) 4-49 longtemps+viendra (3) **4-49 *sera respandu* (2)**	***10-35*** 10-36 ronge (6) **10-36 tyrannie (3)**
2	***6-76*** **6-76 tyran (9)** **6-77 *fraudulente* (2)** **6-77 *chef meurtry* (4)** 6-77 victoire (12) 6-77 deceu (12)	***9-37*** 9-38 deceu (12)	***7-4*** **7-5 *sera respandu* (2)** 7-3 fraud (8) 7-5 tiers+Pyze (2) **7-3 *victoire* (12)**	***9-5*** **9-5 tyran (9)** 9-5 tiers+Pyze (2)
3	***4-43*** **4-42 *fraudulente* (2)** 4-43 mis a mort (3) 4-43 voudront (6) **4-44 *Bourdeaux* (4)**	***10-31*** 10-30 mis a mort (3) 10-31 voudront (6)	***9-98*** **9-97 *victoire* (12)**	***6-19***
4	***1-91*** **1-90 *Bourdeaux* (4)**	***7-10*** 7-10 Barcelone (6)	***6-65*** 6-64 Barcelone (6) 6-66 sepulchre (6)	***1-37*** 1-37 sepulchre (6)

Table 6. Alliteration is direct (words are highlighted in red italics) and cross in quatrains calculated in four steps according to the I chronology in the forward and reverse direction from the starting quatrain 3–56. The calculated quatrain numbers are in italics; the actual numbers are indicated next to the repeated words. The numbers in parentheses are the frequency of occurrence of words.

The first chronology was used in Tables 4–6. Let's find out whether quatrain 3–56 should also be used as a reference point for the II chronology. It turns out that if you count the letter combinations "an" starting from the last quatrain 10–100, then the number 1,506 corresponding to "Noah" from the II chronology is

reached on the quatrain 3–55 (!). This practically coincides with the quatrain 3–56, as we allow an error of +-1 when calculating the quatrain number.

Let's assume that the counting of letter combinations "an" according to the II chronology continues from quatrain 3–55 further in the same direction. The results of the corresponding calculation are given in the lower part of Table 7. The calculated position "flood" corresponds to the quatrain 1–14, and a remarkable situation is realized for the adjacent quatrains 1–15, 1–16. Firstly, in quatrain 1–16 there is the word “AUGE”, highlighted in capital letters in the original for no apparent reason. Considering this word and the letters “de l” adjacent to it, it is easy to find that through a cyclic permutation of letters, the word "Deluge" ("Flood") is formed, which correctly characterizes this position in chronology: "[A]UGE del" ->"deluge."

Secondly, in the second line of each of the quatrains 1–15 and 2–45, corresponding to "the flood" and "Abraham," there is a rare combination of words with the roots "sang" + "espand" ("blood is shed," *F* =9), already familiar to us from Table 4. The probability of accidental realization of such a phrase in an arbitrary quatrain is estimated at about 0.01, and taking into account the coincidence of the highlighted words by position in the quatrain and the similar situation in Table 4, a random coincidence seems extremely unlikely. Thirdly, we observe semantic coincidence and strong alliteration also in quatrains 1–16 and 2–46, adjacent to the above-mentioned ones: they both tell us that during the "renovation of the century" ("renovation de siecle"), "famine and peste" will occur. The last example demonstrates an important feature of the cipher: apparently, not only one but also two adjacent quatrains can correspond to a chronologically calculated position.

Calculation of the quatrain number (from 10-00)	**Tha actual quatrain**	**Frequencies of characteristic words and letter combinations**
-490 «an» → **8-79 «Temple»**	**8-76** Plus Macelin que Roy en **Angleterre**, Lieu obscur n'ay par force aura l'**empire**: Lasche sans foy sans loy saignera **terre**, Son temps s'approche si pres que ie souspire. **8-77** L'antechrist trois bien tost annichilez, Vingt & sept ans sang durera sa guerre: Les heretiques morts, captifs exilez, ***Sang*** corps ***humain*** eau rogie gresler terre.	F(«Angleterre»+ «empire»)=2 F(«sang»+ «humain»)=6
0 «an» → **10-100 «Jesus»**	**10-100** Le grand **empire** sera par **Angleterre**, Le pempotam des ans de trois cens: Grandes **copies passer par** mer & **terre**, Les Lusitains n'en seront par contens.	F(«pass»+«copies»+ «par»)=2 F(«Angleterre» +«empire»)=2
1506 «an» → **3-55 «Noah» (II chr.)**	**3-54** […] **Passant copies par** les hautes montaignes Devastant tout & puis en paix regner. **3-55** En l'an qu'un oeil en France regnera, La court sera a un bien fascheux trouble: Le grand de Bloys son ami tuera: Le regne mis en mal & doute double.	F(«pass»+«copies»+ «par»)=2
(1506+ 600) «an» → **1-14 «Flood»**	**1-15** Mars nous menasse par la force bellique Septante foys sera le **sang espandre**: […] **1-16** Faulx a l'estang joinct vers le Sagitaire En son hault ***AUGE de l'***exaltation, **Peste, famine**, mort de main militaire: Le **siecle** approche de **renouation**.	F(«sang»+ «espand»)=9 F(«siecle»+ «renov»)=4 F(«peste»+ «famine»)=4
(1506+ 600+ 1+ 295) «an» → **2-46 «Abraham»**	**2-45** Trop le ciel pleure l'Androgyn procree, Pres de ce ciel **sang** ***humain*** **respandu**, […] **2-46** Apres grand trouble ***humain***, plus grand s'aprest Le grand mouteur les **siecles renouvele**. Pluie, ***sang***, laict, **famine**, fer, & **peste** Au ciel veu, feu courant longue estincele.	F(«sang»+ «espand»)=9 F(«siecle»+ «renov»)=4 F(«peste»+ «famine»)=4 F(«sang»+ «humain»)=6

Table 7. The arrangement of quatrains in the vicinity of the selected quatrain 3–56 in accordance with the II chronology, provided that the counting of letter combinations "an" is conducted from the quatrain 10–100.

Now consider the quatrains of the chain preceding 3–55 (upper part of Table 7). At the first step, a strong alliteration of quatrains 3–54 and 10–100 is detected by means of the phrases "copies passer par" and "passant copies par," which in a similar form are not found anywhere except in these quatrains. In the second step, there is an equally strong alliteration of quatrains 10–100 and 8–76 through the words "Angleterre" +"empire," which are present together only in these quatrains. And finally, as before in Table 4, the alliteration of quatrains is found in the second step between the upper and lower parts of Table 7. In quatrains 2–45, 2–46, the word "humain" is repeated, which attracts attention to it, like the word "Dole" from Table 4. Checking the correspondence of the word "humain" with the upper part of the table, we find that the combination of the words "sang" +"humain" ("human blood," *F*=6) is present in quatrains 8–77 and 2–45, i.e., in the second step, at the top and bottom of Table 7, respectively. Further verification led the author to the conclusion that alliteration in this series of quatrains persists with a larger number of steps.

Let's discuss how the series of quatrains obtained using chronologies can be assigned real-time dates. The following equalities were observed in [16] (see also Fig.1 in [16]):

$$2242 - (4758 \bmod 687) = 1606 \quad (4)$$
$$1555 + (4173 \bmod 687) = 1606 \quad (5)$$

where 1555 and 2242 are the start and end dates of the time interval for which the prophecies are calculated, 687=2242-1555 is the length of this interval, 4173 and 4758 are the lengths of chronologies, 1606 is the reference point. The meaning of this pattern is that the algorithm of the modified scytale should probably be used to calculate dates according to chronologies, and in both cases, the year 1606 acts as a reference point corresponding to the "creation of the world" in chronology. The count of years I or II of the chronology starts from this year in the direction of increasing or decreasing real time, respectively. When the limit dates 2242 or 1555 are reached, the direction of movement along the time axis changes to the opposite. Then, the ends of the chronologies (4758 and 4173) will correspond to 1555 and 2242 years, and with a cyclic repetition of the chronologies, the counting can continue further. Thus, the calculation by chronology should probably be performed in parallel, both on a set of quatrain numbers and on a time interval. As a result, each quatrain of the calculated chain will be assigned a certain date.

An interesting feature of the II chronology is that its calculated length is 4092 years and 2 months, while Nostradamus himself calls the resulting amount 4173 years and 8 months. According to the author, this difference is not due to omissions and errors but was introduced specifically based on the needs of the cipher. Due to the presence of this difference in the calculation of the sequence of quatrains, the current sum of years does not return to the starting point after reaching the end of the chronology, so the quatrain numbers obtained on the first and second passes differ. The return to the starting point is achieved only at the end of the 51st pass because 4092*51 ≈ 4174*50. This means that the calculated quatrains 8–79 and 10–100 at the top of Table 7 are actually the final ones and correspond to the completion of the 51st passage; it is after these quatrains that the chain returns to its starting point. At the same time, quatrain 10–99 really refers to the completion of prophecies and mentions the keyword "end," and quatrain 8–77 (close to the calculated 8–79) mentions the Antichrist (*F*=2), which is quite logical. The word "Antichrist" occurs for the second time in quatrain 10–66, which in this calculation scheme is implemented in the last position of the previous 50th passage. This shows that in the calculated sequence of quatrains, in addition to formal signs of ordering (alliteration), there is a certain logic regarding the placement of quatrains in the time interval 1555–2242. However, this issue requires further research.

4. Discussion.

It is shown that the order of quatrains in the *Prophecies* is not random but is calculated using formulas of simple ciphers similar to the well-known "scytale" cipher. Also, apparently, by means of such ciphers, quatrains are put in accordance with real-time dates. The criterion for the correct arrangement of

quatrains is the repetition of identical rare words or letter combinations in neighboring quatrains (the principle of alliteration). The criterion for the correctness of the algorithm for assigning dates to quatrains should be the coincidence of calculated dates with openly named dates in several quatrains.

The prerequisites of the "alliteration principle," at first glance, are quite obvious, they have long been noticed by commentators who grouped and discussed quatrains based on the presence of identical or similar words in them, for example, identical proper names [5–14]. In recent observations by D. Hamatulin [21], this principle took shape in a more abstract and independent form: it was noticed that quatrains with non-random repetitions of words are not necessarily related in meaning; the reasons for this circumstance remained unclear and mysterious.

Unresolved problems related to the arrangement and dating of quatrains still remain. When calculating the order of the quatrains according to chronologies, the quatrain 3–56, apparently, is not the only starting point. Preliminary calculations by the author showed that other starting points are quatrains 6–54 and 8–71, which also mention the year 1607. At the same time, a quatrain with a given number may be repeatedly present on various branches of the cipher, and the criteria for choosing the right branch for a given quatrain remain unclear at the moment. Therefore, assigning certain dates to quatrains seems premature, this issue requires additional research.

A hint of several branches of the cipher can be seen already in the first two quatrains of the *Prophecies* (1–01, 1–02), where for no apparent reason, the words "ESTANT" and "BRANCHES" are highlighted in capital letters. The first of these words is successfully anagrammed: "ESTANT" à "NATTES," and the resulting phrase "NATTES BRANCHES" translates as "woven branches." In addition, in French medieval poetry, the word "branches" had a second meaning: These were the names of small poetic short stories, the purpose of which was to entertain and instruct listeners.

Nostradamus's use of cryptography techniques allows us to consider the predictor in the general context of the development of steganographic thought during the Renaissance period. In the introduction of the work [16], the surge of public interest in the art of cryptography in Europe in the first half of the sixteenth century was discussed. At the same time, no sources indicate that Nostradamus was interested in theoretical mathematics. Therefore, steganography had an applied meaning for him. However, at the moment, due to the lack of knowledge about the meaning of the observed patterns, it seems ambiguous whether the predictor used steganographic techniques strictly for their intended purpose, with a purely rational purpose (to convey a hidden message to descendants), or gave them the meaning of magical practice. Around 1499, the "Steganography" of Trithemius, one of the founders of cryptography, was written, where a rather peculiar view of this art was presented, including the evocation of spirits to convey secret messages to them. At the same time, the rational component of the book, including the development of new techniques of cryptography, was mostly not understood by readers in the sixteenth century [22]. The book remained unpublished until 1606, but there were handwritten versions. It is unclear whether Nostradamus was familiar with it. In the preface addressed to his son César, the soothsayer mentions that he was even interested in magical literature, although he later burned it. Quatrain 1–02 (with the mention of the word "BRANCHES") is a paraphrased quote from the treatise of Iamblichus, "On the Egyptian Mysteries," according to which the mechanism of prophecy involves the evocation of a spirit ("deity") through a certain magical practice ("sitting on a brass chair with three legs [...] holding a rod in his hands"). Although nowadays this quatrain is often understood as a poetic fleur, for Nostradamus, it could have, if not literal, then at least a specific metaphorical meaning. The predictor was, of course, not only a scientist (an "astrophile" and a cryptographer) but also a mystic.

Taking into account the new results presented in this article, as well as the graphical cipher [17] and other statistical anomalies [16], the large amount of computational work invested in the text of the *Prophecies*, which is generally not typical for the Middle Ages, and moreover, somewhat unexpected for Nostradamus, is surprising. The predictor finds himself at the forefront of scientific thought of his time, coming up with

new algorithms and implementing promising methods of hidden information transmission. In this sense, the text of Nostradamus can be considered a kind of textbook of medieval steganography, where the actual presentation of various cipher methods may turn out to be the main content. However, this does not exclude the fact that the prognostic message encrypted in the *Prophecies* still exists for posterity.

5. Conclusions.

(i). In the *Prophecies* of Nostradamus, there are ciphers of a simple and modified scytale for calculating the order of quatrains. The keys for the cipher of a simple scytale are set using the words *Provence* ("Provence") and *Concorde* ("Concord"), placed equidistant in the space of quatrains numbers. The keys for the cipher of the modified scytale are given by the biblical chronologies from the epistle to King Henry II. This allows us to consider Nostradamus not only as an inspired poet but also as a mystical scientist and a specialist in steganography.

(ii). Calculated sequences of quatrains obey the principle of alliteration: identical words or letter combinations are much more common in neighboring quatrains of these sequences than in randomly taken quatrains. Both direct (between adjacent quatrains in the same row) and cross (between different rows) alliteration are noted.

(iii). Within the framework of professional historiography, the time interval, 1555–2242, for which the *Prophecies* were calculated, seems to be reliably established. Apparently, the arrangement of quatrains in this time interval should obey the encryption algorithms presented in this paper.

(iv). Although, according to the author, the existence of the cipher can be considered proven, its practical use for assigning quatrains to any date is premature. In particular, the rules of interaction between the various branches of the cipher remain unclear and require further research.

Appendix. Statistical evaluation of alliteration in the "Provence" and "Concorde" series.

The author has written a computer program to assess the probability of accidental realization of repetitions of letter combinations in quatrains. For the selected pair of quatrains (*i,j*), the program determines a list of repeated letter combinations in the words used. For each letter combination from this list, the repeat significance indicator is calculated using the formula

$$H = L * K / F / (1+R) \qquad (П1)$$

where *L* is the length of the letter combination (number of characters), *K* is the ratio of the length of the letter combination to the full length of the word, *F* is the frequency of occurrence of this letter combination in the text, *R* is the difference modulo the ordinal numbers of the quatrains in which the letter combination is detected. Thus, this formula leads to large values of *H* if the letter combination is long enough, occupies a significant part of the word, is rarely found in the text, and is found in the lines of the considered pair of quatrains (*i,j*) with close or equal ordinal numbers. Next, three-letter combinations with maximum values of *H* are selected, and the total index *S = H 1 +H 2+ H 3 is calculated*, which characterizes the degree of alliteration of the selected pair of quatrains. The formula estimates the degree of alliteration for a given series of quatrains

$$Q = \sum_{k=2}^{N-1} \sqrt{S_{k,k-1} * S_{k,k+1}} \qquad (П2)$$

where *N* is the number of members of the series. This formula gives the maximum result for a chain of quatrains in which the quatrain with the number *k* has a high degree of alliteration with both the preceding quatrain *k*-1 and the subsequent *k*+1. Next, the program generates 1E+06 pieces of random rows of the same size with non-repeating quatrain numbers and calculates the value of *Q* for each case. The proportion of the number of random series for which the value *Q* turned out to be greater than for

the original series is an estimate of the probability *P* of a random realization of alliteration of quatrains in the original series.

It turned out that *P*=0.002 for the series "Provence I," *P*=0.008 for "Concorde," and *P*=0.90 for "Provence II." It follows from this assessment that direct alliteration seems to be present in the series "Provence I" and "Concorde" but is absent in the series "Provence II." Similarly, the evaluation of the cross-alliteration between the rows was performed. As a result, *P*=0.04 was obtained for cross-alliteration between the rows "Provence I" and "Concorde."

It should be noted that the formula (P1) does not consider a number of signs of order. So in Table 2, quatrains 5–19 and 10–87 begin with the same phrase, "Grand Roy" ("Great King"), which is quite rare (*F*=14). However, in the computational procedure, the search for letter combinations is conducted inside words, and the words themselves are considered separately. Otherwise, the estimated time increases enormously. Since the words "grand" and "roy" occur separately very often, the calculated value of *S* for this pair of quatrains turns out to be low. In quatrains 3–75 and 9–43, the word *Proche* is present at the beginning of the last and first lines, respectively. However, the formula (P1) does not take into account the relative position of words in the lines, while the difference in the ordinal numbers of the lines, in this case, is the maximum, which again leads to an underestimation of the value of *S* compared to the intuitive estimate. Finally, the computer calculation completely neglects the consonances of words, such as, for example, *l'escript* and *le sceptre* in quatrains 8–27 and 6–03 (see Table 1). Taking into account these and other similar circumstances would lead to a significant complication of the computational procedure. Nevertheless, it can be assumed that the obtained estimates of *P* are overestimated rather than underestimated.

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Peer Review

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When censorship restrictions were lifted in the era of Perestroika on the wave of democratization and glasnost, the book market was overwhelmed by a wave of pseudoscientific literature, which sought to gain commercial profitability with its sensationalism. A variety of riddles and mysteries of the past have received the attention of various authors, including the prophecies of Nostradamus. It is no secret that when studying the life and work of Nostradamus, many authors resort to various falsifications, the more important is a truly scientific study of the personality of this figure. These circumstances determine the relevance of the article submitted for review, the subject of which is the rules for the arrangement of quatrains in the "Prophecies" of Nostradamus. The author sets out to analyze the quatrains of the "Prophecies", as well as to consider possible ciphers for their decryption. The work is based on the principles of analysis and synthesis, reliability, objectivity, the methodological basis of the research is a systematic approach, which is based on the consideration of the object as an integral complex of interrelated elements. The scientific novelty of the article lies in the very formulation of the topic: the author, based on various sources, seeks to characterize the rules for the arrangement of quatrains in the "Prophecies" of Nostradamus. As the author notes, "the quatrains were not the result of poetic inspiration and prophetic ecstasy alone… There is some consistency in them, the concealment of which required painstaking calculations from the predictor." Considering the bibliographic list of the article as a positive point, its scale and versatility should be noted: in total, the list of references includes 22 different sources and studies. The undoubted advantage of the reviewed article is the attraction of foreign literature, including in English and French. From the sources attracted by the author, we will point to the works of Nostradamus himself. Among the studies used, we will point to the works of A.A. Penzensky, A.A. Sapelkin, I.K. Razumov, which focus on various aspects of the study of the prophecies of Nostradamus. Note that

the bibliography of the article is important both from a scientific and educational point of view: after reading the text of the article, readers can turn to other materials on its topic. In general, in our opinion, the integrated use of various sources and research contributed to the solution of the tasks facing the author. The style of writing the article can be attributed to a scientific one, at the same time understandable not only to specialists, but also to a wide readership, to everyone who is interested in both the work of Nostradamus in general and his prophecies in particular. The appeal to the opponents is presented at the level of the collected information received by the author during the work on the topic of the article. The structure of the work is characterized by a certain logic and consistency, it can be distinguished by an introduction, the main part, conclusion, and appendix. At the beginning, the author determines the relevance of the topic, shows that the "Prophecies" of Nostradamus have been exciting the minds of mankind for almost 500 years, giving rise to many popular interpretations, but the scientific study of the life and work of the French fortune teller began relatively recently." The paper shows that "the order of quatrains in the Prophecies is not random, but is calculated using formulas of simple ciphers similar to the well-known cipher of the scytale. The author draws attention to the fact that "Nostradamus's use of secret writing techniques allows us to consider the predictor in the general context of the development of steganographic thought of the Renaissance period." It is noteworthy that, as the author of the reviewed article notes, "the existence of the cipher can be considered proven, its practical use for assigning quatrains to any dates is premature." The main conclusion of the article is that "the text of Nostradamus can be considered as a kind of textbook of medieval steganography, where the actual presentation of various cipher methods may be the main content." The article submitted for review is devoted to an urgent topic, is provided with a drawing and 7 tables, will arouse readers' interest, and its materials can be used both in training courses and in the framework of studying the European prophetic tradition. In general, in our opinion, the article can be recommended for publication in the journal "Historical Informatics".