

# AN INVITATION TO MATHEMATICAL MODELLING OF ARTISTIC SPACE IN LITERARY CRITICISM: MASOCHISM RECONSIDERED

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## **Abstract**

*Mathematical methods have been employed in literary criticism for more than a century. The vast majority of the works using mathematical approaches in literary criticism is based on statistics. However, statistical methods are not the only mathematical approaches producing new results valuable for literary criticism. Literary criticism often use mathematical and physical terms and objects metaphorically. Such is 'artistic space', a term attracting great attention. Various theories of space in narrative texts were developed by many scholars, including most notably M. Bakhtin, Yu. Lotman, and G. Zoran. Their use of 'space', which is a fundamental concept in hard and life sciences, motivates one to enrich our understanding of special phenomenology by using mathematical tools. Taking as an example two world-famous masochistic novellas, we demonstrate how mathematical modelling reveals the structure of the artistic space in such kind of narrative. The modelling of love dynamics via differential equations, as well as the application of cluster analysis, reveals the undoubted similarity of 'Venus in Furs' by Leopold von Sacher-Masoch and 'Torrent of Springs' by Ivan Turgenev. Our Analysis shows that the artistic space of the masochistic text is divided into two sub-spaces, each having its own peculiarities. Though a mathematical method cannot be viewed as a 'rigorous proof' in literary theory, the suggested interdisciplinary approach allows one to compare the two love plots in such a way as to highlight their intrinsic topical, and not just stylistic, likeness as well as typological affinity.*

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## **Introduction**

Mathematical methods have been employed in literary criticism for more than one and a half century now, their history beginning with the letter of Augustus de Morgan to his friend William Heald (1851) in which he assumed that the texts

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of different authors of the same historical period (e.g. Herodotus and Thucydides) demonstrate different average word length. Later similar ideas were presented by Thomas Mendenhall (1887) and Conrad Mascoll (1888). The demonstration of statistical method in stylometry can be found in Andrei Bely's *Symbolism* (1910) where formal statistical method was applied to the study of poetry. The approaches based on statistics still prevail in literary studies (see, for instance, the research of Stanford Literary Lab and Franco Moretti (2013)). Also, the mainstream of such researches is the authorship problem. The powerful mathematical machinery, including data mining technique, artificial neural networks, etc., is used for this purpose (Khosmood & Kurfess, 2005; Zhao & Zobel, 2007; Koppel et al, 2009).

While recognizing the progress made in this field, we ask, what other mathematical approaches can be useful in the field of literary theory? Statistical methods are not the only mathematical approach producing new results related to literary criticism. An attempt of general consideration of the relation between mathematics and literary criticism can be found in the article of Richard Schoek (1968). In particular, he was critical of metaphorical usage of mathematical terms in literary criticism. He discussed the application of some specific methods (topology, vector analysis) to literary criticism.

*Mathematical modelling* of literary plots can reveal new crucial aspects of a piece of fiction under study. This fact appears to be quite surprising, since mathematics, on the one hand, and literary criticism, on the other, have been historically aimed at entirely different matters. This is the underlying reason why there are so few studies in which mathematics 'serves' close reading, despite the fact that some prominent scholars urged their colleagues to use mathematical approaches in literary criticism, as Yuri Lotman did (1997).

What are the prerequisites for applying mathematical modelling in literary criticism? First of all, any literary text can be viewed as a model. The writer simulates his/her perception of the world, his aspirations, some specific situations, etc. But this kind of modelling is still quite unlike the modelling in mathematical sense. Nevertheless, we can easily find the ideas that guide us to mathematical modelling. 'Artistic space' is one of such concepts. Historically this idea is rooted in the chronotope theory of Mikhail Bakhtin (1937). Various theories of artistic space and literary space (Bakhtin, 1920-1930; Blanchot, 1955; Lotman, 1968; Uspensky, 1970; Zoran, 1984) display general features.

Artistic space differs from space in physics or mathematics. It includes dissimilar elements such as loci, characters, storylines, etc. Also, it can include remembrances, fantasies, dreams, etc. All this shows that artistic space is multi-dimensional and that its dimensions are of different origin. Nonetheless, the concept of space suggests some structure. The apparent completeness of a piece

of fiction allows one to view it as a model of the world. Indeed, the 'plotless' piece of art has certain structure and, consequently, some structured artistic space. For this reason it is tempting to use corresponding mathematical machinery to study the structure of artistic space. Graph theory, methods of algebraic topology, and some other approaches can be used for the investigation of artistic space structure. An example of skillful and interesting analysis of space and time aspects in Turgenev is found in the book by Elizabeth Allen: "Turgenev artfully manipulates the spatial and temporal dimensions of his narratives in order to set very deliberate physical, metaphysical, and moral parameters within which the events he portrays can distinctively unfold. [...] In Turgenev's fictional universe, space is not an infinite extension and time is not an endless continuum. Both are portrayed as confined and confining." (Allen, 1992, p. 73)

'Dynamics' is another concept found in literary theory. For instance, Zholkovsky and Scheglov (1987) use such terms as 'path', 'jump', 'sudden turn', 'dynamization'. Lotman speaks about 'crossing the border' (1977). Another example of the discussion of dynamics is Wolf Schmid's *Narratology* where he claims: "Literary theories must do more than just register the presence of changes of state. Even the shortest stories, [...] will represent a vast number of changes. [...] We require categories which allow us to distinguish between the countless natural, actional, and mental changes – from thunderclap to victory in battle to a hero's moral conversion or psychological transformation." (Schmid, 2005, p. 8)

We use both concepts - *dynamics and artistic space* - in our research. We distinguish three stages in our approach to modelling. First, we map an object (artistic space) into certain mathematical set (often a space in mathematical sense). Then we investigate this mathematical space by mathematical methods. The last stage is mapping the result into the initial object, translation from mathematical language into the language inherent to the object. There are no definite prescriptions for the first and the third stages of the investigation. The mapping of artistic space into a mathematical object, as well as the turning of mathematical results back into the language of literary criticism, is a kind of art. The novelty and the credibility of the results are the basis for the estimation of a particular research.

In the present paper, we demonstrate the potential of mathematical modelling in literary criticism by employing both differential equations and cluster analysis to study two novellas. The first one is *Venus in Furs* by Leopold von Sacher-Masoch (1870), the author who gave his name to the term 'masochism'. The second one is the *Torrents of Spring* (1871), the novel by Russian writer Ivan Turgenev, the favorite author of Henry James (1873; 1896) and Joseph Conrad (1921). Turgenev's collection of short stories pointed against slavery and serfdom *A Sportsman's sketches* (1852) became the Russian equivalent of *Uncle Tom's Cabin*

(Stowe, 1852) and made its author famous as a writer, public figure and human rights champion in the 19th century.

Our interest in masochism is caused by the following facts. The phenomenon of masochism is culturally widespread as it is based on the imitation of the social submissive relations that are political rather than sensual in their origin, like those between the master and the slave, the sovereign and the vassal, etc. Masochistic relationship, though belonging to a variety of romantic relationships, has its own distinctions. The chosen novellas exemplify two different masochistic experiences: the one that can be considered as purely romantic and the other based on the repetitive imitation of social relationships. We intend not only to demonstrate the typological likeness of the novellas and clarify important aspects of their structure, but also to elucidate the subtle distinction in the origin of masochistic relationships.

### ***1. The Analysis of Love Dynamics by means of differential equations***

We demonstrate the potential of mathematical modelling in literary criticism by employing differential equations to analyze two novellas: *Venus in Furs* (1870) by Leopold von Sacher-Masoch and Ivan Turgenev's *Torrents of Spring* (1871). The similarity of these two texts, as well as the resemblance of their authors' personalities, was emphasized in the book by Larissa Poluboyarinova (2006).

Mathematical modelling of love affairs dates back to the articles of mathematicians (Strogatz, 1988; Rinaldi et al., 2013; Rinaldi et al., 2015). Their aim was to illustrate the possibilities of love dynamics modelling using the systems of differential equations. We apply this approach to analyze the love dynamics in the novellas and then to connect the models with the ideas and methods of literary criticism. The model is constructed in such a way as to render major - obvious - features of the dynamics of the relations between the characters, such as the growing attachment of Dmitri Sanin to Maria Nikolaevna in Wiesbaden or *qualitative* 'love/enmity' relations between Severin and Wanda. There can hardly be offered a quantitative scale to measure feelings between either characters in fiction or between real persons. Still, we use the relations like 'love/hatred', 'greater/less' to make a judgment about love dynamics. The analysis of the differential equations solutions, which model the relationship dynamics reveals previously undetected very important features of the artistic space structure. It should be noted *that the discovered features were not embedded in the model in the process of its construction.*

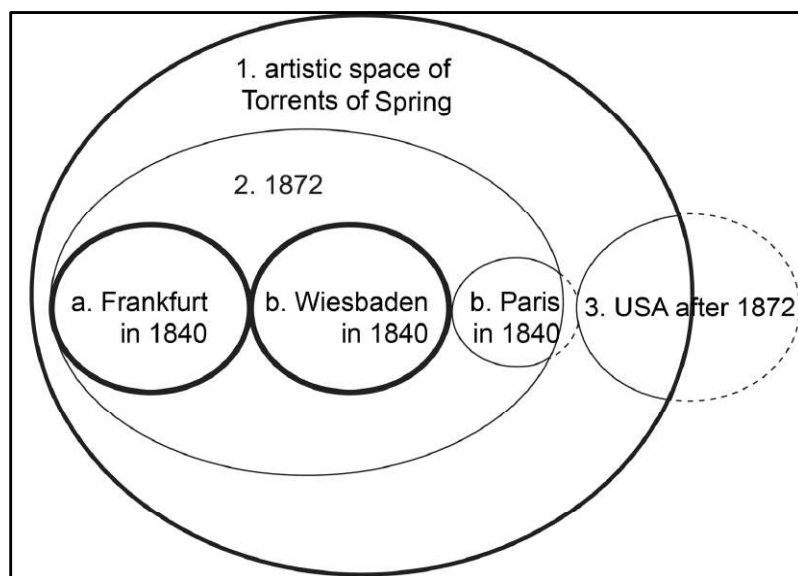


Fig. 1. Projection of the artistic space of *Torrents of Spring* onto 'loci subspace'.

We try to avoid metaphorical use of mathematical concepts. Still, sometimes what looks like a metaphor is actually an element of new construction. The following example clarifies this idea. We have emphasized that artistic space includes heterogeneous elements. For our purposes, we do not need to take into account all elements, all relationships between the elements. What we need can be called the 'projection' of the whole artistic space onto some subspace. It is convenient in our case to 'project' the artistic space onto locus subspace. The loci we distinguish in the artistic spaces of *Torrents of Spring* and *Venus in Furs* are presented in Figs 1 and 2 correspondingly. Further investigation of this 'projection' is based on the modelling of love dynamics by means of the systems of differential equations.

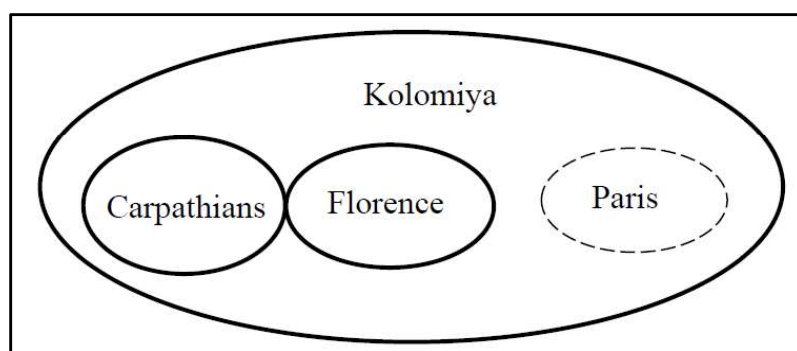
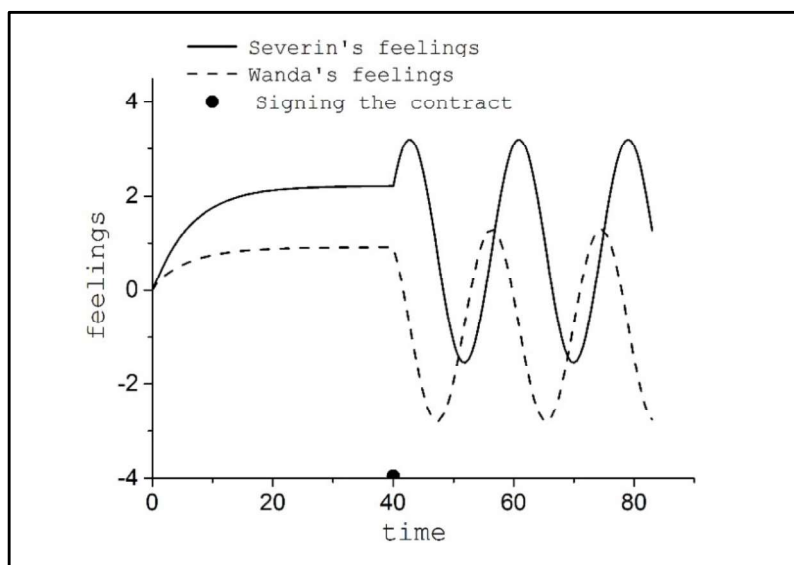


Fig. 2. Projection of the artistic space of *Venus in Furs* onto "loci subspace".

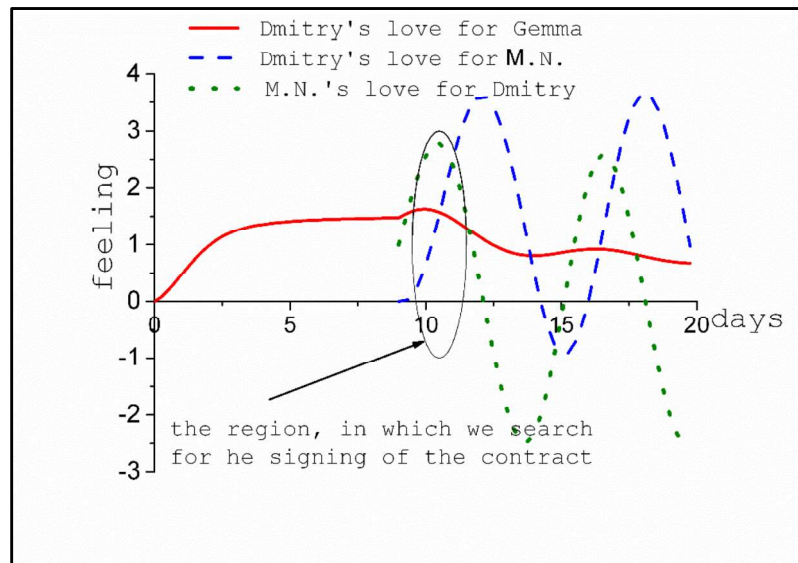
The detailed explanation of the equations' construction can be found in our work (Zhuravlev et al., 2014). The solutions of the equations give the time dependence

of feelings. These functions are presented in Figs. 3 and 4. The analysis of the obtained results proves that *Torrents of Spring* and *Venus in Furs* can be equally labeled as 'masochistic' texts; their love plots revealing the unmistakable likeness. We have summed up the typological features of the mathematical model reproducing the specific dynamics of 'masochistic' love in fiction. They are as follows: 1) the function of distance underscoring the importance of the closeness of the protagonist to the object of his perverse passion. 2) The crucial difference in love dynamics in the two subspaces of the general artistic space in masochistic novellas. The subspaces are not necessarily connected with loci. 3) The extraordinary character of relations of the masochistic couple in stationary regime is expressed in its oscillatory nature. 4) The role of masochistic pact. The above-mentioned subspaces specified in the mathematical model and the corresponding regimes of love relations are separated in *Venus in Furs* by a highly symbolic event – by signing the masochistic contract, and in *Torrents of Spring* – by the moment when Sanin accepts an iron ring from Maria Nikolaevna. The graphs presented in Figs. 3 and 4 demonstrate this similarity.



*Fig. 3. Time dependence of Wanda and Severin's feelings. The borderline between the areas of different time dependence correlates with the moment of Severin's signing the masochistic contract (This figure is taken from Zhuravlev et al., 2015).*

We would like to emphasize how accurately mathematical modelling, as we happened to find out, indicates the point on the temporal axis that correlates with the moment of signing the contract. Without mathematical modelling, we would not be able to indicate the moment of offering the ring in Turgenev's text as a starting point in the new modus of the relations between characters, on the one hand, and as an equivalent of signing the masochistic contract, on the other.



*Fig. 4. Time dependence of Dmitry Sanin, Gemma and Maria Nikolaevna (M.N.) feelings in Torrents of Spring. We search for the analogue of masochistic contract signing in the vicinity of the borderline between the areas of different types of love dynamics.*

Indeed, at first glance, the turning point in the love affair of Sanin and Maria Nikolaevna seems to be the love scene in the mountains. Without our mathematical model, we would wrongly treat the handing of the ring to Sanin as a form of marriage proposal. Neither could we notice that such dramatic turn in Sanin's fate does not strictly correspond with the border between the subspaces of Frankfurt and Wiesbaden. All this illustrates the difference between 'pure' close reading, still rather popular in literary criticism, and our modelling. The suggested interdisciplinary approach allows one to compare the two love plots in such a way as to highlight their intrinsic topical, and not just stylistic, likeness. This method also reveals typological affinity that we determine as specifically masochistic.

## **2. Q-analysis for Masochistic Novels**

Among various versions of cluster analysis, the one proposed by Ron Atkin (1981) is especially suited for literary study. Atkins named his version of cluster analysis 'Q-analysis'. It has been thought that Q-analysis can be applied primarily to the investigation of urban economy, management, economy planning and other problems related to large-scale systems. However, it was Atkin, who demonstrated a possible application of Q-analysis to the investigation of literary texts. (cf. Casti, 1979) Another important work where Q-analysis was applied to study a literary text is Lawrence O'Toole paper (1980), which presents the analysis of the *Book of Genesis* and that of James Joyce's novella "Eveline" from *Dubliners* (1914). O'Toole went into details when he considered



such an important procedure of the analysis as the definition of semiotic axis in semiotic space. The term 'semiotic space', as it appears in O'Toole's article, can be viewed as synonymous to 'artistic space'.

Following O'Toole, our first step in constructing the semiotic space of a text is to establish a hierarchy inside the groups of homogeneous elements. The groups constitute the semiotic axis. Fig. 5 gives the example of such axes in the semiotic space of *Torrents of Spring*. For instance, consider the axis, which represents the Values. We distinguish two elements on higher levels: Christianity and Paganism. The next level includes such elements as Cross, Snake, Garden of Eden, Aeneas, Sorceress, etc., referred to in the text of the novel. Each element of this level belongs to either sphere of Christianity or that of Paganism. The other two axes in Fig. 5 represent loci and characters.

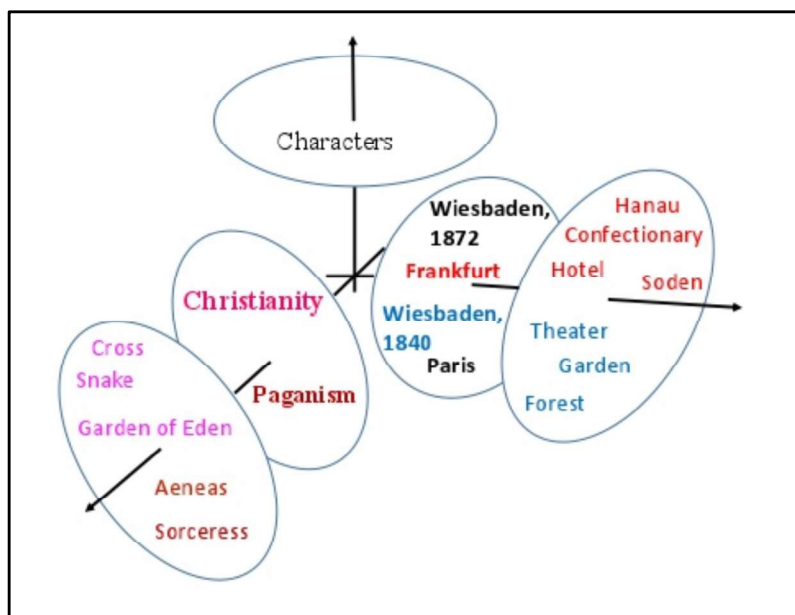







Fig. 5 Visual representation of the semiotic axes in the semiotic space of *Torrents of Spring*.

Comparing this representation with the analysis performed in the preceding section, we find that the love dynamics was considered in a specific hierarchical level of loci (cities – Frankfurt and Wiesbaden where the stages of love story differ tremendously). So, one can conclude, that the 'city' level of the Loci axis constitutes the inbuilt 'natural scale' of love dynamics in Turgenev's novella. It is worth mentioning that O'Toole referred to the attempts of Yuri Lotman and Roland Barthes to relate spatial opposition to plot dynamics.

Now we demonstrate how the approach developed by Atkin and O'Toole can be applied to the analysis of the chosen novellas. Q-analysis represents the elements of a system and the relations between them in the form of simplicial complex. Simplicial complex is a multigraph, i.e. a set of nodes connected by the edges.



Two nodes may be connected by more than one edge. In our case, a set of nodes is a set of homogeneous elements of artistic space. An edge represents a relation between the elements of artistic space. The relations are chosen and mapped in the process of reading. For instance, the characters may be grouped according to the loci where they appear. This relation can be represented as an incidence matrix – the matrix whose elements are either 0 or 1. ‘1’ means that the character is present in this locus. The Loci and Characters-Loci incidence matrix for *Venus in Furs* is as follows:

Symbol (Fig.6)	Wanda W	Severin S	Wanda’s friend F	Painter P	Alexis A	Narrator N	Venus V
Kolomea 	0	1	0	0	0	1	1
The Carpathians 	1	1	1	0	0	0	1
Vienna 	1	1	0	0	0	0	1
Florence 	1	1	0	1	1	0	1
Dream 	0	1	0	0	0	1	1

*Table 1. Incidence matrix for Characters-Loci simplicial complex for Venus in Furs.*

Each locus determines a simplex (or cluster). We include not only geographical locations but also the dreams in the set of the loci. If we combine all these simplexes in one figure, we obtain a simplicial complex (Fig. 6).

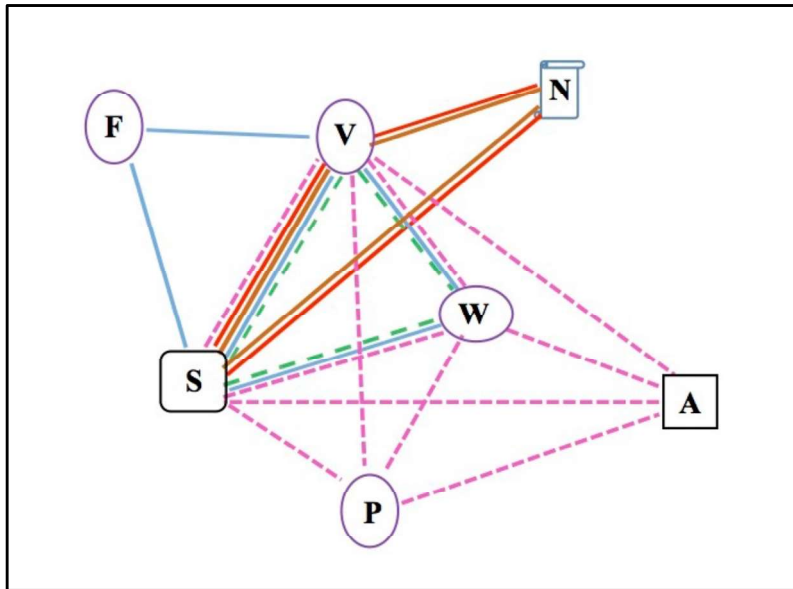


Fig. 6 Simplicial complex based on Characters-Loci relations for *Venus in Furs*.

Considering Fig. 6, we find that this simplicial complex reveals that Severin and Venus are present in every locus. We have to underscore that Venus is a metaphorical representation of Severin's erotic fantasies. She appears first as a figure in Titian's painting, then as a Greek goddess in the protagonist's night-dream. The artist who paints Wanda's portrait also indicates Venus. He refers to the legend of medieval German poet Tannhäuser<sup>3</sup> without mentioning his name. According to this legend poet was captured by Venus, the pagan goddess who turned into the sorceress and lives in exile in a magic mountain Venusberg. Apparently Venus is not identical to Wanda in artistic space of Masoch's novella. However, Wanda appears alongside with Venus in every locus. This fact proves that Wanda always features as a hypostasis of Venus. Such pervasive accent on symbolic, mythological representation of erotic fantasy is exemplary of Masoch's method. This representation of 'masochistic' love as *idée fixe* is quite different from Turgenev's method.

The loci seem to be a most natural relation (from the mathematical point of view) connecting the characters. Nevertheless, other relations bear important information concerning the semiotic organization of the text. To illustrate this statement, let us consider the Characters-Values simplicial complex for *Torrents of Spring* (Fig. 7). The corresponding incidence matrix and the notations are

<sup>3</sup> The story of this poet became famous after Richard Wagner's wrote his opera *Tannhäuser and the Minnesingers' Contest at the Wartburg* (1845).

presented in Table 2.





Symbol (Fig.7)	Dmitr y Sanin <b>D</b>	Maria Nikola -evna <b>M</b>	Gemm a <b>G</b>	Ippolit Polozov <b>I</b>	Dönhof <b>D</b>	Emilio <b>E</b>	Lenore <b>L</b>	Panta leone <b>P</b>	Klüber <b>K</b>
Love 	1	0	1	0	0	0	0	0	0
Passion 	1	1	1	0	1	0	0	0	0
Family 	1	0	1	1	0	1	1	1	1
Slavery 	1	1	0	1	1	0	0	1	1

Table 2. Incidence matrix for Characters-Values simplicial complex for Torrents of Spring.

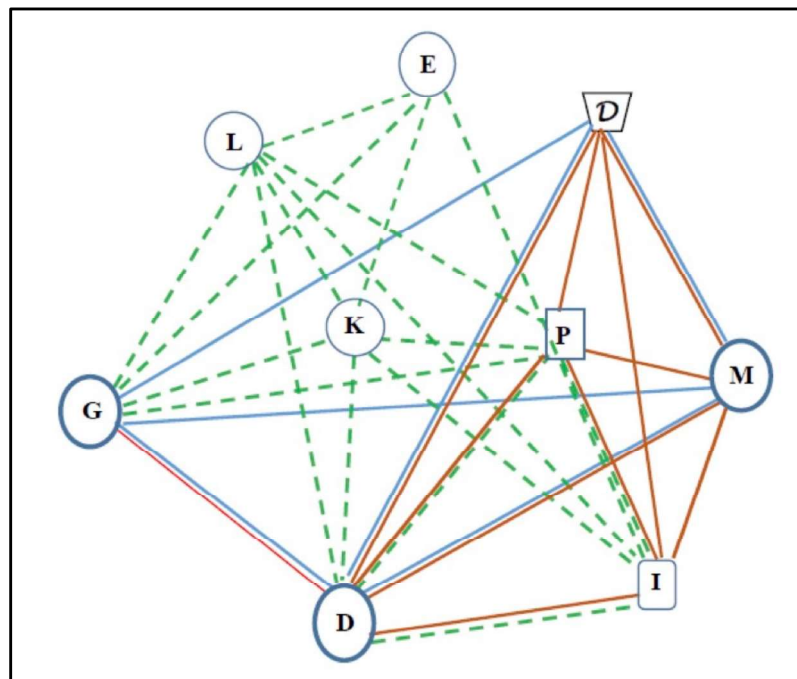


Fig. 7. Characters-Values simplicial complex for Torrents of Spring.

This simplicial complex shows strong correlation between Passion and Slavery. We believe that this correlation demonstrates how strong a masochistic vein is in Turgenev's world picture. This finding is supported by psycho-biographical study of Turgenev [Peace, 2008]. Also, this complex shows that Sanin and Panteleone are marginal in the Family pool (see the Family edge in the simplicial complex, Fig. 7). Indeed, they have no families and there is very little hope that they will.

We have analyzed only one possible simplicial complex for each of the two chosen texts. More complexes can be constructed for both novellas that would reveal the typology of dramatis personae (their beliefs, values, morals, etc.) and highlight the links between them.

### **Conclusion**

In the present article, we have demonstrated how mathematical methods can be used to study the structure of narrative texts. We applied two different mathematical methods for the investigation of two novellas. Both of them speak about transformation of the romantic feeling. The first one, *Venus in fur* (1870) is notoriously famous for being masochistic. The second one, *Spring torrents* (1871) describes the similar romantic situation and supposed to be masochistic too.

The essential element of our research was the artistic space – the concept, introduced and analyzed in several theoretical works. We demonstrated how useful this concept is for the application of mathematical modelling in the research of various layers of meaning in the works of literature.

The analysis of love dynamics by means of the systems of differential equations has allowed us to objectively compare two love stories in such a way as to show their essential, and not just stylistic similarity and the analogous mode. It means that we prove that *Spring torrents* is also a masochistic novel. Rather, mathematics reveals a typological kinship in the construction of the masochistic topos. We have demonstrated that our modeling has prognostic potential. Differential equations and the graphs constructed on their basis are not a 'mathematical paraphrase' of the plot. They have a general meaning, showing the essence of the model of the artistic world in a particular work. In principle, this kind of reading is able to predict the future of the characters, the mode of their potential destiny. We also draw attention to the fact that the use of mathematical models creates a convenient framework for comparing texts.

Considering the dynamics in romantic plots, we not only clarify or literalize the concept of 'artistic space-time' or graphically represent the evolution of characters. Rather, the above mathematical interpretation of the plot (we

emphasize that this is not a quantitative but a qualitative method) is an alternative way to represent meanings and composition, if not authorial intentions, such method being inherently analogous to more traditional reading modes. Still, the proposed method brings about new knowledge.

Using the two masochistic novellas as an example, we showed the Q-analysis machinery is a promising instrument for the investigation of artistic space. The analysis of the simplicial complexes based on the constructed axes of semiotic space allows one to draw solid conclusions concerning the structure of the artistic space of the text. Moreover, simplicial complexes clearly demonstrate the focal messages that are to be found in the narrative structure. Finally, this method has considerable advantages allowing the critic to make an objective comparative research of the texts without referring to intertextuality. In our opinion, Q-analysis is quite universal comparing with other mathematical methods applied to literary studies. In general, mathematical modelling seems to have wide potential application in literary theory. It can be based on various branches of mathematics. As a consequence, not only the statements obtained in the framework of traditional literary studies can be verified but also new results can be obtained.

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