

Commission for employment,  
Biocomplexity Institute,  
Indiana University  
Prof. Yves V. Brun

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## Application letter

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I'm happy receiving an envelope containing your letter and call for applications, in which you asks to distribute and forwarding your information on open positions. I will done this, undoubtly. But in same time I would like ask you on a possibility for me.

I'm Armenak Gasparyan, a mathematician whith PhD. degree in mathematics and being working in senior scientist position more than 17 year in Program System Institute of RAS (located in city Pereslavl-Zaleskii, Russia).

My research interests are multidisciplinary laying in mathematics, physics, chemistry, biology, sociology and computer science. But more concretely, my professional interest is going around study of complex systems, especially networks of different type arising in diverse areas of science..

In the early past, my scientific activity was devoted to the creating a new matrix and determinant theory generalizing them up to mult-idimensional (multi-indexed) matrix and determinant theory (just this was the theme of my dissertation in 1984). After receiving PhD I have choosed to enhance and generalize mathematical techniques adapting them for the solving complex problems in mathematics and other natural sciences. Some interesting results vere obtaiBED in combinatorics where I have found an original and effective method, the matrix network method. Later this my approach shoved it as a very adequate tool to modeling real networks in different scientific disciplines.

Beginning from January 2002, and until now, I was dealing with investigation of application techiques and creating of an universal approach to modelling networks and networked systems. Results have been presented at international conferences, such as Com2Mac Conference on Combinatorial Matrix Theory (CMT'02), SUNBELT'02 Social Network Conference, MATHTOOL'03, MODSIM'03, ICCS'04, COSIN'04, ICTMA'05, ECMTB'05.

In present time I'm sufficiently active in the systematic scientific research as in generating new powerful ideas. But, unfortunately, in this year August I was dismissed from work in Program System Institute, on grounds of redundancy. The motivation was that I have not published my results in peer-reviewed journals. But this is a narrowed motif, indeed I was one of most active scientists over the Institute, and for simplicity, this my refreement from my workplace was the result of personal ambitions of high staff of Institute. I was just dealing with preparation of papers for publication in peer journals.

I writte this letter to make selfitroduction with brief explanation of my resources and skills for scientific research work, and, what is my important goal, to ask for a job in one appropriate senior level position. I'm certain that, being working in your Institute, I could provide very much successful research on a series of hot topics and chalenging problems, especially in mathematical modelling of typically biological networks and in study them by appropriate matrix network analytic techniques. Additionally, we could apply this methods also in other areas someway connected to complex biological systems.

Curriculum Vitae and the list of publications are prepared in TeX and I send you immediately by attached files as this one.

Unfortunately, I have not yet in this moment any letter from referees, but I can realize this part nearly soon. Meantime, I think that I'm not so young beginning to be valued by sided recommendations. Instead of, I send you some of my abstracts to conference talks, there you may find enough data on my professional outlook.

Please help me to be lucky working in your institution.

The aim of this application is receiving job in a senior-level position to work in direction 3) "Biomolecular networks, including signaling, regulatory and metabolic networks". In case of your positive decision, I'm intended also to additional duties such as doing some regular and facultative courses for undergraduate and graduate students, forming small working group for systematic storming of actual problems.

Look forward on your decision

Best regards,

Armenak Gasparyan.

My address:

Dr. Armenak Gasparyan,  
hom. 19, app. 43, 152026,  
Pereslavl-Zalesskii, Russia.

Email: [armen@armen.pereslavl.ru](mailto:armen@armen.pereslavl.ru)

## LIST OF PUBLICATIONS

Armenak Gasparyan

Pereslavl-Zalesskii, Russia

e-mail: *armen@armen.pereslavl.ru*

1. A. S. Gasparyan, **Applications of Multidimensional Matrices to Study of Polynomials (in russian)**, Dokl. Armenian Acad. Sci, v.70, n.3, 1980.
2. A. S. Gasparyan, **A Multidimensional Matrix Analog of Cauchy-Bine't Formula (in russian)**, Dokl. Russ. Acad. Sci., v.273, n.2 1983.
3. A. S. Gasparyan, **Some Applications of Multidimensional Matrices in russian**, Computing Center of Russian Acad. Sci., Transactions on Applied Mathematics, Moscow, 1983.
4. A. S. Gasparyan, **Inequalities for Hyperbolic Polynomials (in russian)**, Dokl. Russ. Acad. Sci., .276, n.6, 1984.
5. Armen Gasparyan, **Multidimensional Matrix Networks: a New Approach to Combinatorial Problems**, Abstracts Com2MaC Conf. on "Combinatorial Matrix Theory", POSTECH, Pohang, Korea, January 14-17, 2002.
6. A.S. Gasparyan, **Compound Clifford Algebras and Clifford Networks**, Abstracts 6th Conference on Clifford Algebras, Cookeville, TN, USA, May 20-25, 2002.
7. A. S. Gasparyan, **Hyperdeterminants and Generalized Chebyshev Inequalities (in russian)**, Abstracts Intern. Conf. "Mathematical Ideas of Chebyshev and Their Applications to Problems in Modern Natural Sciences", Obninsk, May 14-18 2002.
8. Armenak Gasparyan, **General Compositional Homomorphism Problem for Multidimensional Matrix Functions**, Abstracts 10th ILAS Conference - "Challenges in Matrix Theory", Auburn, AL USA, June 10-13, 2002.
9. Armenak S. Gasparyan, **Generalized A.D.Alexandrov Inequalities**, Abstracts Conf. Second Russian-German Geometry Meeting dedicated to 90-anniversary of A.D.Alexandrov, St. Petersburg, Russia, June 16-23, 2002.

10. Armenak Gasparyan, **Hyperdeterminants and Fundamental Theorems of Calculus**, Abstracts of the VALLEY SYMPOSIUM - Summer Symposium in Real Analysis XXVI, Lexington, VA USA, June 25-29, 2002.
11. Armenak Gasparyan, **Matrix Theory and Physics**, Abstracts GROUP-24, the XXIV International Colloquium on Group Theoretical Methods in Physics, Paris, France, July 15-20, 2002
12. Armenak Gasparyan, **Multidimensional Matrices and Quantum Theory of Multiparticle Systems**, Abstracts TH-2002, International Conference on Theoretical Physics, Paris, UNESCO, July 15-20, 2002.
13. Armenak S. Gasparyan, **Results in the Theory of Multidimensional Matrices and Determinants**, Abstract ICMTA, Fifth International Conference on Matrix Theory and its Applications, Shanghai, China, August 14-18, 2002.
14. Gasparyan, Armenak, **Multidimensional Gramians and Volumes in P-Hilbert Spaces**, Short Communication ICM-2002, International Congress of Mathematicians, Beijing, China, August 20-28, 2002.
15. Armenak S. Gasparyan, **Multidimensional Matrices and Substructural Combinatorics**, Abstracts AHA-2002, 8th International Congress "Algebraic Hyperstructures and Applications", Samothraki, Greece, September 1-9, 2002.
16. A. S. Gasparyan, **Generalized Grassmann Algebras and Multidimensional Determinants (in russian)**, Abstracts, Intern. Algebraic Conf. dedicated to the Memory of Z.I. Borevich, St. Petersburg, Russia, Sept. 17-23 2002.
17. Armenak S. Gasparyan, **Multidimensional Matrix Networks: a New Approach to Modelling Social Networks**, Abstracts International SUNBELT Social Network Conference XXIII, Cancun, Quantana Roo, Mexico, Feb 12-16, 2003.
18. A. S. Gasparyan, **Multidimensional Determinants and the new mean value theorems (in russian)**, Abstracts Intern. Conf. "General Control Problems and Applications", devoted to Kolmogorov's centenary, Tambov, Russia.

19. Armenak S. Gasparyan, **Counting Words with Given Properties: a Matrix Method**, Abstracts Internayional Conference on Group Theory: combinatorial, geometric, and dynamical aspectsof infinite groups, Gaeta, Italy, June 1-6 2003.
20. Armenak S. Gasparyan, **Multidimensional Matrix Algebras and Their Applications**, Abstracts International Conference "Groups and Group Rings", Wisla, Poland, June 10-14, 2003.
21. Armenak S. Gasparyan, **Inequalities Involving Cross-Section Volumes**, Abstracts International Conference "Curvature in Geometry", in honour of Professor Lieven Vanhecke, Lecce, Italy, June 11-14 2003.
22. Armenak S. Gasparyan, **Stochastic Networks, Stochastic Processes and Multidimensional Matrices**, Abstracts International Conference "Kolmogorov and Contemporary Mathematics", Moscow, June 16-21, 2003.
23. Armenak S. Gasparyan **PolyGrassmann Algebras and Polydeterminants**, Abstracts 66th Workshop on General Algebra, Klagenfurt, Austria, June 19-22, 2003.
24. Armenak S. Gasparyan, **The Matrix Networks: a New Tool for Modelling Networked Systems**, Abstracts MATHTOOLS'2003 - Fourth International Conference "Tools for Mathematical Modelling", Saint-Petersburg, Russia, June 23-28, 2003.
25. Armenak S. Gasparyan, **Multidimensional Gram Determinants and Several Generalizations of Classical Inequalities**, Abstracts SIAM Conference on Applied Linear Algebra, Williamsburg, VA, USA, July 16-19, 2003.
26. Armenak S. Gasparyan, **The Matrix Network Models: a New Approach to Modelling Complex Systems**, Abstracts MODSIM'2003 - 2003 International Congress on Modelling and Simulation, Queensland, Australia, July 14-17.
27. Armenak S. Gasparyan, **Multidimensional Correlation Matrices and Related Inequalities**, Abstracts IWMS'2003 - 12th International Workshop on Matrices and Statistics, Dortmund, Germany, Aug. 5-8, 2003.

28. Armenak S. Gasparyan, **The Polysymmetry Theory**, Abstracts LOOPS'03 - International Mathematical Conference, Prague, Czech Republic, Aug. 10-17, 2003.
29. Armenak S. Gasparyan, **Computing the Multiplicity Patterns: a Method Based on Discriminant Tableaux**, Abstracts ENUMATH 2003 - The European Conference on Numerical Mathematics and Advanced Applications, Prague, Czech Republic, Aug. 18-22, 2003.
30. Armenak S. Gasparyan, **Matrix Networks: Theory and Applications**, Abstracts International Conference "Mathematics in Armenia: Advances and Perspectives", Yerevan, ARMENIA, Sept. 30 - Oct. 7, 2003.
31. Armenak S. Gasparyan, **Multidimensional Matrix Algebras and Their Applications**, Abstracts AAA'67, Workshop on General Algebra, Potsdam, Germany, March 26-28, 2004.
32. Armenak S. Gasparyan, **The Matrix Network Approach to Modelling General Complex Systems**, Abstracts ICCS 2004, International Conference on Complex Systems, New England, USA, May 16-21, 2004.
33. A. S. Gasparyan, **Multidimensional Determinantal Identities and Inequalities**, Abstracts International Algebraic Conference, MSU, Moscow, Russia, May 26 - June 2, 2004.
34. A.S.Gasparyan, **Poly-Grassmann Algebras and Polydeterminants**, Abstracts International Algebraic Conference, MSU, Moscow, Russia, May 26 - June 2, 2004.
35. Armenak S. Gasparyan, **Schematic Compositions and Their Derivatives**, Abstracts RAE, Real Analysis Exchange, the Symposium at the Rook, Slippery Rook, Philadelphia, USA, June 8-13, 2004.
36. Armenak S. Gasparyan, **Discriminant-Resultant Families and Root Multiplicity Analysis**, Abstracts AAA'68, Workshop on General Algebra, Dresden, Germany, June 10-13, 2004.
37. Armenak S. Gasparyan, **Enumeration of Gamma-Latin Configurations: Solution of Extended problem on the Number of Latin Rectangles (in russian)**, Abstracts DAOR'04, Intern. Conf. on Discrete Analysis and Operations Research, Novosibirsk, Russia, June 28 - July 2, 2004.

38. A. S. Gasparyan, **Multidimensional Matrix Identities and Inequalities. The Higher Analogs of Classical Inequalities (in russian)**, Abstracts II International Conf." Chebyshevs Ideas in Mathematics and Their Applications to Modern Problems of Natural Science", Obnonsk, Russia, November 26-29 2004.
39. Armenak S. Gasparyan **Molecular Matrix Networks**, Abstracts Complexity at the Molecular Level, Endhoven, The Netherlands, December 2-3, 2004.
40. Armenak S. Gasparyan, **Matrix Networks: Theory and Applications**, Abstracts The 2005 Haifa Matrix Theory Conference, Technion, Haifa, Jsrael, January 3-7, 2005.
41. Armenak S. Gasparyan, **Computing Probability and Statistics over Stochastic Networks**, Abstracts Final COSIN Meeting "Conference on Complex Networks: Evolution and Statistical Properties", Salou, Taragona, Spain, March 14-18, 2005.
42. Armenak S. Gasparyan, **Matrix Theory of Symmetric Functions**, Abstracts 69th Workshop Allgemaine Algebra and its Applications, and 20th Conference for Yong Algebraists, Potsdam, March 18-20, 2005.
43. Armenak S. Gasparyan, **Heterogeneous Relational Association Schemes**, Abstracts AL-COMA'05 — Algebraic Combinatorics and Applications, Designs and Codes, Bayreuth, Germany, April 7-11, 2005.
44. Armenak S. Gasparyan, **Hyperdeterminantal Generalizations of Cauchy and Lagrange Mean-Value Theorems (in russian)** , Abstracts International Conference and Workshop "Function Spaces, Approximation Theory and Nonlinear Analysis", dedicated to 100th birthday of academician S.M.Nikolsky, Moscow, May 23-29, 2005.
45. Armenak S. Gasparyan, **Some Applications of Multidimensional Matrix Theory** , Abstracts The 12th ILAS Conference, Regina, Canada, June 26-29.
46. Armenak S. Gasparyan, **The Matrix Network Models to Computational Genomics** , Abstracts 6th ESMTB Conference, Dresden, Germany, July 18-22, 2005.

47. Armenak S. Gasparyan, **A Matrix Technique to the Graph Colouring Enumeration** , Abstracts 11th Workshop on Graph Theory "Colorings, Independence and Domination", CID, Karpacz, Poland, September 18-23, 2005.



# THE MATRIX NETWORK MODELS TO COMPUTATIONAL GENOMICS

Armenak S. Gasparyan

Program Systems Institute of RAS,

Pereslavl-Zalesskii, Russia

E-mail: *armen@math.botik.ru*

## Abstract

The *network structures* arise by studying of *complex systems* in which a family of units come to mutual interactions. Most all of scientific disciplines in their recent development becomes a methodology applying networks as modelling and analysing tools. Typical examples are the physics (spin glasses), computer science (computer and automata networks), artificial intelligence (neural networks), sociology (social networks), chemistry (reaction networks), biology (metabolic, neutral and gene networks).

The mathematics is a rich source of network constructions enabling the modelling of real world networks. Moreover, the *mathematical network models* serve as a theoretical background by the investigation within particular disciplines. Purely from mathematical point of view one requires an universal canonical language enabling to represent arbitrary network structure. We propose such a tool naming it "*matrix network theory*" and illustrate its facilities in several applications. *The matrix network* shortly is a family of *multidimensional matrices* (vertices) and an additional family of their *multiplications* (links). Being connected by multiplications, these matrices compose a resulting matrix — the network matrix whose structure is strongly determined by proper structure of the matrix network and its constituent matrices. Therefore we can reduce the study of a real network, as well as the processes inside it, to pure computational procedures over the *matrix network model*.

Our this report is devoted mainly to exemplify above described *matrix network approach* in the context of *chemical and biological networks*. We formulate the key principles of *matrix network method* applied to quantitative and computational genetics investigating a series of example networks from molecules to chemical reactions to gene interactions.

# THE MATRIX NETWORKS: A NEW TOOL FOR MODELLING NETWORKED SYSTEMS

Gasparyan A.S.

Program Systems Institute of RAS,

Pereslavl-Zalesskii, Russia

e-mail: armen@math.botik.ru

The network modelling method can be considered as most powerful research tool in entire fundamental science. As has been appears in last decades, the network models can play very important role also within same mathematics. This relates not only to the problem solving area, but also to investigation of universal mathematical methods for researching network structures such as relational networks, neural networks, communication or exchange networks, industrial networks and so on.

It is natural that a mathematics suitable to investigation network structures should use, as fundamental tool, such type mathematical objects that potentially represent most entire diversity of network structures. The category of objects (let we name it by network category) contain a canonical class - the class of matrix networks. A matrix network be a family of multidimensional matrices mutually connected by other multidimensional matrices (connection or contraction matrices).

Note that the usual matrix calculus uses at most two-dimensional matrices. Therefore, the matrix expressions which can be obtained from such stuff are chain like expressions. If we try to use, besides of two-dimensional matrices, also the multidimensional ones at same time, we obtain new possibilities for building the matrix expressions having network like constitution and allowing to model network structures and processes very well, due to their algebraic and analytic properties. Instead of usual matrix representation of the structures with binary operations and relations, we obtain the possibility to represent arbitrary networks via matrix networks, reflecting also group like relations and operations of higher arity.

In proposed paper we represent the basic notions and principles of the matrix network theory and its application to modelling network systems. After theoretical considerations we try to clarify and demonstrate on several sample results the key features of new approach. Then we discuss some questions relating to computer realization of matrix algorithms in solving network problems.

# Matrix Networks: Theory and Applications

Armenak S. Gasparyan

Program Systems Institute of RAS,

Pereslavl-Zalesskii, Russia

E-mail: *armen@math.botik.ru*

A *matrix network*  $N(A^{(1)}, \dots, A^{(r)}, \dots)$  is defined as an object obtained from a family of one-, two- or multidimensional matrices  $A^{(r)} = \|a_{i_1, \dots, i_{k_r}}^{(r)}\|$  being interconnected by means of different type matrix multiplications. In particular case if we constrain us with use of only one- or two-dimensional matrices, the only possible networks are chain-type matrix networks, i.e. usual matrix formulas in traditional (two-dimensional matrix) theory. But in general case if we use matrices with arbitrary (finite) dimensionality, we obtain universal possibilities to express and modelling wide diverse of complex structures and systems, especially the network-type systems. The matrix network models have some surprising facilities, e.g. general associativity and distributivity, that allows to structure and analyse several important properties of modelled systems.

The authors idea of matrix network approach arized for the first time in 80-ties in attempts to solve some decomposition problems on multivalued logic functions and other type tensor objects, and later the matrix networks have arized by the work on problems of enumerative combinatorics and graph theory. In parallel, beginning from year 2001, author deals with application of matrix networks to modelling network systems naturally appearing within context of different disciplines such as sociology, psychology, economics, industry, chemistry, biology.

The aim of the talk is to familiarize the matrix-theoretic audience with key principles of matrix network theory and to report on several application results in solving problems by matrix network method. In addition we propose some problems arising by efforts to extend well known facts relating two-indexed matrices and determinants to multiindex matrices and matrix networks.