

CURRICULUM VITAE

1. PERSONAL RECORD.

Full name: **Dr. Hovhannes Khudaverdyan**

(in most of scientific articles H. Khudaverdian or O. Khudaverdian)

Nationality: British, Armenian

Date and place of birth: 28 May 1955, Yerevan (Armenia)

Marital status: Married with two adult sons.

Place of residence: 33 Highfield Road, Prestwich, Manchester M25 3AQ.

Languages: Armenian and Russian mother tongues, English fluent, French competent

Phone: (0161) 200 8975

FAX: (0161) 200 3669

E-mail: khudian@manchester.ac.uk

2. EDUCATION AND QUALIFICATIONS.

Ph.D. in Theoretical and Mathematical Physics. 1982

Thesis: *Multiplicative and Additive Functionals; their Role in Quantum Field Theory*

Advisor: Professor A.S. Schwarz.

Referees: Professor V.I. Ogievetsky, Professor Yu.I. Manin

1978–1981 *Postgraduate student*

Department of Theoretical Nuclear Physics

Moscow Physical Engineering Institute (MPEI).

M.S. in Physics (with Honors). 1978.

Thesis: On Anomalies in Quantum Field Theory.

Advisor: Professor A.S. Schwarz.

1975–1978 Department of Theoretical Nuclear Physics

Moscow Physical Engineering Institute.

1972–1975 Department of Physics

Yerevan State University.

3. PROFESSIONAL EXPERIENCE.

Current position:

Since August 2005 Senior Lecturer in Pure Mathematics, University of Manchester

Previous positions:

2001—2005	Lecturer in Pure Mathematics, UMIST (University of Manchester from 2004)
2000	Academic Visitor, UMIST
Autumn 1999	Guest Professor Max-Planck-Institut für Mathematik (Bonn)
1996—2005	Senior Researcher, Laboratory of Computing Technique and Automation Joint Institute for Nuclear Research (Dubna, Russia)
Since 1985	Senior Researcher, Department of Theoretical Physics Yerevan State University (Yerevan, Armenia)
Autumn 1994	Professor of Mathematics, Advanced Institute of Basic Sciences (Zanjan, Iran)
1988–1989	Visiting Researcher, Department of Theoretical Physics Geneva University (Geneva, Switzerland)
1981–1985	Junior Researcher, Laboratory of Theoretical Physics Yerevan Physics Institute (Yerevan, Armenia)

Research grants:

October 2010	LMS (scheme 2)
October 2007 and July 2008	Royal Society grants for conferences
2000-2001	EPSRC
1996–1998,	INTAS-RFFI: European Union and Russian Foundation for Basic Research
1993–1995	International Science Foundation

Invited talks at seminars(after 2000):

Novembre 2010	Seminar in Centre de Physique Theorique, Luminy, Marseille
Novembre 2010	Seminar in Mathematical Physics, Universite Lyon 1, Institut C.Jordan
January 2010	Analysis and Geometry Seminar in Newcastle University
December 2009	Mathematics Seminar in Valenciennes University (France)
December 2009	Mathematical Physics Seminar in Lille University (France)
October 2009	Geometry and Topology Seminar in Aberdeen University
May 2008	Mathematical Physics Seminar in Bordeaux University (France)
April 2008	W.Brauer Special topology seminar in Princeton University (USA)
January 2008	S.P. Novikov Geometry and Topology Seminar, V.A. Steklov Mathematical Institute (Moscow)
November 2007	Applied Mathematics Seminar in Brunel University
January 2007	All-Moscow seminar "Globus"
December 2006	Geometry seminar in Independent University
January 2006	Geometry Seminar in Edinburgh University
September 2004	I.R.Shafarevitch Algebra Seminar, Steklov Institute (Moscow)
February 2004	Seminar on Mathematical Physics, University of Loughborough
December 2003	Analysis/Geometry Seminar, King's College
October 2003,	Bristol Pure Mathematics Seminar
October 2003,	Liverpool Pure Mathematics Colloquium
September 2003	I.V. Tamm Department of Theoretical Physics, Moscow
April 2003,	Geometry of differential equations Seminar, Moscow, IU
July 2002	International Workshop Quantum Gravity and Superstrings, Dubna
November 2001,	Geometry with Brackets and Quantization, Warwick
December 2000	Geometry and Theoretical Physics Seminar, King's College London
November 2000	N. Hitchin Geometry and Analysis Seminar, Oxford University
November 2000	Departmental Colloquium, Sheffield University
July 2000	International Workshop on Quantization, Warwick
April 2000	Mathematical Physics Seminar, Loughborough University
February 2000	I.V. Tamm Department of Theoretical Physics, Moscow

Plenary & invited talks at conferences (after 2000):*Plenary talks:*

XII-th (July 2003), XXV-th (July 2006) and XXVII-th (July 2008), workshops on Geometry in Physics. Bialowieza, Poland.

Conference "Conformal Field Theory and Integrability", Nor-Amberd, Armenia, October 2007.

International workshop "Quantum Gravity and Superstrings". Dubna, Russia, 11—18 July, 2002.

Invited talks:

International workshop "Supersymmetry in Integrable Systems - SIS'10" August 24-28, 2010, Yerevan, Armenia.

Third International Conference on Geometry and Quantization GEOQUANT at the University of Luxembourg. September 7—11, 2009.

International workshops "Supersymmetry and Quantum Symmetries. Dubna, Russia, July 2005, July 2007, and July 2009.

XVIII International Colloquium "Integrable Systems and Quantum Symmetries" Prague, Czech Republic, June 18—20, 2009.

One-day Geometry workshop Lyon—Manchester—Loughborough in Loughborough University. March 13, 2009.

"Integrable Day" in Loughborough University November 2006.

LMS Northern Meeting and international workshop "Quantization, deformations, and new homological and categorical methods in mathematical physics". Manchester, 7-13 July 2001. *Invited talk*

Reviewing: Mathematical Reviews (1994–1996), Zentralblatt (2000—2003)

Refereeing: Lett.Math.Phys and Journal of Math. Physics.

Editorial work: member of editorial board of the Armenian Journal of Mathematics (since 2008).

4. RESEARCH ACTIVITY.

Main area of research interests: Mathematical problems of Quantum Field Theory, in particular geometry of supermanifolds

Ph.D. thesis:

My Ph.D. thesis was devoted to the following questions:

1. Investigation of objects which can be integrated over supersurfaces in superspace – generalization of differential forms on superspace [1,2,3,4,6].
2. Constructing of Poincaré-Cartan integral invariants for even symplectic structure on superspace [5] and analysis of normal forms of real surfaces in complex superspace [7]; these investigations were applied to problems of supergravity.

An exposition of the results of my thesis was published in [8].

Geometry of odd bracket: In 1986 I started the investigation of the geometry of supermanifolds endowed with odd symplectic structure and its application to quantum field theory. This geometry is natural framework of Batalin-Vilkovisky formalism. I was the first to give the invariant definition of the the BV "delta-operator" (see [14], also [12,13]). Since 1987 I continued these investigations with my postgraduate student A.P. Nersessian [10—20]. In particular we give an interpretation of the Master Equation as the nilpotency condition and related BV formalism with integration theory on (super)manifolds.

For odd symplectic superspace a certain divergence-like operator and a non-trivial analogue of the Poincaré-Cartan integral invariant – a density that depends on second derivatives, – were constructed in [11,23]. These objects

have no analogues in even symplectic geometry. They can be considered as superanalogues of the mean curvature of hypersurfaces.

In 1999 I defined a new canonical Δ -operator on semidensities. This gives explicit geometrical picture on Batalin-Vilkovisky quantum and classical master-equation and fulfills the gap in the previous considerations. Then I performed a complete studying of the relations between semidenstities in (p,p) -dimensional symplectic supermanifolds and differential forms on $(p,0)$ -dimensional Lagrangian supersurfaces [25,27,29,31].

Geometry associated with differential operators: Encouraging by results related with Δ -operator on semidensity in a collaboration with T.Voronov I studied odd Laplacians on an supermanifold with odd Poisson structure. We obtained results which disclose deep relations between standard Riemannian and odd Poisson geometry [29]. Then we describe geometry of second order differential operators on an arbitrary manifold [30]. In particular we studied the pencil of second order operators acting on the space of densities of arbitrary weight, studied the peculiar role of semidensity and classify second-order odd differential operators on supermanifold [32,33].

Generalization of Campbell-Hausdorff formulae: I introduced a special class of algebras (so called CH -algebras), obtained a generalized Campbell-Hausdorff formula for them and applied it to the problem of connectivity of Feynman graphs in field theory [18] and statistical physics. Recent development has shown that this construction can be useful with the connection to homotopy algebras and their generalization.

Linear algebra in supercase With T.Voronov we studied Cayley-Hamilton like identities for linear operators in superspace. In particular we obtained new formulae expressing Berezinians (superdeterminant) of supermatrix as a rational function of supertraces [34, 35] and studied the meaning of numerator and denominator of this fraction in terms of resultant of polynomials. We obtained beautiful relations between recurrent sequences and traces of wedged products for linear operators in superspace. This can help to explain some peculiar properties of integration theory on supermanifolds.

p -homomorphisms With T. Voronov we introduced the notion of $p|q$ -symmetrical product of commutative associative algebras and $p|q$ -homomorphisms [36, 38]. These constructions are natural generalisations of symmetric product of commutative algebras and Buchstaber-Rees p -homomorphisms. On the other hand they are intimately related with invariants of linear operators in superspace. In particular using our approach we give the conceptually short proof of the main theorem about p -homomorphisms [42]¹.

¹Buchstaber-Rees p -homomorphisms are linear maps which obey the special recurrent relations. Buchstaber and Rees proved the Theorem that for two commutative associative algebras A and B under some technical assumptions, there is a one-to-one correspondence between the algebra homomorphisms of $S^p A \rightarrow B$ and the p -homomorphisms $A \rightarrow B$ ($S^p A$ is the p -th symmetric power of the algebra A). In particular, when $A = C(X)$ for a compact

Complexes related with calculus of variations. Cohomology in Physics: In the papers [21,24] with my student D.A. Sahakyan I calculated the cohomological hierarchy in the space of Lagrangians which are defined on a given configuration space and which are weakly invariant w.r.t. a given symmetry algebra. These methods can be successfully used for the investigation of constrained systems and particularly in the BV formalism from the point of view of homological algebra [22,24]. In the paper [27] with Th.Th. Voronov we studied some geometrical aspects of jets geometry and investigated relations between different variational complexes.

Other research: I studied anomalies in field theory using the technique of Seeley coefficients (M.S. thesis, see also [9]).

My projects.

I am planning to do the following:

1. Using formulae constructed for Berezinians in my previous work I plan to consider generalisation of tubes formula for hypersurfaces in superspace: The generating function of volume of tube will be a rational function (in the usual case it is polynomial). I will try to attack the problem of characteristic classes of supersurfaces analysing this rational function. There are mysterious relations between ζ -function for arithmetic surfaces in algebraic number theory and characteristic functions for Berezinians in linear superalgebra. I am trying to analyse these relations and reveal the meaning of Frobenius map in terms of supermathematics. I did some preliminary work in [37].

2. To study the famous relations between Casimir operators for symplectic and orthogonal groups using technique of characteristic functions and parity reversing functors developed in my papers [34,35]. This work I plan to do in collaboration with R. Mkrtchyan.

3. I plan to study in collaboration with T. Voronov Lie algebroids, "non-linear" Lie algebroids and arising algebraic structures. As the example of these structures I plan to study higher Poisson brackets induced by a pseudodifferential form by Legendre transform. We did preliminary work in [40].

4. To continue the studying of geometry of odd symplectic supermanifold in the following direction:

The existence of canonical odd Laplacian and canonical semidensity on surfaces on odd symplectic supermanifold obtained in the previous works [23,31] are the indicators of the fact that one can consider the differential geometrical constructions which depend on the class of symplectic connection. This is interesting since there is no the distinguished Levi-Civita connection on symplectic manifold. These studying are based on one hand on the results obtained by Bering and Batalin about relation of canonical Laplacian with scalar curvature of symplectic connection, on the results of my paper

Hausdorff space X and $B = \mathbf{R}$, this gives the following extension of the classical theorem of Gelfand & Kolmogorov (1939): for any p , the symmetric power $\text{Sym}^p X = X \times \dots \times X$ is canonically embedded into the linear space $C(X)^*$ so that the image of the embedding is the set of all p -homomorphisms $C(X) \rightarrow \mathbf{R}$.)

[39] and on the preliminary results on this topic are in my talk in Yerevan , August 2010 (see my homepage: "www.maths.manchester.ac.uk/ khudian").

5. TEACHING.

During my life from 1978 till now I taught different courses in Moscow, Yerevan and Manchester in Mathematical and Theoretical Physics and in Mathematics: Electrodynamics, Quantum Mechanics, Differential Geometry, Applications of Differential Geometry in Theoretical Physics, Group Theory, Homological methods in Physics, Galois Theory, Elements of Functional analysis e.t.c. Now I teach the new course "Introduction in Geometry" for second years students and this year I will teach also the new course "Riemannian Geometry"

Supervision of research students:

Last 7 years I share my PhD students with Ted Voronov. We supervised these years 6 PhD students. Four of them already finished their thesis and three of them defended their viva.

One of my former PhD students (Armen Nersessian, PhD in 1992, Yerevan Physics Institute) now days is the leading researcher in mathematical physics in Armenia.

I regularly supervised projects of undergraduate and master students in Galois Theory and Differential Geometry.

I was three times internal examiner and once the external examiner (Aberdeen 2010) in PHD oral examinations.

I make regularly projects with foundation year students.

6. Social Activity.

1. From 2001 I am helping on the regular basis in organising weekly sessions of Manchester Geometry Seminar

2. From 2003 till 2006 I was responsible for organising staff development proccess in our Department.

3. From 2007 till 2010 I was a member of promotion commitee in the School of Mathematics.

4. I am actively interesting in the process of mathematical education of children in UK. I prepared the talk "Euler Theorem for polyhedra" which I give during interview days for sixthformers. In March 2005 I participated in the conference "Where will the next generation of UK mathematicians come from?"

In February 2008 I had a lecture for general audience "Tubes formula"

5. Now I am fire marshal in our School.

7. PUBLICATIONS.

1. A.V. Gayduk, O.M. Khudaverdian, A.S. Schwarz. *Multiplicative Functionals on Curves, Additive Functionals on Surfaces; their significance in QFT*. In Proceedings: "Group Theor. Methods in Physics", vol. 2, p. 201-205, Zvenigorod 1979.
2. O.M. Khudaverdian, A.S. Schwarz. *A Few Comments on the String Representation of Gauge Fields*. Phys. Lett. v. 91B (1980), p. 107-110.
3. O.M. Khudaverdian, A.S. Schwarz. *Additive and Multiplicative Functionals*. Preprint ITEP-3-1980.
4. O.M. Khudaverdian, A.S. Schwarz. *Multiplicative Functionals and Gauge fields*. Theor. Math. Phys. (in Russian), v. 46 (1981) p. 187-198 (transl. into English: p. 124-132).
5. O.M. Khudaverdian, A.S. Schwarz, Yu.S. Tyupkin. *Integral invariants for Supercanonical Transformations*. Lett. Math. Phys., v. 5 (1981), p. 517-522.
6. A.V. Gayduk, O.M. Khudaverdian, A.S. Schwarz. *Integration over Surfaces in Superspace*. Theor. Math. Phys. (in Russian), v. 52 (1982), p. 375-383 (transl. into English: p. 862-868).
7. O.M. Khudaverdian, A.S. Schwarz. *Normal Gauge in Supergravity*. Theor. Math. Phys., v. 57 (1983), p. 354-362 (transl. into English: p. 1189-1195).
8. O.M. Khudaverdian, A.V. Rosly, A.S. Schwarz. *Supergravity and Complex Geometry*. In book: News of Science and Technics. Modern Problems of Mathematics. v. 9, 1986, p. 247-284 (in Russian) (transl. into English: "Encyclopedia of Modern Mathematics", Springer-Verlag).
9. O.M. Khudaverdian, R.L. Mkrtchian, L.A. Zurabian. *On the Axial Anomalies in External Tensor Fields*. Theor. Math. Phys. v. 71 (1987) p. 393-401.
10. O.M. Khudaverdian, A.P. Nersessian. *Formulation of Hamiltonian Mechanics with Even and Odd Poisson Bracket*. Preprint EFT 1031-81(87), Yerevan (1987).
11. O.M. Khudaverdian, R.L. Mkrtchian. *Integral Invariants of Buttin Bracket*. Lett. Math. Phys. v. 18 (1989), p. 229-231 (Preprint EFI-918-69-86- Yerevan (1986)).
12. O.M. Khudaverdian, A.P. Nersessian. *Superspaces with Odd and Even Canonical Two-Forms and the Strange Superalgebra*. Izv. Acad. Nauk Arm. SSR, v. 24, No. 6, (1989) p. 288-294 (transl. into English: Soviet Journal of Contemp. Phys., v. 24 No.6, p. 22-27).
13. O.M. Khudaverdian, A.P. Nersessian. *The Supergeneralization of $CP(N)$ as Reduced Phase Space of Super-Hamiltonian Systems*. Izv. Acad.

Nauk Arm. SSR, v. 25, No. 6, (1990) p. 330-337 (transl. into English: Soviet Journal of Contemp. Phys., v. 25 No.6.)

14. O.M. Khudaverdian. *Geometry of Superspace with Even and Odd Brackets*. J. Math. Phys. v. 32 (1991) p. 1934-1937 (Preprint of the Geneva University, UGVA-DPT 1989/05-613).

15. O.M. Khudaverdian, A.P. Nersessian. *Canonical Poisson Brackets of Different Grading and Strange Superalgebras*. J. Math. Phys. v. 32 (1991) p. 1938-1941 (Preprint of the Geneva University, UGVA-DPT 1989/05-614).

16. O.M. Khudaverdian, A.P. Nersessian. *Even and Odd Symplectic and Kählerian Structures on Projective Superspaces*. J. Math. Phys. v. 34 (1993), p. 5533-5548.

17. O.M. Khudaverdian, A.P. Nersessian. *On Geometry of Batalin-Vilkovisky Formalism*. Mod. Phys. Lett. A, v. 8 (1993), No. 25, p. 2377-2385.

18. O.M. Khudaverdian. *Algebras with Operator and Campbell-Hausdorff Formula*. Lett. Math. Phys., v. 35 (1995), pp.27-38.

19. O.M. Khudaverdian. *Batalin-Vilkovisky Formalism and Odd Symplectic Geometry*. In: Proceedings of International Workshop "Geometry and Integrable Systems", P.N.Pyatov and S.N.Solodukhin, eds. World Scientific Publishing Co., 1996, p. 144-181.

20. O.M. Khudaverdian, A.P. Nersessian. *Batalin-Vilkovisky Formalism and Integration Theory on Manifolds*. J. Math. Phys., v. 37 (1996), p. 3713-3724.

21. O.M. Khudaverdian, D.A. Sahakyan. *Cohomological Aspects of Noether Theorem for Lagrangians of Classical Mechanics*. Proceedings of the conference "Secondary calculus and Cohomological Physics", Moscow, 1997, in Electronic Proceedings of EMIS, <http://www.emis.proceedings/SCCP97>

22. O.M. Khudaverdian. *Algebraic and Geometric Aspects of Constrained Systems*. In survey: "Collaboration JINR-YSU (1992-1997)", JINR E-98-12, Dubna (1998).

23. O.M. Khudaverdian. *Odd Invariant Semidensity and Divergence-like Operators on Odd Symplectic Superspace*. Comm. Math. Phys., v. 198 (1998), p. 591-606.

24. O.M. Khudaverdian, D.A. Sahakyan. *Double Complexes and Cohomological Hierarchy in the Space of Weakly Invariant Lagrangians of Mechanics*. Acta Applicandae Mathematicae., v. 56 (2/3), (1999), p. 181-215.

25. O.M. Khudaverdian. *Delta-Operator on Semidensities and Integral Invariants in the Batalin-Vilkovisky Geometry*. Preprint of Max-Planck-Institut für Mathematik, MPI-135 (1999), Bonn.

26. O.M. Khudaverdian. *Evolution of oscillator wave function and Fourier transformation*. In: “Symmetries and Integrable Systems”, collected papers. A.N. Sissakian, ed., Dubna, 2000, p. 269–272.
27. H.M. Khudaverdian, T.Voronov *On complexes related with calculus of variations.*, J. Geom. Phys. 44 (2-3) (2002), 221-250
28. H.M. Khudaverdian *Laplacians in odd symplectic geometry.*— In *Quantization, Poisson Brackets and Beyond*, Theodore Voronov, ed., Contemp. Math., Vol. 315, Amer. Math. Soc., Providence, RI, 2002, pp. 199-212.
29. H.M. Khudaverdian, T.Voronov *On Odd Laplace operators.* Lett. Math. Phys. 62 (2002), 127-142
30. H.M. Khudaverdian, T.Voronov *Geometry of differential operators, and odd Laplace operators.* Russian Math. Surveys 58 (2003)
31. H.M. Khudaverdian. *Semidensities on odd symplectic supermanifold.*, Comm. Math. Phys., v. 247 (2004), pp. 353-390
32. H.M. Khudaverdian, T.Voronov *On odd Laplace operators. II.* In book: *Geometry, Topology and Mathematical Physics. S. P. Novikov’s seminar: 2002 - 2003*, V. M. Buchstaber, I. M. Krichever, eds., Amer. Math. Soc. Transl. (2), Vol. 212, 2004, pp.179–205
33. H.M. Khudaverdian, T.Voronov *Geometry of differential operators, odd Laplacians, and homotopy algebras* Journal of Nonlinear Math. Phys. **11**, Supplement (2004), pp. 217–227. arXiv:math.DG/0402292
34. H.M. Khudaverdian, T.Voronov. *New facts about Berezinians.* In book: *Supersymmetries and Quantum Symmetries 2005*. Proceedings of International Workshop, Joint Institute of Nuclear Research, Dubna, 27-31 July 2005, E. Ivanov and B. Zupnik, eds., Dubna, 2006, 393-398, arXiv:math-ph/0512031.
35. H.M. Khudaverdian, T.Voronov. *Berezinians, Exterior Powers and Recurrent Sequences.*— Lett. Math. Phys. (Berezin memorial volume), 74 (2005), 201-228 (arXiv:math.DG/0309188)
36. H.M. Khudaverdian, T.Voronov. *On generalized symmetric powers and a generalization of Kolmogorov-Gelfand-Buchstaber-Rees theory.* Russian Mathematical Survey 2007, arXiv:math.RA/0612072.
37. H.M. Khudaverdian. *Tube formula, Berezinians and Dwork formula.* Journal of Geometry and Symmetry in Physics, v10, 2007, pp.29–40, arXiv:math.DG/0402292
38. H.M. Khudaverdian, T.Voronov. *Operators on superspaces and generalizations of the Gelfand-Kolmogorov theorem.* In: XXVI Workshop on Geometric Methods in Physics. Bialowieza, Poland, 1 - 7 July 2007. AIP Conference Proceedings 956, Melville, New York, 2007, p. 149-155. arXiv:0709.4402 [math-ph].

39. H.M. Khudaverdian, T.Voronov. *Differential forms and odd symplectic geometry*. Amer. Math. Soc. Transl (2) Vol 224, 2008 pp.159—171
40. H.M. Khudaverdian, T.Voronov. *Higher Poisson brackets and differential forms*. In: Geometric Methods in Physics. AIP Conference Proceedings 1079, American Institute of Physics, Melville, New York, 2009, 203-215. arXiv:0808.3406v2 [math-ph].
41. A. Borovik, O.M. Khudaverdian. *Merkator projection, logarithm and...(in Russian)* Matematicheskoe Prosveshchenie no. 14 (2010), 58–82.
42. H.M. Khudaverdian, T.Voronov. *On a short proof of Buchstaber—Rees Theorem*. Phil. Trans. R. Soc. A. 2010 (in press).