CURRICULUM VITAE

1. PERSONAL RECORD.

Full name: **Dr. Hovhannes Khudaverdyan**

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

Marital status: Married with two children.
Place of residence: 33 Highfield Road, Prestwich, Manchester M25 3AQ.
Languages: Armenian, Russian, English, French

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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)
1978–1981	Research Fellow, Department of Theoretical Nuclear Physics Moscow Physical Engineering Institute (Moscow, Russia)

Research grants:

2000-2001	EPSRC
1996–1998,	INTAS-RFFI: European Union and Russian Foundation for Basic Research
1993–1995	International Science Foundation

Recent invited talks:

April 2008	W.Brauder Special topology seminar in Princeton University
January 2008	S.P. Novikov Geometry and Topology Seminar, V.A. Steklov Mathematical Institute (Moscow)
January 2007	All-Moscow seminar "Globus"
December 2006	Geometry seminar Independent University
January 2006	Geometry Seminar in Edinbuirg 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,	Manchester Algebra seminar
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, November 2002	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
November 2000, March 2000	Manchester Geometry Seminar,
July 2000	International Workshop on Quantization, Warwick
April 2000	Mathematical Physics Seminar, Loughborough University
February 2000	I.V. Tamm Department of Theoretical Physics,
November 1999	Theoretical Physics Seminar, Leiden University
July 1999	S.P. Novikov Geometry and Topology Seminar, V.A. Steklov Mathematical Institute (Moscow)
July 1999	Annual conference "Supersymmetry and Quantum Symmetries" (Dubna)
May 1999	International workshop QFTHEP-99 (Moscow)

Meetings:

Invited Plenary talk on the conference "Conformal Filed Theory and Integrability", Nor-Amberd, Armenia, October 2007

Invited talk on "Integrable Day" in Loughborough University November 2006

XXV Workshop on Geometry in Physics. Bialowieza, Poland, July 2006, Plenary talk: "Beresinians and invariants of polynomials"

International workshop "Supersymmetry and Quantum Symmetry". Dubna, Russia, 27—31 July, 2005. Invited Talk: Berezenians.

10-th International Conference Symmetry Methods in Physics. Yerevan, 13–20 August, 2003. Talk presented: Geometry of differential operators.

XXII Workshop on Geometry in Physics. Bialowieza, Poland, July 2003, Plenary talk: Odd symplectic geometry.

International workshop "Quantum Gravity and Superstrings". Dubna, Rus-

sia, 11—18 July, 2002. Plenary Talk: Odd Laplacians.
LMS Northern Meeting. Manchester, 6 July 2001 and LMS-sponsored international workshop "Quantization, deformations, and new homological and categorical methods in mathematical physics". Manchester, 7-13 July 2001. Talk presented at the above workshop: Delta-operator on semidensities on an odd symplectic supermanifolds
Participation in regular seminar: Geometry with Brackets (Sheffield–Manchester–Warwick). International Workshop on Quantization (Warwick, July 2000)
Invited speaker many years since 1989. Annual conference "Supersymmetry and Quantum Symmetries" (Dubna). International workshop QFTHEP-99. (Moscow, May 1999)

International conference "Secondary Calculus and Cohomological Physics". (Moscow, August 1997)

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

Refereeing: Lett.Math.Phys.

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 particularly 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 Riemanian and odd Poisson geometry [29]. Then we describe geometry of second order differential operators on an arbitrary manifold [30]. In particularly 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-Haussdorff 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 identites for linear operators in superspace. In particular we obtained explicit formulae expressing Berezinians (superdeterminant) of supermatrix as a rational function of supertraces [33] 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.

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 [28] 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]).

I studied some geometrical aspects of algebraic number theory in collaboration with M.Taylor

My projects for 2005–2007. During these two years 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 (Collaboration with Th. Voronov and with PHD student A. Hunch)
2. I try to study projective connections which arise naturally in the analysis of differential operators on the algebra of densitites (Collaboration with Th. Voronov).
3. Study applications of Batalin-Vilcovisy formalism in topological field theories (Collaboration with Th. Voronov and with A.Lazarev (Bristol)).
4. There are mysterious relations between ζ-function for arithmetic surfaces in algebraic number theory and characteristic functions for berezinians in linear superlagebra. I am trying to analyse these relations and reveal the meaning of Frobenius map in terms of supermathematics.

5. TEACHING.

I taught various courses in differential geometry, theoretical and mathematical physics in 1978–1981 at the Moscow Physical Engineering Institute, and at the Yerevan State University in 1981–1996. From 1986 till 1996 I developed and taught the course "Applications of Differential Geometry in Theoretical Physics" at the Yerevan State University. In 1994 I taught the course "Differential Geometry" to graduate students at the Advanced Institute of Basic Sciences (Zanjan, Iran). In 1997 I taught the course "Homological Methods in Physics" to junior researchers at the Joint Institute for Nuclear Research (Dubna).
From 2002 I am teaching course of Galois theory (for IV-th year students) and course of Functional analysis (for III-rd year students) in UMIST and from 2004 I am teaching course of Differentiial Geometry (for III-rd year students)

Supervision of research students: Currently I have three PHD student in Differential Geometry and I am supervising project on Galois Theory of fourth year student

Last year I was also twice internal examiner in PHD oral examination in 2004.

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 I am responsible for organising staff development proccess in our Department.

3. 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"

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. Word 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 Intergrable 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. *Differential forms and odd symplectic geometry.* arXiv:math.DG/0606560.

37. 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.

38. 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