Maurice A. de GOSSON

University of Vienna

PREAMBLE

Academic qualifications

- *Habilitation à Diriger des Recherches* (1992): Université Paris 6; supervisor: Jean Leray (Collège de France)
- *Doctorat de 3. cycle* (1978): Université de Nice; supervisor: Jacques Chazarain (Nice).
- Qualified for holding a professorship in pure or applied mathematics in the French academic system.

Contact details:

Professional address: Faculty of Mathematics, University of Vienna, Nordbergstrasse 15, AT-1090 Wien, Austria.

E-mail: maurice.de.gosson@univie.ac.at , maurice.degosson@gmail.com (private)

Telephone: +43 (1) 4277 50697 (office), +43 (0) 676-7877995 (mobile)

General information

2006-... Resaerch Professor, University of Vienna

1994–2006: *Professor of Mathematics* in Sweden (U. of Kalmar, U. of Karlskrona)

September 2006-February 2008: *Senior Postdoc*, NuHAG Group of H. Feichtinger, Faculty of Mathematics, University of Vienna

March 2008–July 2011: FWF *Senior Postdoc*, NuHAG Group of H. Feichtinger, Faculty of Mathematics, University of Vienna

Website: http://homepage.univie.ac.at/maurice.de.gosson/ and http://www.freewebs.com/cvdegosson interview feature. See the site http://www.iop.org/EJ/

Languages: fluency in English, French, German, Swedish

Marital status: married, four adult children

Country of Citizenship: France. Applying for Austrian citizenship. *Born* in Berlin, 1948.

Visiting positions: Yale University, University of Colorado at Boulder, Max-Planck-Institut Bonn, Université Paul Sabatier (Toulouse), Jacobs University (Bremen), ESI Vienna.

Research Interests

- **The principle symplectic camel.** This surprising property of canonical transformations (linear or not) was discovered in 1985 by the mathematician M. Gromov. It says –and this is very unexpected because it gives a "quantum flavor" to classical mechanics– that if you deform a phase space ball with radius R using canonical transformations (for instance a Hamiltonian flow) then the area of the projection of this deformed ball on a plane of conjugate coordinates q_j, p_j will never decrease below its original value πR^2. This property has allowed me to reformulate the uncertainty principle (in its strong Robertson–Schrödinger form, with covariances) in terms of the notion of symplectic capacity, directly related to the principle of the symplectic camel. It has also allowed me to prove, using methods from statistical analysis, that mathematically speaking the uncertainty inequalities are classical. This discovery was highlighted in the New Scientist in 2009: http://www.newscientist.com/article/mg20126973.900-how-camels-could-explain-quantum-uncertainty.html The study of this principle and of its implication in QM deserve to be studied and applied further. I think it could be used to characterize the entanglement of multi-partite quantum systems in terms of the "quantum blobs" I have introduced in related work (a quantum blob is a subset of phase space which is the deformation of a phase space ball with radius $\sqrt{\hbar}$ by a canonical transformation).

- **Phase space formulation of weak values**. I am working (with some success...) on the phase space definition of the notion of weak measurement (in the sense of Aharonov et al.) This is performed using the cross-Wigner transform $W(\psi, \phi)$ of the preselected state ψ and the postselected state ϕ. Doing this, not only does one immediately see that weak values correspond to a complex probability amplitude (which is well-known, of course), but also justifies (at least mathematically) the fact that weak values are sensitive to signals coming from the future. Of course, one should be particularly prudent in such controversial issues, but the Wigner approach certainly opens new doors. In particular, it rather easily solves the problem of "reconstruction" of quantum states, which is a popular topic, in which the notion of MUB (mutually unbiased bases) plays a crucial role. The properties of the cross-Wigner transform allow, via an inversion formula, to do this in a more straightforward (and simpler) way. Let us say that the experience of time-frequency analysis I have gained in H. Feichtinger's group has been very helpful for it has allowed me to work with analogies from signal theory.

- **Foundational questions in QM.** Besides my proof of the fact that the Robertson–Schrödinger inequalities can be (formally) derived within classical mechanics using the principle of the symplectic camel, I like to work on other foundational questions in QM. For instance, I have recently proved (Imprints of the Quantum World in Classical Mechanics. *Foundations of Physics* 2011) with my coauthor Basil Hiley that the Schrödinger equation can be *mathematically* derived, without the use of any external physical property, from Hamiltonian mechanics. This does of course not mean that I am saying that QM is a subset of CM! An equation is not a physical theory unless one gives an ontological sense to its solutions. That Schrödinger's and Hamilton's equations are rigorously equivalent for quadratic Hamiltonians (e.g. the harmonic oscillator) has actually been known for a long time (the early 60's?) by mathematicians working in the theory of the metaplectic representation (of which I am an expert). For physicists, this equivalence is often attributed to Feynman path-integral techniques. The extension to arbitrary Hamiltonians I have given is not trivial mathematically; it makes use of Stone's theorem for evolution operators and of the symplectic/metaplectic covariance of Weyl operators. I will present this result at the conference on Emergent Themes in Quantum Mechanics at the University of Vienna in November 2011. The title of my talk "*Schrödinger's equation is classical. Cheers!*" sounds provocative; it is intended to be. Other themes which are of great interest to me are Bohmian mechanics, to which I have been introduced by Basil Hiley (with whom I am collaborating), and QM in phase space. My 2001 Imperial College Press book "*The Principles of Newtonian and*

Quantum Mechanics: the Need for Planck's Constant h; with a foreword by B. Hiley" was an early attempt to try to learn more about all these fascinating questions.

- **Mathematics.** My early background being that of a pure mathematician, I also indulge in certain appetites for harmonic analysis (Wigner–Moyal formalism) and the theory of partial differential equations. This has allowed me to solve a few problems around the following themes: Maslov index, metaplectic representation, Landau's magnetic operators, etc.

Publications

[N.B.: There are inevitably overlaps between both categories "Physics and Mathematical Physics" and "Mathematics"]

Physics and Mathematical Physics

1. **Book**: Symplectic Methods in Harmonic Analysis and Applications to Mathematical Physics; Birkhäuser (2011)
2. Quantum Blobs. B. Hiley Festschrift. Submitted to Found. Phys.
3. On the Fermi Function of Squeezed Coherent States. arXiv:1107.5010
4. (With B. Hiley) Zeno Paradox for Bohmian Trajectories: The Unfolding of the Metatron. arXiv:1010.2622
5. (With F. Luef) Preferred Quantization Rules: Born–Jordan vs. Weyl; Applications to Phase Space Quantization. To appear in *Journal of Pseudodifferential Operators and Applications,* Volume 2, Number 1, 115–139 (2011), DOI: 10.1007/s11868-011-0025-6
6. On the Transformation Properties of the Wigner Function Under Hamiltonian Symplectomorphisms. *Journal of Pseudodifferential Operators and Applications*
7. (With B. Hiley) Imprints of the Quantum World in Classical Mechanics. *Foundations of Physics* 2011
8. Quantum Blobs. B. Hiley Festschrift. Submitted to Found. Phys.
9. On the Fermi Function of Squeezed Coherent States. arXiv:1107.5010
10. (With B. Hiley) Zeno Paradox for Bohmian Trajectories: The Unfolding of the Metatron. arXiv:1010.2622
11. On the Use of Minimum Volume Ellipsoids and Symplectic Capacities for Studying Classical Uncertainties for Joint Position–Momentum Measurements. *Journal of Statistical Mechanics* 2010
12. (With N. Dias, J. Prata, F. Luef) A Deformation Quantization Theory for Non-Commutative Quantum Mechanics. Journal of Mathematical Physics **51**, 072101 (2010)
13. (With F. Luef) Symplectic Capacities and the Geometry of Uncertainty: the Irruption of Symplectic Topology in Classical and Quantum Mechanics. *Physics Reports* **484** (2009) 131–179 179DOI 10.1016/j.physrep.2009.08.001
14. The Symplectic Camel and the Uncertainty Principle: The Tip of an Iceberg?[1] *Found. Phys.* **99** 194–214 (2009)
15. (With F. Luef) A new approach to the $\star$-genvalue equation. *Lett. Math. Phys.* **85**, 173–183 (2008) [on line 16 Aug. 2008; DOI 10.1007/s11005-008-0261-8]
16. Semi-Classical Propagation of Wavepackets for the Phase Space Schrödinger Equation; Interpretation in Terms of the Feichtinger Algebra. *J. Phys.A: Math. Theor.* **41** (2008) [Preprint available from the Erwin Schrödinger Institute Preprint Series: http://www.esi.ac.at/Preprint-shadows/esi1951

[1] See "New Scientist" http://www.newscientist.com/article/mg20126973.900-how-camels-could-explain-quantum-uncertainty.html

17. (With F. Luef) Principe d'Incertitude et Positivité des Opérateurs à Trace; Applications aux Opérateurs Densité. *Ann. H. Poincaré* **9**(2), 2008.

18. (With F. Luef) Quantum States and Hardy's Formulation of the Uncertainty Principle: a Symplectic Approach. *Lett. Math. Phys.*, **80**, 69–82, 2007

19. (With J. Isidro) Abelian Gerbes as a Gauge Theory of Quantum Mechanics on Phase Space. *J. Phys. A: Math. Theor.* **40** 3549-3567, 2007

20. (With J. Isidro) A Gauge Theory of Quantum Mechanics. *Modern Physics Letters A*, **22**(3), 191–200, 2007

21. (With F. Luef) Remarks on the fact that the uncertainty principle does not characterize the quantum state. *Phys. Lett. A.* **364**, 453–457, 2007.

22. Schrödinger Equation in Phase Space, Irreducible Representations of the Heisenberg Group, and Deformation Quantization. Resenhas **6** , no. 4, 383–395, 2006

23. Weyl Calculus in Phase Space and the Torres-Vega and Frederick Equation. *Proceedings of the AIP.* Volume **810**, Issue 1, 300–304 January 4, 2006

24. The adiabatic limit for multi-dimensional Hamiltonian systems; *Journ. Geom. and Symmetry in Physics* **4** 19–44 2005–2006

25. Uncertainty principle, phase space ellipsoids, and Weyl calculus. *Operator Theory: Advances and applications*, Vol. **164**, 121–132, Birkhäuser Verlag, Basel, 2006.

26. Symplectically Covariant Schrödinger Equation in Phase Space. *J. Phys.A:Math. Gen.* **38**, no. 42, 9263–9287, 2005

27. Cellules quantiques symplectiques et fonctions de Husimi–Wigner[2]. *Bull. Sci. Math.* **129** 211–226, 2005

28. Extended Weyl Calculus and Application to the Phase-Space Schrödinger Equation[3]. J. Phys. A 38 , no. 19, L325–L329, 2005

29. The Weyl Representation of Metaplectic operators. *Letters in Mathematical Physics* **72** 129–142, 2005.

30. The optimal pure Gaussian state canonically associated to a Gaussian quantum state. *Phys. Lett. A*, **330**:3–4, 161–167, 2004

31. On the notion of phase in mechanics[4]. *J. Phys. A: Math. Gen.* **37**(29), 7297–7314, 2004.

32. Phase Space Quantization and the Uncertainty Principle. *Phys. Lett. A*, **317**/5-6, 365–369, 2003

33. On probability waves in classical and quantum mechanics. Växjö Conference on Quantum Mechanics. *World Scientific*, 2003

34. A class of symplectic ergodic adiabatic invariants. Foundations of probability and physics, 2 (Växjö, 2002) 151–158. *Växjö Univ. Press,* Växjö, 2003

35. The "symplectic camel principle" and semiclassical mechanics, *J. Phys. A: Math. Gen* **35**(32) 6825–6851, 2002

36. Fonctions d'ondes semi-classiques et équations de Schrödinger (with S. de Gosson); in *Partial Differential Equations and Mathematical Physics*, Marcel Dekker, 2002

[2] Ranked among the 11 most downloaded papers of the journal (2005)
[3] Downloaded over 500 times (information from IOP)
[4] Downloaded over 250 times (information from IOP)

37. The symplectic camel and phase space quantization[5]. *J. Phys.A:Math. Gen.* **34**, 47, 10085–10096, 2001
38. The classical and quantum evolution of Lagrangian half-forms. *Ann. Inst. Henri Poincaré* **70**(6), 547–573, 1999.
39. The quantum motion of half-densities and the derivation of Schrödinger's equation. *J. Phys. A:Math. Gen.* **31**(2) 158–168, 1998.
40. On half-form quantization of Lagrangian manifolds and quantum mechanics in phase space. *Bull. Sci. Math.* **121**(4), 301–322, 1997
41. On the Leray–Maslov quantization of Lagrangian submanifolds. *J. Geom. Phys.* **13**(2), 158–168, 1994

Mathematics(With N. Dias, J. Prata, F. Luef)

1. A pseudo-differential calculus on non-standard symplectic space; spectral and regularity results in modulation spaces. *Journal des Mathématiques Pures et Appliquées*
2. (With F. Luef) The Multi-Dimensional Hardy Uncertainty Principle and its Interpretation in Terms of the Wigner Distribution; Relation With the Notion of Symplectic Capacity [Submitted]
3. (With F. Luef) Spectral and Regularity properties of a Pseudo-Differential Calculus Related to Landau Quantization. *Journal of Pseudo-Differential Operators and Applications* **1**(1) 2010
4. A pseudodifferential calculus on non-standard symplectic space. To appear in *Applicable Analysis* 2010
5. On the usefulness of an index due to Leray for studying the intersections of Lagrangian and symplectic paths. *Journal de Mathématiques Pures et Appliqués* **91** (2009) 598–613 [Preprint MPIM2007-119, Max Planck Institute for Mathematics preprint server: http://www.mpim-bonn.mpg.de/ preprints/retrieve (2008)]
6. (With F. Luef) On the usefulness of modulation spaces in deformation quantization. *J. Phys. A: Math. Theor.* 42 315205 (2009)
7. Spectral Properties of a Class of Generalized Landau Operators. *Communications in Partial Differential Operators* **33**(11), 2096–2104 (2008)
8. Phase-Space Weyl Calculus and Global Hypoellipticity of a Class of Degenerate Elliptic Partial Differential Operators (Invited paper). To appear in *Recent Developments in Pseudo-Differential Operators* 2008/09 in the Birkhäuser "Operator Theory: Advances and Applications". Preprint available at: http://www.mpim-bonn.mpg.de/preprints/retrieve
9. (with S. de Gosson and P. Piccione) On a product formula for the Conley–Zehnder index of symplectic paths and its applications. *Ann. Glob. Anal. Geom.* **34**, 167–183 (2008) [online 14 March 2008) DOI 10.1007/s10455-008-9106-z; preprint 2006, arXiv: math.SG/0607024]
10. Metaplectic Representation, Conley–Zehnder Index, and Weyl Calculus on Phase Space. *Rev. Math. Physics*, **19**(8), 1149–1188, 2007
11. (With S. de Gosson) An extension of the Conley–Zehnder Index, a product formula and an application to the Weyl representation of metaplectic operators . *J. Math. Phys.,* **47** (available on line 13. December 2006)*,* 2006

[5] Included in "IOP select" in 2002

12. The Maslov Index indices of Periodic Hamiltonian Orbits (with S. de Gosson). *J. Phys. A:Math. Gen.* **36**(48), 615–622, 2003

13. The cohomological interpretation of the indices of Robbin and Salamon, (with S. de Gosson). Jean Leray ´99 Conference Proceedings. *Math. Phys. Studies* **4**, Kluwer Academic Press, 2003

14. Symplectic path intersections and the Leray index (with S. de Gosson). *Progr. Nonlinear Differential Equations Appl.* **52** Birkhäuser, 2003.

15. Some p-adic differential equations (with B. Dragovich and A. Khrennikov), in "p-adic functional analysis". *Lecture Notes in Pure and Appl. Math.* 222, 91–102 Marcel Dekker, 2001.

16. Lagrangian path intersections and the Leray index. Aarhus Geometry and Topology Conference. *Contemp. Math., Amer. Math. Soc., Providence, RI,* **258**:177–184, 2000.

17. The structure of q-symplectic geometry, Journal Math. *Pures et Appl.* **71**(5), 429–453, 1992.

18. Cocycles de Demazure–Kashiwara et géométrie métaplectique. *J. Geom. Phys.* **9**(3), 255–280, 1992.

19. Maslov indices on the metaplectic group $\mathrm{Mp}(n)$. *Ann. Inst. Fourier* **40**(3), 537–555, 1990

20. La définition de l'indice de Maslov sans hypothèse de transversalité. *C.R. Acad. Sci.*, Paris, Série I, Math. **310**(5), 279–282, 1990

21. La relation entre $Sp_\infty(n)$ le revêtement universel du groupe symplectique $Sp(n)$, et $Sp(n)\times\mathbb{Z}$. *C.R. Acad. Sci. Paris* Série. I, Math. **310**(5), 245–248, 1990.

22. Étude de la régularité à la frontière des solutions d'une classe de problèmes elliptiques singuliers. *C.R. Acad. Sci.,* Paris, Série I, Math. **310**(7), 355–358, 1985

23. Microlocal regularity at the boundary for pseudo-differential operators with the transmission property. *Ann. Inst. Fourier* (Grenoble) **32**(3), 183–213, 1982

24. Paramétrix de transmission pour des opérateurs de type parabolique et application au problème de Cauchy microlocal. *C.R. Acad. Sci.* Paris, Série I, Math. **292**(1), 51–53, 1981

25. Résultats microlocaux en hypoellipticité partielle à la frontière pour des opérateurs pseudo-différentiels de transmission. *C.R. Acad. Sci.* Paris, Série. A, **290**(24), 1123–1125, 1980

26. Hypoellipticité partielle à la frontière des opérateurs pseudo-différentiels de transmission. *Ann. Mat. Pura Appl.* **123**(4), 1980 [PhD thesis]

Books and Monographs

1. Symplectic Geometry and Quantum Mechanics. Birkhäuser, Basel, series "Operator Theory: Advances and Applications" (subseries: "Advances in Partial Differential Equations"), Vol. 166 (2006)

2. The Principles of Newtonian and Quantum Mechanics: the Need for Planck's Constant h; with a foreword by B. Hiley. Imperial College Press (2001), *ca* 380 pages

3. Maslov Classes, Metaplectic Representation and Lagrangian Quantization. Mathematical Research **95**, Wiley VCH (1997), *ca* 190 pages

4. Symplectic Methods in Harmonic Analysis and Applications [working title]; to be published by Birkhäuser, in the series "Pseudo-Differential Operators, Theory and Applications" 2010/2011.

5. Proceedings of the Karlskrona Conference in the Honor of Jean Leray, Springer Verlag (2003), *ca* 580 pages. Ed. Maurice de Gosson.