

CURRICULUM VITAE

José Manuel Cidade Mourão

2018

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1 General

- **Google Scholar**
 - 1 publication with more than 600 citations
 - 2 publications with 100–200 citations
 - 6 publications with 50–100 citations
- Personal web page: <http://www.math.tecnico.ulisboa.pt/~jmourao>
- Co-author of one book:
Lecture Notes in Physics, 349, Springer-Verlag, Berlin 1989.
- Minicourse taught at the International School on Geometry, Grupoids and Quantization, University of Hong Kong, November 2013:
Decomplexification of integrable systems, quantization and Kähler geometry.
- Minicourse taught at the Institute for Quantum Gravity of Erlangen University in the Fall of 2014:
Quantum Mechanics and Kähler Geometry.
- Minicourse taught at the Mathematics Department of Geneva University, Fall 2015:
Imaginary time in Kahler geometry, quantization and tropical amoebas.
- Minicourse taught at the Physics Department of Beijing Normal University, December 2015:
Quantum Mechanics versus Complex Geometry.
- Colloquium at the Physics Department of Beijing Normal University, December 2015:
Quantum mechanics and complex observables.
- Hong Kong Geometry Colloquium, December 2016:
Complexified Hamiltonian Symplectomorphisms and Solutions of the Homogeneous Complex Monge-Ampere Equation.

2 Scientific Degrees and Academic Career

2.1 Scientific Degrees

- Habilitation (Agregação) in Physics, Instituto Superior Técnico (June, 1995).
- Ph.D. in Physics and Mathematics by the State University of Moscow, M.V. Lomonosov, August 3, 1988.
- M.Sc. in Physics and Mathematics by the State University of Moscow, M.V. Lomonosov, June 24, 1986.

2.2 Place of Work

Mathematics Department, Instituto Superior Técnico.

2.3 Category

Full Professor.

2.4 Academic Positions

- 1- From 01/10/1988 to 08/11/1988: Teaching Assistant (Assistente Estagiário) at the Mathematics Department of Instituto Superior Técnico, Universidade Técnica de Lisboa, Lisboa, Portugal.
- 2- From 09/11/1988 to 14/02/1989: Teaching Assistant (Assistente Estagiário) at the Mathematics Department of Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Lisboa, Portugal.
- 3- From 15/02/1989 to 01/03/1990: Assistant Professor (Professor Auxiliar) at the Mathematics Department of Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Lisboa, Portugal.

- 4- From 02/03/1990 to 05/2001: Assistant Professor at the Physics Department of Instituto Superior Técnico, Universidade Técnica de Lisboa, Lisboa, Portugal.
- 5- Visiting Assistant Professor at the Center for Gravitational Physics and Geometry, Pennsylvania State University, 1993/94 (on sabbatical leave from IST).
- 6- From 01/11/1994 to 31/10/1996: Invited Assistant Professor at the Physics Department of University of Algarve (on leave from IST).
- 7- From 05/2001 to 29/12/2015: Associate Professor at the Mathematics Department of Instituto Superior Técnico, Universidade Técnica de Lisboa, Lisboa, Portugal.
- 8- From 30/12/2015: Full Professor at the Mathematics Department of Instituto Superior Técnico, Universidade Técnica de Lisboa, Lisboa, Portugal.

3 Teaching Experience

3.1 MSc and PhD Courses

- Feynman integral and applications, 2017/18 and 2018/19.
Mathematics Dep., IST
- Differential Geometry, 2010/2011, 1st Semester.
Mathematics Dep., IST.
- Lie groups and Lie algebras, 2001/2002, 2nd Semester.
Mathematics Dep., IST.
- Lie groups, 1990/1991, 1st Semester.
Physics Dep., Faculdade de Ciências, University of Lisbon.
- Lie groups, 1989/1990, 1st Semester.
Physics Dep., Faculdade de Ciências, University of Lisbon.

3.2 Undergraduate Courses

- Linear Algebra (IST, 2011-present)
- Differential and Integral Calculus II (IST, 2006-2009)
- Mathematical Analysis III (IST, 2001-2006)
- Mathematical Methods in Physics (IST, 1996-2000)
- Physics I (Mechanics; IST, 1996-2000)
- Theoretical Mechanics (Univ. Algarve, 1995/1996)
- Physics II (Thermodynamics; Univ. Algarve, 1995/1996)
- Atomic and Molecular Physics I (Univ. Algarve, 1994/1995)
- Physics I (IST, 1989-1992, Univ. Algarve, 1994/1995, 1995/1996)
- Mathematical Analysis VI (Partial Derivative Equations; Univ. Nova Lisboa, 1989/1990)
- Dynamical Systems (Univ. Nova Lisboa, 1988/1989)
- Applied Mathematics II (Equations of Mathematical Physics; Univ. Nova Lisboa, 1988/1989-1989/1990)
- Applied Mathematics I (Complex Analysis; Univ. Nova Lisboa, 1988/1989-1989/1990)

4 Supervision of Thesis

4.1 Supervision of PhD Thesis

- Paulo M. Sá, 1993 (co-supervisor; Supervisor: A.B. Henriques).
Title: *Inflationary models*.
P.M. Sá is Associate Professor at the Physics Department, University of Algarve.

- Paulo V. Moniz, 1993 (co-supervisor; Supervisor: P. Crawford).
Title: *Symmetries in General Relativity and exact solutions*.
P.V. Moniz is Full Professor at the Physics Department, University of Beira Interior.
- João Nuno Tavares, 1994.
Title: *Mathematical methods in the quantization of systems with 1st class constraints*.
J.N. Tavares is Associate Professor at the Mathematics Department, Porto University.
- José M. Pé-Curto Velhinho, 2000 (supervisor; Co-supervisor: Nenad Manojlovic)
Title: *Quantization of systems with non trivial phase spaces*.
J.M. Velhinho is Assistant Professor at the Physics Department, University of Beira Interior.
- Pedro M. Matias, 2006.
Title: *Geometric Quantization and the Coherent State Transform*.
P. Matias is Project Coordinator at the Agency for Assessment and Accreditation of Higher Education in Portugal.

4.2 Supervision of MSc Thesis

- Fernando Henrique Passos Silva, 2002.
Title: *Representations of the Virasoro algebra and conformal field theories*.
- Nelson Sousa, 2007.
Title: *Equivariant cohomology and supersymmetric quantum mechanics*.
- Marco Robalo, 2009.
Title: *Galois theory towards dessins d'enfants*.
- Pedro Silva, 2018.
Title: *Complex flows and geodesics in the space of Kähler metrics*.

4.3 Supervision of Undergraduate Thesis

- João Mourão Furtado, 1993.
Title: *Finite dimensional constrained systems*.
- Luis Matos Ferreira, 1993.
Title: *Some aspects of non perturbative quantum gravity in Ashtekar variables*.
- Gonçalo Matias, 1999.
Title: *Constrained systems from the Lagrangean and Hamiltonian points of view*.
- Nelson Sousa, 2002.
Title: *Equivariant cohomology and localization in Hamiltonian mechanics*.

5 Publications

5.1 Book

- [K89] Yu. A. Kubyshin, J.M. Mourão, G. Rudolph and I.P. Volobuev, *Dimensional reduction of gauge theories, spontaneous compactification and model building*, Lecture Notes in Physics, **349**, Springer-Verlag, Berlin 1989, 80p. DOI: 10.1007/3-540-51917-3

5.2 Publications in International Journals

- [DMNQ18] P. Dang, J. Mourao, J.P. Nunes and T. Qian, *Clifford coherent state transforms on spheres*, J. Geom. Phys. **124** (2018), 225–232.
arxiv:1612.01319
- [MNQ17] J. M. Mourão and J. P. Nunes and Tao Qian, *Coherent state transforms and the Weyl equation in Clifford analysis*, J. Math. Phys. **58** (2017), 013503.

- [KMNQ16] W. D. Kirwin, J. M. Mourão and J. P. Nunes and Tao Qian, *Extending coherent state transforms to Clifford analysis*, J. Math. Phys. **57** (2016), 103505. arXiv:1601.01380.
- [KMN16] W. D. Kirwin, J. M. Mourão and J. P. Nunes, *Complex symplectomorphisms and pseudo-Kähler islands in the quantization of toric manifolds*, Math. Ann. **364** (2016), 1–28. arXiv:1411.2793.
- [EMN15] J. N. Esteves, J. M. Mourão and J. P. Nunes, *Quantization in singular real polarizations: Kähler regularization, Maslov correction and pairings*, J. Phys. A: Math. Theor. (Fast Track Communication) **48** (2015), 22FT01.
- [MN15] J. M. Mourão and J. P. Nunes, *On complexified analytic Hamiltonian flows and geodesics on the space of Kahler metrics*, Int. Math. Res. Notices (2015). arXiv:1310.4025.
- [KMN14] W. D. Kirwin, J. M. Mourão, J. P. Nunes, *Coherent state transforms and the Mackey-Stone-Von Neumann theorem*, J. Math. Phys. **55** (2014) 102101.
- [KMN13b] W. D. Kirwin, J. M. Mourão, J. P. Nunes, *Degeneration of Kähler structures and half-form quantization of toric varieties*, J. Sympl. Geom. **11** (2013) 603–643.
- [KMN13a] W. D. Kirwin, J. M. Mourão, J. P. Nunes, *Complex time evolution in geometric quantization and generalized coherent state transforms*, J. Funct. Anal. **265** (2013) 1460–1493.
- [BFMN13] I. Biswas, C. Florentino, J. Mourao and J.P. Nunes, *Quantization of some moduli spaces of parabolic vector bundles on $\mathbb{C}P^1$* , Ann. Glob. Anal. and Geometry **43** (2013) 161–176.
- [BFMN11] T. Baier, C. Florentino, J. M. Mourão, J. P. Nunes, *Toric Kähler metrics seen from infinity, quantization and compact tropical amoebas*, J. Diff. Geometry **89** (2011) 411–454.

- [BMN10] T. Baier, J. Mourão, J. P. Nunes, *Quantization of Abelian Varieties: distributional sections and the transition from Kähler to real polarizations*, J. Funct. Anal. **258** (2010) 3388–3412.
- [F06] C. Florentino, P. Matias, J. Mourão and J.P. Nunes, *On the BKS Pairing for Kähler Quantizations of the Cotangent Bundle of a Lie Group*, J. Funct. Anal. **234** (2006) 180–198.
- [F05] C. Florentino, P. Matias, J. Mourão and J.P. Nunes, *Geometric quantization, complex structures and the coherent state transform*, J. Funct. Anal. **221** (2005) 303–322.
- [FMN04] C. Florentino, J. Mourão and J.P. Nunes, *Coherent State Transforms and Theta Functions*. Proc. Steklov Inst. Math. **246** (2004) 283–302.
- [FMN03] C. Florentino, J. Mourão and J.P. Nunes, *Coherent State Transforms and Vector Bundles on Elliptic Curves*, J. Funct. Anal. **204** (2003) 355–398.
- [FMN02] C. Florentino, J. Mourão and J.P. Nunes, *Coherent State Transforms and Abelian Varieties*. J. Funct. Anal. **192** (2002) 410–424.
- [A00] Abhay Ashtekar, Donald Marolf, José Mourão and Thomas Thiemann, *Constructing Hamiltonian quantum theories from path integrals in a diffeomorphism invariant context*. Class. Quant. Gravity **17** (2000) 4919–4940.
- [MTV99] J.M. Mourão, T. Thiemann e J.M. Velhinho *Physical properties of quantum field theory measures*. J. Math. Phys. **40** (1999) 2337–2353.
- [MMT97] D. Marolf, J.M. Mourão e T. Thiemann, *The status of diffeomorphism superselection rules in euclidean (2+1) gravity*. J. Math. Phys. **38** (1997) 4730–4740.
- [A97] A. Ashtekar, J. Lewandowski, D. Marolf, J.M. Mourão e T. Thiemann, *SU(N) quantum Yang Mills theory in two dimensions: a complete solution*. J. Math. Phys. **38** (1997) 5453–5482.

- [A96] A. Ashtekar, J. Lewandowski, D. Marolf, J.M. Mourão e T. Thiemann, *Coherent state transforms for spaces of connections*. J. Funct. Anal. **135** (1996) 519–551.
- [LMT96] R. Loll, J.M. Mourão, J.N. Tavares, *Complexification of gauge theories*. J. Geom. Phys. **18** (1996) 1–24.
- [A95] A. Ashtekar, J. Lewandowski, D. Marolf, J.M. Mourão e T. Thiemann, *Quantization of diffeomorphism invariant theories of connections with local degrees of freedom*. J. Math. Phys. **36** (1995) 6456–6493.
- [MM] Donald Marolf, José M. Mourão, *On the support of the Ashtekar-Lewandowski measure*. Comm. Math. Phys. **170** (1995) 583-606.
- [LMT95] R. Loll, J.M. Mourão, J.N. Tavares, *Generalized coordinates on the phase space of Yang-Mills theory*. Class. Quant. Grav. **12** (1995) 1191–1198.
- [BMP] O. Bertolami, J.M. Mourão, J. Perez-Mercader, *Quantum gravity and the large scale structure of the universe*. Phys. Lett. **B311** (1993) 27–33.
- [B93] M.C. Bento, O. Bertolami, P.V. Moniz, J.M. Mourão, P.M. Sá, *On the cosmology of massive vector fields with $SO(3)$ global symmetry*. Class. Quant. Grav. **10** (1993) 285–298.
- [MMS] P.V. Moniz, J.M. Mourão, P.M. Sá, *The dynamics of a flat Friedmann-Robertson-Walker inflationary model in the presence of gauge fields*. Class. Quant. Grav. **10** (1993) 517–534.
- [BKM] O. Bertolami, Yu.A. Kubyshev, J.M. Mourão, *Stability of compactification in Einstein-Yang-Mills theories after inflation*. Phys. Rev. **D45** (1992) 3405–3414.
- [BM] O. Bertolami, J.M. Mourão, *The ground state wave function of a radiation dominated universe*. Class. Quant. Grav. **8** (1991) 1271–1282.

- [MM91] P.V. Moniz, J.M. Mourão, *Homogeneous and isotropic closed cosmologies with a gauge sector*. *Class. Quant. Grav.* **8** (1991) 1815–1832.
- [B91] O. Bertolami, J.M. Mourão, R.F. Picken, I.P. Volobuev, *Dynamics of euclideanized Einstein-Yang-Mills systems with arbitrary gauge groups*. *Int. J. Mod. Phys.* **A6** (1991) 4149–4180.
- [HMS] A.B. Henriques, J.M. Mourão, P.M. Sá, *Inflation in a Bianchi-IX cosmological model. The roles of primordial shear and gauge fields*, *Phys. Lett.* **B256** (1991) 359–368.
- [VKM89b] I.P. Volobuev, Yu.A. Kubyshin, J.M. Mourão, *Symmetric spaces and Higgs models in the method of dimensional reduction. 2: Theories with one multiplet of scalar fields*. *Theor. Math. Phys.* **78** (1989) 191–200.
- [VKM89a] I.P. Volobuev, Yu.A. Kubyshin, J.M. Mourão, *Symmetric spaces and Higgs models in the method of dimensional reduction. 1: Potentials of the scalar fields of the reduced theory*. *Theor. Math. Phys.* **78** (1989) 41–49.
- [KMV89b] Yu.A. Kubyshin, J.M. Mourão, I.P. Volobuev, *Multidimensional Einstein-Yang-Mills theories: Dimensional reduction, spontaneous compactification and all that*. *Nucl. Phys.* **B322** (1989) 531–554.
- [KMV89a] Yu.A. Kubyshin, J.M. Mourão, I.P. Volobuev, *Scalar fields in the dimensional reduction scheme for symmetric spaces*. *Int. J. Mod. Phys.* **A4** (1989) 151–171.
- [KMV88] Yu.A. Kubyshin, J.M. Mourão, I.P. Volobuev, *Spontaneous compactification and dimensional reduction*. *Phys. Lett.* **203B** (1988) 349–352.

5.3 Preprints and Unpublished works

- [BMN17] T. Baier, J. Mourão and J.P. Nunes, *Picard group and quantization of toric orbifolds*, arxiv:1702.02626.

- [MNR17] J. Mourão, J.P. Nunes and T. Reis, *A new approximation method for geodesics on the space of Kahler metrics using complexified symplectomorphisms and Gröbner Lie series*, arxiv:1701.01709.
- [M88] J.M. Mourão, *Spontaneous compactification to homogeneous spaces*. JINR-E2-88-155, Mar 1988. 19pp.

5.4 Edition of Proceedings

- J.M. Mourão, J.P. Nunes, R. Picken, J.C. Zambrini, *Prospects in Mathematical Physics*, Proceedings of the YRS of 14th ICMP, 2003. Contemporary Mathematics, 246 pp, 2007.
- M.C. Bento, O. Bertolami, J. Mourão and R. Picken, *Proceedings of the First Iberian Meeting on Gravity* (Évora, Portugal, 21-26 Sept 1992). World Scientific, Singapore, 1993.

5.5 Contributions to Proceedings of International Conferences

- C. Florentino, J. Mourão and J.P. Nunes, *Theta Functions, Geometric Quantization and Unitary Schottky Bundles*, in *The Geometry of Riemann Surfaces and Abelian Varieties*, Proceedings of the III Iberoamerican Congress on Geometry, Salamanca, June 2004, ed. J. M. M. Porras, S. Popescu and R. E. Rodriguez, Contemporary Mathematics Vol. 397 (2006) 55-73.
- J. Mourão, *Aspects of the connections between Path Integrals, Quantum Field Theory, Topology and Geometry*. Lectures at the XII Fall Workshop on Geometry and Physics, Coimbra University, 2003. Publicaciones de la Real Sociedad Matemática Española, **7** (2004) 3-51.
- Abhay Ashtekar, Jerzy Lewandowski, Donald Marolf, José M. Mourão, Thomas Thiemann, *A manifestly gauge-invariant approach to quantum theories of gauge fields*, Em: Proceedings da “Conference on Con-

strained Dynamical Systems”, Isaac Newton Institute, Cambridge, Junho de 1994.

- Abhay Ashtekar, Donald Marolf, José M. Mourão, *Integration on the space of connections modulo gauge transformations*, Em: Proceedings da “Lanzos Conference”, Raleigh, Dezembro de 1993.
- R. Loll, J.M. Mourão, J.N. Tavares, *Symplectic reduction via complex group actions*. Em: Proceedings do “2nd Workshop on Constraints Theory and Quantization Methods”, Montepulciano, Italia, Junho de 1993.
- J.M. Mourão, *Symmetric solutions of Einstein-Yang-Mills equations*. Em: *Classical and Quantum Gravity*. Proceedings of the 1st Iberian Meeting on Gravity, World Scientific, Singapore, 1993, 217-221.
- M.C. Bento, O. Bertolami, P.V. Moniz, J.M. Mourão, P. Sá, *Friedmann-Robertson-Walker cosmologies in the presence of massive vector fields*. Em: *Classical and Quantum Gravity*. Proceedings of the 1st Iberian Meeting on Gravity, (Évora, Portugal, 21-26 Sep 1992). World Scientific, Singapore, 1993, 251-255.
- O. Bertolami, J.M. Mourão, J. Pérez-Mercader, *Explaining the large scale structure of the Universe using quantum gravity*. Em: *Classical and Quantum Gravity*. Proceedings of the 1st Iberian Meeting on Gravity (IMG-1), (Évora, Portugal, 21-26 Sep 1992). World Scientific, Singapore, 1993, 280-284.
- O. Bertolami, J.M. Mourão, Yu.A. Kubyshin, *Stability of compactification in Einstein-Yang-Mills theories*. Em: *The Physical Universe: The Interface Between Cosmology, Astrophysics and Particle Physics*, Proceedings of the XII Autumn School of Physics, (Lisbon, Portugal, 1990). Springer Verlag Lecture Notes in Physics, **383**, Berlin, 1991, 237-252.
- O. Bertolami, J.M. Mourão, *Euclideanized Einstein-Yang-Mills equations, wormholes and the ground state wave function of a radiation*

dominated universe. Em: Proceedings of the XII Autumn School of Physics, (Lisbon, Portugal, 1990). Springer Verlag Lecture Notes in Physics, **383**, Berlin, 1991.

- O. Bertolami, J.M. Mourão, Yu.A. Kubyshin, *Stability of compactification in Einstein-Yang-Mills theories after inflation*. Em: Proceedings of the VI Marcel Grossmann Meeting, (Kyoto, Japan, 1991).
- J.M. Mourão, Yu.A. Kubyshin, I.P. Volobuev, *Graphic schemes of root ordering in simple Lie algebras*. Em: Proceedings of the XVIII International Symposium on Group Theoretical Methods in Physics. (Moscow, June, 1990). Nova Science, New York, 1991, 261-264.
- J.M. Mourão, Yu.A. Kubyshin, I.P. Volobuev, *Spontaneous compactification with extra time-like dimensions in Einstein-Yang-Mills theories*. Em: Proceedings of the XII International Workshop (Protvino, USSR, July, 1989). Nauka, Moscow, 1990, 73-76.
- J.M. Mourão, Yu.A. Kubyshin, I.P. Volobuev, *Stable compactifying solutions and new possibilities for model building in symmetric spaces with simple isotropy group*. Em: Proceedings of the XI International Workshop (Protvino, USSR, July, 1988).
- J.M. Mourão, Yu.A. Kubyshin, I.P. Volobuev, *Spontaneous compactification to homogeneous spaces in Einstein-Yang-Mills theories*. Em: Proceedings of the 5th Marcel Grossmann Meeting (Perth, Australia, August, 1988). Abstracts. University of Western Australia, 1988, 86.

5.6 Most significant scientific publications

My research career up to the present point can be naturally divided in four parts. I have selected few representative publications from all these parts.

5.6.1 PART I: Spontaneous compactification in Einstein-Yang-Mills theories, [K89]

[K89] [Book: 70 citations in Google scholar] For my PhD I worked on exact solutions of the coupled Einstein-Yang-Mills (EYM) equations. G -invariant connections on principal K -bundles $P \rightarrow G/H$ are reduced, via Wang's theorem, to a representation theoretic linear problem on finding certain spaces of intertwining operators. In [K89] the original results obtained by the authors on applying Wang's theorem to finding interesting homogeneous solutions of the EYM theories on manifolds of the form, $\mathbb{R}^{1,3} \times G/H$, are described in detail. The consistent application of Wang's theorem lead to a significative number of new solutions. A representation theoretic approach, called coset space dimensional reduction (CSDR), to describe the dimensional reduction of the initial theory to Minkowski space-time, $\mathbb{R}^{1,3}$, is described in detail.

5.6.2 PART II: Application of Coset Space Dimensional Reduction (CSDR) Techniques in Classical and Quantum Cosmology, [B91, BM]

After returning to Portugal in 1988 I proposed to several colleagues to apply Wang's theorem in the context of classical and quantum cosmological models. This study was carried out in several joint publications.

[B91] [77 citations in Google scholar] We found a wide class of new finite action solutions of the euclideanized EYM cosmological equations with arbitrary gauge groups. These EYM configurations correspond to worm-hole solutions.

[BM] [72 citations in Google scholar] The semiclassical solutions of [B91] were used to find the wave function for a homogeneous and isotropic universe satisfying the Hartle-Hawking (no)boundary conditions, in the presence of non-abelian Yang-Mills fields (connections). The connection degrees of freedom decouple and for the geometry we obtain the wave function of a radiation dominated universe.

5.6.3 PART III: Projective Techniques and Diffeomorphism Constraint in Loop Quantum Gravity, [MM, A96, A95]

My research on cosmological models and the work of supervision of my PhD student João Nuno Tavares, shifted my interest to the problem of quantizing constrained systems in general and nonperturbative quantum gravity in particular. Motivated by this interest I spent a sabbatical leave in 1993/1994 with Abhay Ashtekar's group in Penn State University. Abhay Ashtekar is one of the leading experts in the field of nonperturbative quantum gravity and loop quantum gravity (LQG).

My stay led to many joint works of which I would select as most significant [MM, A96, A95]. The Ashtekar-Isham compactification of the space of connections modulo gauge transformations had been proposed two years before and the diffeomorphism-invariant Ashtekar-Lewandowski measure had just been proposed. I suggested to use projective limit techniques, which proved very useful in the whole programme of LQG.

[MM] [154 citations in Google scholar] In this work we proved properties of the support of the Ashtekar-Lewandowski measure on the projective limit of a family of spaces of connections on graphs. In particular we showed that the space of smooth connections modulo gauge transformations is a zero measure subset.

[A96] [120 citations in Google scholar] One important difficulty with the AIL representation consisted in the use of $SU(2)$ spin connections instead of the $SL(2, \mathbb{C})$ Ashtekar connections, for which the Hamiltonian constraint was expected to become polynomial. While in Penn State I came across the work of B. Hall on a unitary coherent state transform (CST) from $L^2(K, dx)$ to $\mathcal{H}L^2(K_{\mathbb{C}}, d\nu)$, where K is a compact Lie group, $K_{\mathbb{C}}$ its complexification and ν an appropriate heat kernel measure. This work seemed useful to deal with the problem we were facing of “complexifying” the AIL representation. Indeed in [A96] we managed to construct a consistent family of CST transforms inducing a unitary transform from the AIL space of generalized $SU(2)$ -connections onto a L^2 space of generalized $SL(2, \mathbb{C})$ connections.

[A95] [627 citations in Google scholar; ranked 31st in the SLAC/SPIRES list of “Top Cited Articles of All Time (2010 edition) in gr-qc”] We introduced a new “refined algebraic quantization scheme” to deal with the quantization of constrained dynamical systems. We then solved the quantum diffeomorphism constraint for theories of connections with compact gauge groups. We did not address the Hamiltonian constraint in this paper. This problem proved very difficult and there has not been much progress on it since then.

The three references [MM, A96, A95] continue playing a very important role in Loop Quantum Gravity nowadays.

5.6.4 PART IV: Geometric Quantization and Kähler Geometry, [FMN03, F05, BFMN11, KMN13a, MN15]

The difficulties in dealing with the Hamiltonian constraint in nonperturbative quantum gravity motivated my interest in studying mathematical problems in the geometric quantization of finite dimensional systems. I started then a collaboration with Carlos Florentino and João P Nunes, who had complementary motivations and background. More recently our team has been strengthened by Thomas Baier, a former PhD student of João P Nunes, and by William Kirwin, post-doctoral fellow in our institute. We also benefited greatly from several very inspirational contacts we had with Andrei Tyurin. Pedro Matias participated in this collaboration during his PhD.

[FMN03] One long term goal we have consists in coupling CST techniques with geometric quantization to try to develop an analytic theory of nonabelian theta functions for higher genus, $g > 1$, curves. In [FMN03] we studied the simpler, $g = 1$, case. Eventhough simpler, this case already contains several interesting features, some of which may be important for the higher genus case. With the help of an appropriate CST, we identified natural finite dimensional spaces of distributions on $SU(n)$ with the spaces of nonabelian theta functions on the moduli space of rank n semistable vector bundles with trivial determinant on an elliptic curve. This identification includes a shift of level $k \mapsto k + n$, and

therefore provides an intrinsic finite dimensional derivation for this shift.

- [F05] We related the heat operator, which appears in the Hall CST, with the parallel transport for a natural connection on a one-parameter space of Kähler quantizations. Our results relate the CST for compact Lie groups with the Hitchin connection.
- [BFMN11] We identify families of Kähler polarizations in toric varieties, which degenerate to the singular real toric polarization. We show that, under this degeneration, the holomorphic monomial sections converge to distributional sections supported on the Bohr-Sommerfeld (BS) fibers. The degenerations we consider provide the appropriate differential geometric setting for studying the degeneration of toric hypersurface amoebas in large complex structure limits. On the other hand, families of complex structures, which on the open orbit have the form $w = e^{ty+i\theta}$, cannot be extended smoothly to a compact toric manifold as they don't satisfy the Abreu-Guillemin boundary conditions. Considering instead our families, we show that, in the limit $t \rightarrow \infty$, the hypersurface amoebas do tend, in Legendre transformed variables, to tropical amoebas.
- [KMN13a] For the cotangent bundle of a compact Lie group, we study the complex-time evolution of the vertical tangent bundle and the associated geometric quantization Hilbert space under an infinite-dimensional family of Hamiltonian flows. For each such flow, we construct a generalized coherent state transform, which is a unitary isomorphism between $L^2(K)$ and a certain weighted L^2 -space of holomorphic functions. For a particular set of choices, we show that this isomorphism is naturally decomposed as a product of a Heisenberg-type evolution (for complex time $-\tau$) within $L^2(K)$, followed by a polarization-changing geometric quantization evolution (for complex time $+\tau$). In this case, our construction yields the usual generalized Segal-Bargmann transform of Hall. We show that the infinite-dimensional family of Hamiltonian flows can also be understood in terms of Thiemann's "complexifier" method (which generalizes the construction of adapted complex structures).

[MN15] In [MN15] we use the Gröbner theory of Lie series to define actions of the group of complexified Hamiltonian symplectomorphisms on a Kähler manifold. We study the corresponding actions on polarizations and the associated geodesics in the space of Kähler potentials.

6 Research Projects

6.1 Research Projects

- JNICT grant PESO/P/PR0/8/91, 1994-1995.
- JNICT Grant No. STRDA/C/PR0/1032/93, 1994-1995.
- PRAXIS/2/2.1/FIS/286/94, Principal Investigator, Functional analysis and quantum field theory, 1999-2001.
- CERN/P/FAE/1030/95, 1996-1997.
- PCERN/P/FAE/1111/96, 1998.
- PRAXIS/2/2.1/FIS/286/94, 1999-2001.
- PCEX/P/MAT/44/96, 2001.
- CERN/P/FIS/1203/98, 1999-2000.
- POCTI/MAT/33943/99, POCTI/33943/MAT/2000, 2001-2004.
- CERN/P/FIS/40108/2000, 2001.
- POCTI/FP/FNU/50226/2003, 2004-2006.
- POCI/MAT/58549/2004, 2005-2008.
- PTDC/MAT/101913/2008, 2009.
- CERN/FP/109344/2009, 2010.
- PTDC/MAT/112566/2009, 2010.
- PTDC/MAT/119689/2010, Principal Investigator, *Geometry of Quantization*, 2012–2014, 42 000 Euros.
- EXCL/MAT-GEO/0222/2012, core CV, *Geometry and Mathematical Physics*, 2013–2016, 326 000 Euros.

- FDCT (Macau) Project 099/2014/A2, *Two related topics in Clifford analysis*, Co-PI, 2015–2017, MOP 2 130 000.
- PTDC/MAT-GEO/3319/2014, 2016-2018, Quantization and Kähler Geometry.

7 Administrative Duties

- Head of the Physics Sector of Algarve University from November 1995 to October 1996.
- Coordinator of the MSc degree in Applied Mathematics, IST, January, 2003 - December, 2006.
- Member of the Scientific and Pedagogical Council of the Mathematics Department, IST: January, 2010 – July, 2012.
- Member of the Direction of the Research Center of Mathematical Analysis, Geometry and Dynamical Systems (65 members, the largest and most prestigious mathematics research unit in Portugal), February 2011 – January 2013.
- Vice-president of the Mathematics Department of IST, January 2017 – Present.

8 Participation in Committees and Organization of Scientific Meetings

8.1 Thesis Committees

8.1.1 PhD

- Paulo Moniz (as co-advisor), 1993, Faculdade de Ciências, Universidade de Lisboa.
- Paulo Sá (as co-advisor), 1993, IST.

- João Nuno Tavares (as advisor), 1994, IST.
- José Manuel Velhinho (as advisor), 2001, IST.
- Pedro Lopes, 2003, IST.
- Pedro Matias (as advisor), 2006, IST.
- Inaki Garay, 2008, Autonoma University, Madrid, Spain.
- Pedro Vaz, 2008, Algarve University.
- Thomas Baier, 2009, IST.

8.1.2 MSc

- Fernando Passos Silva (as advisor), 2002, Faculdade de Ciências, Universidade de Lisboa.
- Alexandra Margarida Virote da Costa, 2003, Faculdade de Ciências, Universidade do Porto.
- Maria Clementina Timóteo, 2004, Faculdade de Ciências, Universidade de Lisboa.
- Nelson Sousa (as advisor), 2007, IST.
- Marco Robalo (as advisor), 2009, IST.

8.2 Member of the Organizing Committe of International Conferences

- I - XX Porto Meetings on Geometry Topology and Physics, Universidade do Porto, 1992-2012.
<http://www.math.ist.utl.pt/jmourao/om/>

- First CAMGSD Thematic Period on Algebraic Geometry and Topological Strings, IST, 10 de Outubro a 12 de Novembro de 2005.
<http://www.math.ist.utl.pt/strings/AGTS/>
- 2004 Workshop on Algebraic Geometry and Physics, IST, 7-12 Setembro.
<http://www.math.ist.utl.pt/galg/WAGP04/>
- Modern Trends in String Theory II, Universidade do Porto, 21-26 de Junho de 2004.
<http://www.math.ist.utl.pt/~strings/MTST2/>
- XIV International Congress on Mathematical Physics, Universidade de Lisboa, 28/07-02/08 de 2003.
<http://icmp2003.net/>
- Young Researchers Symposium on Mathematical Physics, IST, 25 - 26 de Julho de 2003.
<http://icmp2003.net/yrs/>
- Modern Trends in String Theory IST, 13-17 Julho de 2001.
<http://www.math.ist.utl.pt/~strings/MTST/>
- School on Singularities in Algebraic Geometry & String Theory, Complexo Interdisciplinar da Universidade de Lisboa, 8-17 de Julho de 1999.
<http://www.math.ist.utl.pt/~jmourao/cim/main.html>
- Lisbon School on Superstrings, IST, 16-18 Dezembro, 1998.
<http://alfa.ist.utl.pt/~orfeu/lsss/main.html>
- Workshop on Modern Methods in Classical and Quantum Gravity, Sintra, 1995.
- First Iberian Meeting on Gravity, Universidade de Évora, 1992.

8.3 Member of the Organizing Committee of National Conferences

- IST Lecture Series in Algebraic Geometry & Physics. Web page <http://www.math.ist.utl.pt/~jpnunes/istlectagp.html>
- I-IV Encontros do Algarve em Física de Altas Energias e Gravitação, Universidade do Algarve, 1993-1996.
- Conferência Nacional de Física, “Física 96”, Univ. Algarve, Setembro de 1996.

9 Fellowships

NATO research fellowship (1993/94 - 8 months). Sabbatical leave at the Center for Gravitational Physics and Geometry da Pennsylvania State University.

10 Knowledge of Languages

Fluent in portuguese, english and russian.

Modern greek: fluent in reading and speaking.

11 Seminars and Workshop Lectures

11.1 Workshop Lectures and Minicourses

- Lectures at the XII Fall Workshop on Geometry and Physics, Coimbra University, 2003, *Aspects of the connections between Path Integrals, Quantum Field Theory, Topology and Geometry*, Publicaciones de la Real Sociedad Matemática Española, 7 (2004) 3-51.

- Minicourse given at the International School on Geometry, Grupoids and Quantization, University of Hong Kong, *Decomplexification of integrable systems, quantization and Kähler geometry*, November 2-5, 2013.
- Lectures at the Institute for Quantum Gravity, Friedrich-Alexander Universität Erlangen-Nürnberg, *Quantum Mechanics and Kähler Geometry*, Fall 2014.
- Lectures at the Mathematics Department of Geneva University, *Imaginary time in Kähler geometry, quantization and tropical amoebas*, Fall 2015.
- Lectures at the Physics Department of the Beijing Normal University, *Quantum Mechanics versus Complex Geometry*, December 2015.

11.2 Seminars

- Mathematical Institute, named after Steklov, Moscow
- Nuclear Physics Institute, Moscow
- Complexo II, INIC, Lisboa
- Departamento de Física, Instituto Superior Técnico, Lisbon
- Departamento de Matemática, Instituto Superior Técnico, Lisbon
- Departamento de Física, Faculdade de Ciências de Lisboa
- Departamento de Matemática Pura, Universidade do Porto
- Departamento de Física, Universidade do Porto
- Instituto de Estructura de la Materia, CSIC, Madrid
- Physics Department, Pittsburgh University, Pittsburgh
- Physics Department, Syracuse University, Syracuse

- Physics Department, Barcelona University, Barcelona
- Physics Department, Universidade Autonoma de Barcelona, Barcelona
- Physics Department, Thessalonics University, Thessalonics, Greece
- Physics Department, Cyprus University, Nicosia, Cyprus
- Mathematics Department, Cyprus University, Nicosia, Cyprus
- Physics Department, Pennsylvania State University
- Physics Department, Virginia Politechnical University
- Physics Department, University of Cincinnati
- Mathematics Department, Pennsylvania State University
- Physics Department, University of Florida
- Physics Department, Brandeis University
- Department of Theoretical Physics, Imperial College
- Isaac Newton Institute for Mathematical Sciences, Cambridge
- Invited talk at the Symposium of the London Mathematical Society on “Quantum Concepts in Space and Time”, Durham, England.
- Departamento de Matemática da Universidade do Minho
- Área Departamental de Física, U.C.E.H, Universidade do Algarve
- A. Einstein Institute, Potsdam, Alemanha
- Invited talk at the Encontro Nacional da Sociedade Portuguesa de Matemática.
- Invited plenary talk at the III Iberian Mathematical Meeting, University of Minho, October 1-3, 2010.

- Erlangen University, May, 2012.
- Invited talk at the Conference on Tropical Aspects in Geometry and Topology, Max Planck Institute for Mathematics, Bonn, September 2-6, 2013.
- Seminar at the Faculty of Sciences and Technology, University of Macau, October 16, 2013.
- Seminar at the Mini-Workshop on Geometry, Chinese University of Hong Kong, October 17, 2013.
- Seminar at the Mini-Workshop on Geometry, University of Hong Kong, November 4-6, 2013.
- Seminar at the Physics Department, University of Warsaw, December 17, 2013.
- Seminar at the WaGaRy workshop of the Institute of Mathematics, Polish Academy of Sciences, Warsaw, December 18, 2013.
- Seminar at the Mathematics Department of the University of Michigan, January 24, 2014.
- Felix Klein Seminar at the Mathematics Department of the University of Notre Dame, January 31, 2014.
- Seminar at the Mathematics Department of the University of Illinois at Urbana-Champaign, February 3, 2014.
- Seminar at the Faculty of Sciences and Technology of the University of Macau, February 14, 2014.
- Colloquium at the Physics Department of the Beijing Normal University, December 2015.
- Geometry and Topology Seminar, Centro de Matemática da Universidade do Porto, September 23, 2016.

- Geometry Seminar, The University of Hong Kong, December 2, 2016.
- Hong Kong geometry Colloquium, The University of Hong Kong, December 3, 2016.