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Synopsis

My experience and interests include Bayesian probability calculus, continuum thermomechanics, quantum theory, general relativity, differential geometry. I also have a passion for modern logic and history of physics. In each of the mentioned subjects I have published original research or given popularizing seminars and lectures.

My programming experience includes python, Fortran, R, C++, Matlab, Mathematica, finite differences, neuronal networks.

My teaching and supervising experience ranges from ground-school children to PhD students, in academic institutions and as private tutor.

In research and in teaching, I believe in broadness and interdisciplinarity rather than specialization: the diverse fields in physics, mathematics, and the other sciences are just one, as one is the sky above us.

Research and education	page cv-2
Pedagogical experience	page cv-3
Memberships & associations	page cv-5
Computation & modelling	page cv-5
Laboratory experience	page cv-5
Grants	page cv-6
Journal refereeing	page cv-6
Languages & interests	page cv-6
Referees	page cv-7
Publications & talks	page cv-8

Research and education

- 2014-11 – 2017-03: **Post-doctoral researcher**,
Institute of Neuroscience and Medicine 6, Forschungszentrum Jülich,
Germany.
Bayesian and maximum-entropy methods for detection of behaviour-related
patterns in neural activity and inference of Alzheimer disease from fMRI data.
Relations between finer & coarser theories of brain activity. Improvement of
neuronal simulator algorithms.
- 2011-11 – 2014-01: **Post-doctoral researcher**,
Climate and Ocean Physics group, University of Oxford, UK.
Deterministic & stochastic theories for geophysical fluid dynamics and
their numeric implementation. Relations between finer & coarser dynamical
theories. Maximum-entropy and autoregressive models.
- 2012-08: **Bayesian statistics consultant**,
The Guide Dogs for the Blind Association, UK.
Bayesian exchangeable models for estimation of the number of visually
impaired children in some UK counties, given data from nearby counties.
- 2008-10 – 2011-10: **Post-doctoral fellow**,
Quantum Foundations group, Perimeter Institute for Theoretical
Physics, Canada.
Foundations of quantum theory. Description of quantum phenomena via
stochastic continuum mechanics. Non-equilibrium statistical mechanics.
Continuum theories in general relativity. Theory of hybrid statistical models.
- 2007-08 – 2008-09: **Post-doctoral researcher**,
Non-Linear Physics research group, Umeå University, Sweden.
Quantum kinetic theory for plasmas with spin. Stochastic continuum ther-
momechanics. Non-equilibrium statistical mechanics.
- 2008-08: **PhD**, thesis on *Studies in plausibility theory, with applications to
physics* (<https://portamana.org/>).
- 2002-11 – 2007-06: **PhD studies**,
Quantum Electronics and Quantum Optics group, Royal Inst. of
Technology, Stockholm.
Quantum communication. Quantum optics. Beam- and fibre-based inter-

ferometry for time-bin entanglement. State estimation and tomography techniques. Bayesian statistical models for quantum and hybrid theories.

2002-09 – 2002-10: **Experimental collaborator**,
Quantum Electronics and Optics group, Royal Inst. of Technology, Stockholm.
Quantum communication. Quantum optics. Beam- and fibre-based interferometry for time-bin entanglement.

2001-01 – 2002-08: **Graduate studies**,
Department of Theoretical Physics, Royal Inst. of Technology, Stockholm.
General relativity. Quantum communication theory. Non-linear differential equations.

2000-04: **Italian Laurea** in theoretical physics,
Cagliari University, awarded with maximum grades “cum laude”.
Thesis on *Asymptotic symmetries of anti-de Sitter space in two and three dimensions* (<https://portamana.org/>).
Dilatonic general relativity and its Hamiltonian formulation.

Pedagogical experience

Post-secondary education:

2004 – 2006: **Teacher**, Department of Microelectronics and Applied Physics, Royal Inst. of Technology, Stockholm.
Exercise module of the course *Electromagnetism and waves* (20–30 students); preparation and graduation of written examinations.

2000: **Course tutor**, Department of Biology, Cagliari University.
Physics Laboratory course.

1996 – 1997: **Undergraduate tutor** for junior physics students, Department of Physics, Cagliari University.

1995 – 1996: **Undergraduate teacher**, Department of Physics, Cagliari University.

Introductory lectures in mathematics and physics for first-year undergraduate students (70–150 students).

Phd, Msc, Bsc supervision:

2014 – present: **Co-supervisor** for several PhD students, Forschungszentrum Jülich, Germany.

Projects on maximum-entropy methods, Bayesian models and inference in neuroscience, state-space analysis of neuronal models.

2013: **Assistant supervisor for MPhys thesis**, University of Oxford.

2011 – 2012: **Full supervisor for BSc thesis**, Perimeter Institute for Theoretical Physics, Canada; Royal Inst. of Technology, Stockholm; University of Oxford.

Thesis on *Obtaining Entropy via Coarsening: Microscopic Restrictions on Continuum-mechanical constitutive Equations*. The student Veronica Wallängen obtained maximum grades with distinction for her thesis.

2010: **Supervisor for BA project**, Perimeter Institute for Theoretical Physics, Canada, and Franklin W. Olin College of Engineering, MA, USA.

Project on *The relationships between plausibility theory and logic*.

Secondary education:

2009 – 2011: **Summer-school teacher**, International Summer School for Young Physicists, Perimeter Institute for Theoretical Physics, Canada.

Short courses on *Probability theory as extended logic: elements and fundamental questions*; *Feynman-diagram techniques in classical physics: quantum field theory without “particles”*; and *Pictorial introduction to even and odd vectors and covectors*.

Other pedagogical activity:

1990 – 2000: **Private tutor** in physics, mathematics, Latin; Italy.

Pupils varying from ground-school children to graduating students.

2009 – 2011: **Pedagogical papers**, Perimeter Institute for Theoretical Physics, Canada.

On probability theory and differential geometry.

2003 – 2004: **Pedagogical papers and informal lectures**, Royal Inst. of Technology, Stockholm.

On probability theory, differential geometry, thermomechanics.

2006: Course attendance, **Basic communication and teaching**, Royal Inst. of Technology, Stockholm.

Memberships & associations

Society for Natural Philosophy (<http://www.ms.uky.edu/~snp/>),
2004 – present.

Electronic Frontier Foundation (<https://www.eff.org/>),
2016 – present.

Computational & modelling experience

Coding of time- & event-driven spike-based neuron models (NEST, C++).
Coding and analysis of geophysical-fluid-dynamical models with several timestepping schemes and stochastic components, in Fortran (finite differences) with parallel computing (MPI), and in FEniCS/Dolfin (finite elements).

Programming: very proficient with **Mathematica** (integration, solution of differential equations, data analysis, 3D & 4D plotting, symbolic manipulation, neural-network dynamics), **Matlab** (big data analysis, plotting), **Maple** (3D & 4D plotting); fairly proficient with **R** (inference, data analysis, estimation), **Python** (data analysis, plotting, stochastic dynamics), **Fortran** (solution of partial differential equations, finite-difference simulations), **FEniCS/Dolfin** (solution of partial differential equations, finite-elements simulations), **LabView** (interferometric data recording and analysis), **NEST** (neural-network dynamics), and parallel programming (**MPI**). My **C** (and variants) and **Lisp** are a bit rusty but functioning.

Laboratory experience

Experience in a quantum-optics laboratory and knowledge of its standard maintenance routines and safety measures. Use and care of equipment like lasers, optical elements, and other instruments (oscilloscopes, interferometers, modulators, etc.). I have specific experience with the construction and set-up of a fibre-based interferometer and a beam-based one for detection of time-bin entanglement, including construction

of parts of the metal frame, beam-fibre coupling maximization and stability, beam alignment and collimation, power monitoring and stabilization, placement of a thermal-stabilization and -monitoring system, coupling and programming (LabView) of various measuring and monitoring hardware and software.

Grants

Kempe foundations, Örnsköldsvik, Sweden: EUR 29 100/ USD 45 200 (SEK 275 000), for post-doctoral research in non-linear physics (2007).

*Foundation *Blanceflor Boncompagni-Ludovisi, née Bildt*, Stockholm: EUR 8 500/ USD 13 200 (SEK 80 000), for graduate research in quantum communication theory (2002).*

*Foundation *Angelo Della Riccia*, Florence: EUR 6 900/ USD 10 700 (SEK 65 000), for graduate research in theoretical physics (2001).*

Journal refereeing

Referee for: *Acta Physica Polonica A*, *American Journal of Physics*, *Annals of Physics*, *Foundations of Physics*, *International Journal of Theoretical Physics*, *Journal of Physical Chemistry*, *Journal of Physical Oceanography*, *New Journal of Physics*, *Quantum Information & Computation*, *Proceedings of the Royal Society A*, *Studies in History and Philosophy of Modern Physics*.

Languages & interests

Languages: **Italian**, mother tongue. **English**, fluent, spoken and written. **Swedish**, fluent, spoken and written. **French**, good reading and writing proficiency. **German**, fair reading and writing proficiency (mainly scientific writings). **Latin**, fair reading and writing proficiency. **Esperanto**, fair reading and writing proficiency. Beginner **Japanese**.

Other interests: *Buster Keaton*, *Swing dancing*, *martial arts*, *parkour*, *literature*, *music*, *languages*, *flying*, *art*, *philosophy*, *typography*, *odradek & Urusei Yatsura*.

Referees

Supervisors and mentors

(alphabetically)

Ingemar Bengtsson ingemar@fysik.su.se +46-(0)8-5537-8732
Professor, *Quantum Information & Quantum Optics* group
Stockholm University, Fysikum
Roslagstullsbacken 21, SE-104 06 Stockholm, Sweden

Mariano Cadoni mariano.cadoni@ca.infn.it +39-070675-4908
Professor, *Theoretical and High-energy Physics* group
Cagliari University & Istituto Nazionale di Fisica Nucleare
Cittadella Universitaria di Monserrato, IT-09042 Cagliari, Italy

Lucien Hardy lhardy@perimeterinstitute.ca +1-(519)-569-7600 x7521
Faculty, *Quantum Foundations* group
Perimeter Institute for Theoretical Physics,
31 Caroline St. N, Waterloo, ON N2L 2Y5 Canada

Moritz Helias m.helias@fz-juelich.de +49-(0)246161-9467
Professor, *Theory of Multi-scale Neuronal Networks* group
Forschungszentrum Jülich, Inst. for Neuroscience and Medicine-6
Wilhelm-Johnen-Straße, DE-52425 Jülich, Germany

Abigail Morrison a.morrison@fz-juelich.de +49-(0)246161-9805
Professor, *Functional Neural Circuits and Human Brain Model* groups
Bernstein Center Freiburg
Hansastraße 9a, DE-79104 Freiburg i.Br., Germany

Laure Zanna Laure.Zanna@physics.ox.ac.uk +44-(0)18652-72925
Professor, *Climate and Ocean Physics* group
University of Oxford, AOPP Clarendon Laboratory
Parks Road, OX1 3PU Oxford, UK

Former students

Vahid Rostami (PhD supervision)
v.rostami@fz-juelich.de +49-(0)1777792282
Forschungszentrum Jülich, INM-6,
Wilhelm-Johnen-Straße, DE-52425 Jülich, Germany

Tomos W. David (MPhys supervision)

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University of Oxford, AOPP Clarendon Laboratory,
Parks Road, OX1 3PU Oxford, UK

Veronica Wallängen (BSc supervision)

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University of California Berkeley & Stockholm University
Roslagstullsbacken 21, SE-104 06 Stockholm, Sweden

Daniel Franz (summer-school mentoring)

kwantumo@gmail.com +1-2266006784

Waterloo University,
61 C Eby St. S, Kitchener, ON N2G 3K9 Canada

Cyndia Yu (summer-school mentoring)

cyndiayu@college.harvard.edu +1-(480)-729-2937

Harvard College, Department of Physics,
524 Winthrop Mail Center, Cambridge MA 02138, USA

Publications & talks

Papers and conference proceedings

Electronic copies available at <https://portamana.org/>

[33] J. Krishnan, **P.G.L. Porta Mana**, M. Helias, M. Diesmann, E. Di Napoli: *Perfect spike detection via time reversal*, [arXiv:1706.05702](https://arxiv.org/abs/1706.05702), submitted to Front. Neuroinf. (2017).

[32] **P.G.L. Porta Mana**: *Geometry of maximum-entropy proofs: stationary points, convexity, Legendre transforms, exponential families*, osf.io/vsq5n, [arXiv:1707.00624](https://arxiv.org/abs/1707.00624) (2017).

[31] **P.G.L. Porta Mana**: *Maximum-entropy from the probability calculus: exchangeability, sufficiency*, osf.io/xdy72, [arXiv:1706.02561](https://arxiv.org/abs/1706.02561) (2017).

[30] L. Zanna, **P.G.L. Porta Mana**, J. Anstey, T. David, T. Bolton: *Scale-aware deterministic and stochastic parametrizations of eddy-mean flow interaction*, in

Ocean Modelling (2017); <http://dx.doi.org/10.1016/j.ocemod.2017.01.004>.

- [29] **P.G.L. Porta Mana**, C. Bachmann, S. Buttler, A. Morrison: *Bayesian models for inference of Alzheimer's disease from fMRI data and graph-theoretic measures*, in preparation; draft available upon request (2017).
- [28] C. Bachmann, H. Jacobs, **P.G.L. Porta Mana**, K. Dillen, S. Buttler, A. Morrison: *Graph properties of the functionally connected brain under the influence of Alzheimer's disease*, in preparation. Summary presented as a poster at the Twelfth Göttingen Meeting of the German Neuroscience Society (NWG) (2017).
- [27] **P.G.L. Porta Mana**, I. Bengtsson: *The beauty of Grassmann spaces*, in preparation; draft available upon request (2017).
- [26] V. Rostami, **P.G.L. Porta Mana**, M. Helias: *Pairwise maximum-entropy models and their Glauber dynamics: bimodality, bistability, non-ergodicity problems, and their elimination via inhibition*, [arXiv:1605.04740](https://arxiv.org/abs/1605.04740), under review in PLoS Comp. Biol. (2016).
- [25] J. Jordan, **P.G.L. Porta Mana**: *Assumptions behind Poisson models in neuroscience: exchangeability and statistical models by sufficiency*, in preparation (2016).
- [24] **P.G.L. Porta Mana**: *Eppur ruota: disappearance of rotational momentum upon coarsening to geophysical scales*, in preparation; draft available upon request (2016).
- [23] **P.G.L. Porta Mana**: *Mass, inertia, metric in Newtonian relativity and general relativity*, in preparation; draft available upon request (2016).
- [22] **P.G.L. Porta Mana**, E. Torre, V. Rostami: *Inferences from a network to a subnetwork and vice versa under an assumption of symmetry*, <http://biorxiv.org/content/early/2015/12/11/034199> (2015).
- [21] **P.G.L. Porta Mana**, L. Zanna: *Toward a stochastic parametrization of ocean mesoscale eddies*, in Ocean Modelling (2014); <https://portamana.org/linko.php?w=portamanaea14.pdf>.

- [20] **P.G.L. Porta Mana**, Peter G. Lewis: *On two recent conjectures in convex geometry*, [arXiv:1105.4641](https://arxiv.org/abs/1105.4641) (2011).
- [19] **P.G.L. Porta Mana**: *Conjectures and questions in convex geometry: of interest for quantum theory and other physical statistical theories*, [arXiv:1105.3238](https://arxiv.org/abs/1105.3238) (2011).
- [18] **P.G.L. Porta Mana**: *Notes on affine and convex spaces*, [arXiv:1104.0032](https://arxiv.org/abs/1104.0032) (2011).
- [17] **P.G.L. Porta Mana**: *In favour of the time variable in classical thermodynamics*, [arXiv:1012.3091](https://arxiv.org/abs/1012.3091) (2010).
- [16] **P.G.L. Porta Mana**: *On the relation between plausibility logic and the maximum-entropy principle: a numerical study*, [arXiv:0911.2197](https://arxiv.org/abs/0911.2197) (2009).
- [15] G. Brodin, M. Marklund, J. Zamanian, Å. Ericsson, **P.G.L. Porta Mana**: *Effects of the g-factor in semi-classical kinetic plasma theory*, [arXiv:0809.2382](https://arxiv.org/abs/0809.2382) (also published in Physical Review Letters) (2008).
- [14] **P.G.L. Porta Mana**: *Studies in plausibility theory, with applications to physics*, Ph.D. thesis, <https://portamana.org/linko.php?w=mana070106-thesis.pdf> (2007).
- [13] **P.G.L. Porta Mana**, A. Månsson, G. Björk: *The Laplace-Jaynes approach to induction*, [arXiv:physics/0703126](https://arxiv.org/abs/physics/0703126), [PhilSci:00003338](https://philsci-archive.pitt.edu/00003338/) (2007).
- [12] A. Månsson, **P.G.L. Porta Mana**, G. Björk: *Numerical Bayesian state assignment for a quantum three-level system. II. Average-value data with a constant, a Gaussian-like, and a Slater prior*, [arXiv:quant-ph/0701087](https://arxiv.org/abs/quant-ph/0701087) (2007).
- [11] A. Månsson, **P.G.L. Porta Mana**, G. Björk: *Numerical Bayesian state assignment for a three-level quantum system. I. Absolute-frequency data, constant and Gaussian-like priors*, [arXiv:quant-ph/0612105](https://arxiv.org/abs/quant-ph/0612105) (2006).
- [10] **P.G.L. Porta Mana**, A. Månsson, G. Björk: *'Plausibilities of plausibilities': an approach through circumstances*, [arXiv:quant-ph/0607111](https://arxiv.org/abs/quant-ph/0607111) (2006).

- [9] **P.G.L. Porta Mana**, A. Månsson, G. Björk: *On distinguishability, orthogonality, and violations of the second law: contradictory assumptions, contrasting pieces of knowledge*, [arXiv:quant-ph/0505229](https://arxiv.org/abs/quant-ph/0505229) (2005).
- [8] **P.G.L. Porta Mana**: *Distinguishability of non-orthogonal density matrices does not imply violations of the second law*, [arXiv:quant-ph/0408193](https://arxiv.org/abs/quant-ph/0408193) (2004).
- [7] G. Björk, **P.G.L. Porta Mana**: *Schrödinger-cat states: size classification based on evolution or dissipation*, in 'Proceedings SPIE: Fluctuations and Noise in Photonics and Quantum Optics II', vol. 5468, pp. 335-343, <http://dx.doi.org/10.1117/12.547048> (2004).
- [6] **P.G.L. Porta Mana**: *Probability tables*, [arXiv:quant-ph/0403084](https://arxiv.org/abs/quant-ph/0403084), also published in A. Yu. Khrennikov, ed.: 'Quantum Theory: Reconsideration of Foundations – 2' (Växjö University Press, 2004) (2004).
- [5] G. Björk, **P.G.L. Porta Mana**: *A size criterion for macroscopic superposition states*, [arXiv:quant-ph/0310193](https://arxiv.org/abs/quant-ph/0310193) (also published in Journal of optics B) (2003).
- [4] **P.G.L. Porta Mana**: *Why can states and measurement outcomes be represented as vectors?*, [arXiv:quant-ph/0305117](https://arxiv.org/abs/quant-ph/0305117) (2003).
- [3] **P.G.L. Porta Mana**: *Consistency of the Shannon entropy in quantum experiments*, [arXiv:quant-ph/0302049](https://arxiv.org/abs/quant-ph/0302049) (also published in Physical Review A and in Virtual Journal of Quantum Information) (2003).
- [2] M. Cadoni, **P.G.L. Porta Mana**: *Hamiltonians for a general dilaton gravity theory on a spacetime with a non-orthogonal, timelike or spacelike outer boundary*, [arXiv:gr-qc/0011010](https://arxiv.org/abs/gr-qc/0011010) (also published in Classical and Quantum Gravity) (2000).
- [1] **P.G.L. Porta Mana**: *Asymptotic symmetries of anti-de Sitter space in two and three dimensions*, Cagliari University; <https://portamana.org/linko.php?w=thesis.pdf> (2000).

Seminars and posters

- [33] with C. Bachmann, H. Jacobs, S. Buttler, K. Dillen, G. R. Fink, J. Kukolja, A. Morrison: *Graph properties of the functionally connected brain under the influence of Alzheimer's disease*, poster at the 12th Meeting of the German Neuroscience Society (NWG), Göttingen, Germany (2017).
- [32] *Einstein 1905, Euler 1753: the importance of semantics in science*, Forschungszentrum Jülich, Germany (2017).
- [31] with V. Rostami, M. Helias: *Bimodality and inhibition in pairwise maximum-entropy models for neuroscience*, poster at the 9th Bernstein Sparks Workshop, Göttingen, Germany (2016).
- [30] *The relation between theories on different scales: insights from geophysical fluid dynamics*, invited talk at Cagliari University, Italy (2016).
- [29] *In search of a coarser theory of the brain not suggested by finer theories: lessons from continuum thermomechanics*, Forschungszentrum Jülich, Germany (2015).
- [28] *Inference of variable-rate Poisson model from spike-train data: hidden assumptions and approach via exchangeability*, Forschungszentrum Jülich, Germany (2015).
- [27] *Probability relations between neuronal networks and subnetworks*, Forschungszentrum Jülich, Germany (2015).
- [26] *Introduction to probability logic (Bayesian theory) and its use in neuroscience*, Forschungszentrum Jülich, Germany (2015).
- [25] *Geophysical fluid dynamics and coarse-scale brain activity: similarity of problems! similarity of solutions?*, invited talk at the Forschungszentrum Jülich, Germany (2014).
- [24] *And yet it rotates! (The disappearance of rotational momentum on large scales: modelling large-scale water as a fluid with intrinsic spin)*, University of Oxford, UK (2014).
- [23] *Stochastic parametrization of mesoscale eddies: is water at large scales a liquid polymer?*, University of Oxford, UK (2013).

- [22] with L. Zanna: *Developing a stochastic parameterization of mesoscale eddies*, poster at the European Geosciences Union General Assembly, Austria (2013) and the IUGG Conference on Mathematical geophysics, UK (2012).
- [21] *A critique of the maximum-entropy principle by one of its supporters*, invited talk at the 31st International Workshop on Bayesian Inference and Maximum Entropy Methods in Science and Engineering 'MaxEnt 2011', Waterloo, Canada (2011).
- [20] *Vectors and affine forms, straight and twisted: with applications to electromagnetism and general relativity*, Perimeter Institute for Theoretical Physics, Canada (2011).
- [19] *Parallels between truth logic and probability theory (a pseudo-historical, game-theoretic presentation)*, Perimeter Institute for Theoretical Physics, Canada (2010).
- [18] *Metaphysical deductions and assumptions in quantum physics (or: there can't be only particles behind the wave function)*, invited talk, Perimeter Institute for Theoretical Physics, Canada (2008).
- [17] *A historical review of the 'convex approach' to quantum theory, and an overview of the 'probability table' formalism*, invited talk at the workshop 'Operational probabilistic theories as foils to quantum theory', Department of Applied Mathematics and Theoretical Physics, Cambridge University (2007).
- [16] *Plausibility theory as inductive logic*, Stockholm University (2006).
- [15] *A review on non-completely-positive maps and evolution of non-isolated quantum systems*, Royal Inst. of Technology, Stockholm (2006).
- [14] *Gravitomagnetism, and inertia as a real force. (With an appendix on the effects of weightlessness on the human body)*, Royal Inst. of Technology, Stockholm (2005).
- [13] *Probability theory as an extension of formal logic*, Royal Inst. of Technology, Stockholm (2005).

- [12] with G. Björk: *Uncertainty, information and entropy*, invited talk at the 'Ninth International Conference on Squeezed States and Uncertainty Relations', Besançon, France (2005).
- [11] *Non-orthogonality of statistical matrices and violations of the second law of thermodynamics*, Royal Inst. of Technology, Stockholm (2004).
- [10] *Probability tables: the convex approach to quantum theory*, invited talk at the conference 'Quantum Theory: Reconsideration of Foundations – 2', Växjö University (2004).
- [9] *Notes on entropy assignments, statistical mechanics, and convex sets, for classical and quantum mechanics*, Stockholm University (2004).
- [8] *A panoramic picture of modern rational thermodynamics and thermomechanics*, Royal Inst. of Technology, Stockholm (2004).
- [7] *In between classical and quantum systems: Visualising the convex properties of sets of states and measurements*, Stockholm University and Royal Inst. of Technology, Stockholm (2003).
- [6] *On experimental data tables, sets of states and measurement outcomes, distinguishability, and the boundary between classical and quantum systems*, Royal Inst. of Technology, Stockholm (2003).
- [5] *Maximum-entropy method in statistical mechanics and negative temperatures*, Royal Inst. of Technology, Stockholm (2003).
- [4] *Conceptual adequacy of the Shannon entropy in quantum measurements*, Royal Inst. of Technology, Stockholm, and Cagliari University (2002).
- [3] *Reproduction of quantum phenomena by a deck of cards*, Royal Inst. of Technology, Stockholm, and Cagliari University (2002).
- [2] *Tomography of quantum states*, Royal Inst. of Technology, Stockholm, and Cagliari University (2001).
- [1] *Runge-Kutta methods for nonlinear differential equations and Hopf algebras*, Royal Inst. of Technology, Stockholm (2001).