UNIVERSITÀ DEGLI STUDI DI MILANO

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Codice concorso **3735**

Marco Falconi — Curriculum Vitæ

CONTACT INFORMATIONS

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Germany

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BIRTH

October 5th 1983 in Faenza, Italy.

NATIONALITY

Italian

EMPLOYMENT

- **Fachbereich Mathematik – Universität Tübingen**
  Research Assistant. **January 2018 - Ongoing**
- **Institut für Mathematik – Universität Zürich**
  Postdoc. **April 2017 - December 2017**
- **Dipartimento di Matematica e Fisica — Università di Roma Tre**
  Cond-math postdoc. **April 2016 - March 2017**
- **Institut für Analysis, Dynamik und Modellierung — Universität Stuttgart**
  Research assistant. **October 2015 - March 2016**
- **Centre Henri Lebesgue — Université de Rennes I**
  Postdoc. **January 2014 - September 2015**
- **Dipartimento di Matematica — Università di Bologna**
  Postdoc. **June 2012 - December 2013**
- **Dipartimento di Matematica — Università di Bologna**
  Ph.D. **January 2009 - May 2012**

GRANTS

- **Progetto Giovani GNFM** **€ 3,000**
  Young researchers program of the Italian Group of Mathematical Physics. **2017**

EDUCATION

Alma Mater Studiorum — Università di Bologna, Bologna (Italy)

Dottorato (Ph.D.) in Mathematics. **January 2009 - May 2012**

- Defense: June 8, 2012
- Dissertation: `Classical limit of the Nelson model`
- Advisor: Prof. Giorgio Velo
- Committee: Prof. Piero D'Ancona, Prof. Alberto Parmeggiani, Prof. Marco Peloso

Laurea Specialistica (M.Sc.), Theoretical Physics **2005 - 2007**

- Grade: 110/110 `cum Laude`
- Dissertation: `On the regularization of phase-space path integral in curved manifolds`
- Advisor: Prof. Fiorenzo Bastianelli

Laurea Triennale (B.Sc.), Physics **2002 - 2005**

- Grade: 110/110 `cum Laude`
- Dissertation: `Sulla nozione di distinguibilità e degenerazione (in italian)`
- Advisor: Prof. Loris Ferrari

FIELDS OF INTEREST *Infinite Dimensional Semiclassical Analysis, Mathematical Physics, Functional Analysis*

- Wigner measures and Egorov-type Theorems in infinite dimensions
- Rigorous derivation of effective theories in condensed matter
- Scattering theory for linear and nonlinear evolution systems
- Projective pseudodifferential calculus
- Non-perturbative renormalization for Quantum Field Theories

PUBLICATIONS

Magnetic Schrödinger Operators as the Quasi-Classical Limit of Pauli-Fierz-type Models (with M. Correggi, M. Olivieri) **Preprint, submitted (2017)**
arXiv:1711.07413

Description: We study the quasi-classical limit of the Pauli-Fierz model: the system is composed of finitely many non-relativistic charged particles interacting with a bosonic radiation field. We trace out the degrees of freedom of the field, and consider the classical limit of the latter. We prove that the partial trace of the full Hamiltonian converges, in resolvent sense, to an effective Schrödinger operator with magnetic field and a corrective electric potential that depends on the field configuration. Furthermore, we prove the convergence of the ground state energy of the microscopic system to the infimum over all possible classical field configurations of the ground state energy of the effective Schrödinger operator.

Concentration of cylindrical Wigner measures **Commun. Contemp. Math. 1750055 (2017)**
arXiv:1704.07676
doi: 10.1142/S0219199717500559

Description: In this brief note we aim to characterize the cylindrical Wigner measures associated to regular quantum states in the Weyl C*-algebra of canonical commutation relations. In particular, we provide conditions, at the quantum level, sufficient to prove the concentration of all the corresponding cylindrical Wigner measures as Radon measures on suitable topological vector spaces. The analysis is motivated by variational and dynamical problems in the semiclassical study of bosonic quantum field theories.

Effective Potentials Generated by Field Interaction in the Quasi-Classical Limit (with M. Correggi)
Ann. Henri Poincaré (2017)
arXiv:1701.01317
doi:10.1007/s00023-017-0612-z

Description: In this work we study the partial dynamics of particles linearly coupled with a quantized radiation field, in the *quasi-classical limit*. We prove that, as the field alone becomes macroscopic and the corresponding degrees of freedom are traced out, the effective Hamiltonian of the particles converges in resolvent sense to a self-adjoint Schrödinger operator that contains an additional external potential induced by the field configuration. The explicit form of such potential can be described exactly using techniques from semiclassical analysis. For specific (coherent) field configurations, it is possible to obtain trapping potentials. Finally, we prove convergence of the ground state energy of the full system to a suitable effective variational problem involving the classical state of the field: the original ground state energy converges to the infimum of the ground state energy of the quasi-classical Hamiltonian of the particles, over all (classical) field configurations with finite energy.

Cylindrical Wigner measures **Preprint, submitted (2016)**
arXiv:1605.04778

Description: In this work we characterize the semiclassical, or Wigner, measures associated to regular states that act on the tensor product of a unitary C*-representation of the Heisenberg group of *arbitrary* dimension, and a C*-algebra $\mathfrak{A}$. The Wigner measures are identified with the cluster points of (generalized) sequences of regular states, indexed by the semiclassical parameter $h \to 0$. All the measures are vector-valued, with values in the positive continuous functionals of $\mathfrak{A}$. If the Heisenberg group is infinite dimensional, the Wigner measures are cylindrical measures, *i.e.* finitely additive measures on the algebra of (dual) cylinders. Our analysis shows that, for infinite-dimensional Heisenberg groups, the semiclassical structure that emerges in the limit is richer than in the finite-dimensional case.

Scattering theory for Lindblad master equations (with J. Faupin, J. Fröhlich, and B. Schubnel)
Comm. Math. Phys. 350(3), 1185–1218 (2017)
arXiv:1602.04045
doi:10.1007/s00220-016-2737-1

Description: In this work we study the scattering theory for evolution semigroups of Lindblad type, on the ideal $I_1(\mathscr{H})$ of trace class operators on a Hilbert space $\mathscr{H}$. The semigroups of Lindblad type are C_0-semigroups that map the convex cone $I_1(\mathscr{H})_+ \subset I_1(\mathscr{H})$ of positive elements into itself, preserving the trace. They are used to describe open quantum systems in the Markovian regime. We discuss the regularity assumptions on the non unitary part of the semigroup generator, sufficient to prove existence of the wave operators and the asymptotic completeness of the theory. We also introduce the modified wave operators useful to describe physical systems in which particles can be captured by the target during the scattering process. An important ingredient in our analysis is the scattering theory for dissipative operators in Hilbert spaces.

Bohr's correspondence principle for the renormalized Nelson model (with Z. Ammari)
SIAM J. Math. Anal. 49(6), 5031-5095 (2017)
arXiv:1602.03212
doi:10.1137/17M1117598

Description: Egorov-type theorems characterize the evolution of semiclassical Wigner measures corresponding to quantum states that are evolved by means of a unitary dynamics. To the quantum linear evolution there corresponds, in the semiclassical limit, the pushforward of the Wigner measure by means of the (nonlinear) classical Hamiltonian flow associated to the system. For quantum field theories, proving such type of results provides some serious technical challenges, due to the necessity of performing, at the quantum level, renormalization procedures in order to define the dynamics non-perturbatively. In addition, these procedures may in principle modify the classical dynamics that is obtained in the limit. In this work we prove an Egorov-type theorem for an important model of nonrelativistic quantum field theory widely used in condensed matter physics: the Nelson model. We make crucial use of a family of symplectomorphisms in the classical phase space, that allow to put the classical system of Schrödinger-Klein-Gordon equations in a "normal form" suitable for quantization, providing at the same time a bridge between the undressed and dressed dynamics of the system.

On the rate of convergence for the mean field approximation of Bosonic many-body quantum dynamics (with Z. Ammari and B. Pawilowski) **Commun. Math. Sci. 14(5), 1417-1442 (2016)**
arXiv:1411.6284
doi:10.4310/CMS.2016.v14.n5.a9

Description: In recent years, the derivation of effective mean field dynamical theories from underlying microscopic theories has been a subject of great interest for both the communities of mathematical physics and analysis. In this work, we study the time propagation of the rate of convergence for the reduced density matrices corresponding to generic states in bosonic non-relativistic systems. We prove that the initial-time rate of convergence is preserved by the evolution of the system if it is at most of order $1/n$ (where n is the number of particles in the system). For initial rates of order $o(1/n)$, the time evolution reduces the rate to order $1/n$. This result holds, provided the interaction potential between particles is sufficiently regular, for a very wide class of initial microscopic configurations, and shows that the initial coherent structure *is not a priori necessary* to obtain an optimal rate of convergence. We also verify through numerical analysis that $O(1/n)$ is indeed the optimal rate of convergence, both for initial microscopic states with coherent structure ("mean-field states") and for a class of more entangled states ("twin Fock states").

Self-Adjointness criterion for operators in Fock spaces **Math. Phys. Anal. Geom. 18(1) (2015)**
arXiv:1405.6570
doi:10.1007/s11040-015-9173-x

Description: In this work we discuss a self-adjointness criterion for densely defined symmetric operators in Fock spaces. The criterion applies to polynomials in the creation and annihilation operators, whose "non-diagonal" part (the part with a different number of creation and annihilation operators) is at most of order two. The advantage of this method is that it does not require neither positivity of the operator, nor that one part of it is a small perturbation of the other. Therefore it can be applied also in situations where the aforementioned conditions are not satisfied. Some applications are discussed; of particular interest is the one to Pauli-Fierz type operators.

Wigner measures approach to the classical limit of the Nelson model: Convergence of dynamics and ground state energy (with Z. Ammari) **J. Stat. Phys. 157(2), 330-364 (2014)**
arXiv:1403.2327
doi:10.1007/s10955-014-1079-7

Description: In this work we derive a Schrödinger-Klein-Gordon dynamical system as the classical limit of a microscopic model of non-relativistic bosonic particles in regularized interaction with a scalar bosonic field. Microscopic states evolved in time converge to the push-forward through the S-KG flow of probability measures concentrated in the energy space (Wigner measures). In addition, the ground state energy of the microscopic model converges, when the density of non-relativistic particles is fixed, to the infimum of the S-KG energy functional.

Global Solution of the Electromagnetic Field-Particle System of Equations
J. Math. Phys. 55, 101502 (2014)
arXiv:1311.1675
doi:10.1063/1.4897211

Description: The Newton-Maxwell system describes the nonlinear coupled dynamics of charges (with extended charge distribution) in interaction with the electromagnetic field. We study the global well-posedness of the corresponding Cauchy problem, both in homogeneous Sobolev spaces with negative index, and in non-homogeneous Sobolev spaces with positive index (for the electromagnetic field). The static part of Maxwell's equations act as a constraint on the initial data, and it is satisfied at any time if satisfied at the initial time. The local well-posedness is extended to any time using energy-type estimates, assuming suitable regularity of the particles' charge distribution.

Mean field limit of bosonic systems in partially factorized states and their linear combinations
arXiv e-Print (2013)
arXiv:1305.5699

Description: We study the mean field limit of marginal densities in a system of non-relativistic bosons with pair interaction, corresponding to linear combinations of either coherent or (partially) factorized states. Such marginals converge, in the Hilbert-Schmidt norm, to linear combinations of projectors onto solutions of the Hartree equation corresponding to each initial condition.

Classical limit of the Nelson model with cut off **J. Math. Phys. 54 012303 (2013)**
arXiv:1205.4367
doi:10.1063/1.4775716

Description: In this work we study the classical limit of the Nelson model with cut off, in the regime where both numbers of non-relativistic particles and field excitations are infinitely large. We prove convergence of the expectation value of canonical quantum observables to the solution of the corresponding classical equations, and we characterize the two-parameter evolution group of quantum fluctuations. The expectation values are calculated with respect to coherent and factorized states both for the particles and the scalar field. The choice of factorized states for the scalar field yields a somewhat unexpected quantum residue in the classical limit. It takes the form of an average over all classical solutions corresponding to initial data that differ by a phase.

Mode Regularization for $N = 1,2$ SUSY Sigma Model (with R. Bonezzi)
J. High Energy Phys. 10 (2008) 019
arXiv:0807.2276
doi:10.1088/1126-6708/2008/10/019

Description: Worldline $N = 1$ and $N = 2$ supersymmetric sigma models in curved background are useful to describe spin one-half and spin one particles coupled to external gravity, respectively. It is well known that worldline path integrals in curved space require regularization: we present here the mode-regularization for these models, finding in particular the corresponding counterterms, both in the case of flat and curved indices for worldline fermions. For $N = 1$, using curved indices we find a contribution to the counterterm from the fermions that cancels the contribution of the bosons, leading to a vanishing total counterterm and thus preserving the covariance and supersymmetry of the classical action. Conversely in the case of $N = 2$ supersymmetries we obtain a non-covariant counterterm with both curved and flat indices. This work completes the analysis of the known regularization schemes for $N = 1,2$ nonlinear sigma models in one dimension.

Proceedings

Semiclassical Analysis in Infinite Dimensions: Wigner Measures
Bruno Pini Mathematical Analysis Seminar (2016)
doi:10.6092/issn.2240-2829/6686

Abstract: We review some aspects of semiclassical analysis for systems whose phase space is of arbitrary (possibly infinite) dimension. An emphasis will be put on a general derivation of the so-called Wigner classical measures as the limit of states in a non-commutative algebra of quantum observables.

Latest Oral Communications

BCAM, Bilbao (Spain)
- *Magnetic Laplacians as the Quasi-Classical Limit of Microscopic Models of Pauli-Fierz Type* **November 7th, 2017**
  BCAM Scientific Seminar

Università La Sapienza, Roma (Italy)
- *Semiclassical properties of physical states* **October 25th, 2017**
  Seminario di Fisica Matematica

SwissMAP, Grindelwald (Switzerland)
- *Cylindrical Wigner Measures in Bosonic systems* **September 13th, 2017**
  4th SwissMAP General Meeting

LAGA, Université Paris 13, Paris (France)
- *Cylindrical Wigner Measures in Bosonic systems* **July 5th, 2017**
  Champ moyen quantique et problèmes liés

GNFM, Montecatini (Italy)
- *Potenziali effettivi nell'approssimazione quasi-classica.* **May 4th, 2017**
  Assemblea Scientifica GNFM 2017

Universität Stuttgart, Stuttgart (Germany)
- *External Potentials Generated by the Interaction with a Semiclassical Field.* **April 5th, 2017**
  Spectral Days 2017

IRMAR, Rennes (France)
- *Potentiels effectifs dans l'approximation quasi-classique.* **March 16th, 2017**
  Journée Thématique EDP: Mathematical Analysis of Interacting Quantum Systems

Università La Sapienza, Roma (Italy)
- *External Potentials Generated by the Interaction with a Semiclassical Field* **November 23rd, 2016**
  Seminario di Fisica Matematica

Université de Reims, Reims (France)
- *Wigner semiclassical measures in bosonic quantum field theories* — **November 17th, 2016**
  `Journées Mesures en dimension infinie et applications`

IMI Kyushu University, Fukuoka (Japan)
- *Bohr's correspondence principle in the Nelson model* — **June 6th, 2016**
  `Mathematical quantum field theory and related topics`

Dipartimento di Matematica e Fisica Roma Tre, Roma (Italy)
- *Scattering theory for Lindblad-type open systems* — **April 26th, 2016**
  `Seminari di Fisica matematica`

Casa della Gioventù Universitaria, Bressanone (Italy)
- *Scattering theory in open quantum systems: Lindblad-type evolutions* — **February 11th, 2016**
  `Mathematical Challenges in Quantum Mechanics`

Mathematisches Institut LMU, München (Germany)
- *Bohr's Correspondence Principle for the Nelson Model* — **February 3rd, 2016**
  `Oberseminar Mathematische Physik`

Dipartimento di Matematica, Bologna (Italy)
- *Semiclassical Analysis in Infinite Dimensions: Wigner measures* — **November 27th, 2015**
  `Seminario di analisi matematica Bruno Pini`

Dipartimento di Matematica e Fisica, Roma (Italy)
- *Bohr's correspondence principle and renormalization: linking the Nelson model and the Schrödinger-Klein-Gordon system* — **November 5th, 2015**
  `Seminario di fisica matematica, Università di Roma Tre`

ANR SQFT, Île de Porquerolles (France)
- *Bohr's correspondence principle and classical dressing renormalization in the Nelson model* — **June 11th, 2015**
  `ANR SQFT 3rd Meeting`

Mathematik fakultät, Stuttgart (Germany)
- *Essential self-adjointness of operators in Fock space: a simple proof for "quadratic interactions"* — **June 2nd, 2015**
  `Graduiertenkolleg 1838 Guest Lecture`

IRMAR, Rennes (France)
- *Auto-adjonction des opérateurs quadratiques dans les espaces de Fock* — **March 23rd, 2015**
  `Séminaire Landau`

Institut Élie Cartan de Lorraine, Metz (France)
- *Rate of convergence towards Hartree dynamics for generic quantum states* — **March 6th, 2015**
  `Séminaire EDP, Analyse et Applications`

ANR LODIQUAS, Saint-Malo (France)
- *Bounds on the convergence towards mean field dynamics for systems of many bosons* — **December 9th, 2014**
  `Rencontre LODIQUAS 2014`

Università di Milano-Bicocca, Milan (Italy)
- *Global solution of the Newton-Maxwell equations by energy-type inequalities* — **November 28th, 2014**
  `Seminari del Dipartimento di Matematica e Applicazioni`

IRMAR, Rennes (France)
- *Limite classique et équations de Schrödinger-Klein-Gordon* — **October 23rd, 2014**
  `Séminaire d'équations aux dérivées partielles`

Wolfgang Pauli Institute, Wien (Austria)
- *Schrödinger-Klein-Gordon system as the classical limit of a Quantum Field Theory dynamics* **October 10th, 2014**
  `Workshop on Dispersive equations with nonlocal dispersion - III`

GDR DynQua, Roscoff (France)
- *Classical and mean field limit of field-particle systems* **February 5th, 2014**
  `2014 Annual Meeting`

IRMAR, Rennes (France)
- *Global Solution of the Electromagnetic Field-Particle System of Equations* **January 10th, 2014**
  `Groupe de travail EDP`

RESEARCH VISITS *Short Term*

- *BCAM, Bilbao (invited by Jean-Bernard Bru)* **November 6th-9th, 2017**
- *Università La Sapienza, Roma (invited by Michele Correggi)* **October 23rd-27th, 2017**
- *SISSA Trieste (invited by Alessandro Michelangeli)* **October 16th-20th, 2017**
- *IRMAR Rennes (invited by Zied Ammari)* **March 13th-17th, 2017**
- *Kyushu University (invited by Fumio Hiroshima)* **June 6th-17th, 2016**
- *Ludwig-Maximilians-Universität München (invited by Peter Pickl)* **February 2nd-4th, 2016**
- *Stuttgart Universität (invited by Marcel Griesemer)* **June 1st-3rd, 2015**
- *Institut Élie Cartan de Lorraine (invited by Jérémy Faupin)* **March 6th-14th, 2015**
- *Università di Milano-Bicocca (invited by Diego Noja)* **November 24th-28th, 2014**

TEACHING

Universität Zürich

Institut für Mathematik, Teaching Assistant **September-December 2017**
- Analysis I.

Università La Sapienza

Minicorso (Short course for Ph.D. students) **November 2016**
- *An introduction to semiclassical analysis in infinite dimensions, and its applications to mean and quantum field theories*

Universität Stuttgart

Fachbereich Mathematik, Teaching Assistant **October 2015-March 2016**
- Analysis I, Lehramtsstudiengang Mathematik.

IRMAR — Université de Rennes I

Cours doctoral (Ph.D. Course—given in french) **January-February 2015**
- *Relations de commutation canoniques: représentations en systèmes fini ou infini-dimensionnels*

Alma Mater Studiorum — Università di Bologna

Faculty of Architecture, Teaching Assistant/Member of the Examination Committee **2009-2013**
- Istituzioni di Matematica, CdL Architettura e Processo Edilizio (Elements of Mathematics)
- Istituzioni di Matematiche I e II, Cdl Architettura (Elements of Mathematics I and II)

Facoltà di Ingegneria, Teaching Assistant **2010**
- Analisi Matematica per l'Ingegneria Informatica, CdL in Ingegneria Informatica (Analysis for Engineers)

REVIEWING

Referee for peer-reviewed journals

Reviews in Mathematical Physics ; Mathematical Physics, Analysis and Geometry ; Journal of Mathematical Physics.

Reviewer for MathSciNet

QUALIFICATIONS

Maître de Conferences

Qualification aux fonctions de Maître de conférences **2014-2018**
`Ministère de l'Enseignement supérieur et de la Recherche`

AFFILIATIONS

FIR project Cond-Math **2016, 2017**

Graduiertenkolleg 1838: Spectral Theory and Dynamics of Quantum Systems (GRK1838) **2015, 2016**

Laboratoire d'Excellence Centre Henri Lebesgue **2014, 2015**

Société Mathématique de France (SMF) **2014, 2015, 2016, 2017**

European Mathematical Society (EMS) **2015, 2016, 2017**

American Mathematical Society (AMS) **2016, 2017**

*International Association of Mathematical Physics (*M∩Φ*)* **2014, 2015, 2016, 2017**

Gruppo Nazionale di Fisica Matematica (GNFM) **2017**

HONORS, AWARDS, FELLOWSHIPS

Postdoc Fellowships

Twenty-Four months, Universität Tübingen **January 2018 - December 2019**
`Research Assistant`

Six months, Universität Zürich **April - December 2017**
`Postdoc`

Twelve months, Università di Roma Tre **April 2016 - March 2017**
`Assegnista di Ricerca --- FIR project Cond-Math`

Six months, Universität Stuttgart **October 2015 - March 2016**
`Research Assistant`

Twelve months, Centre Henri Lebesgue **October 2014 - September 2015**
`programme "Investissements d'avenir" --- ANR-11-LABX-0020-01`

Nine months, Centre Henri Lebesgue **January - September 2014**
`programme "Investissements d'avenir" --- ANR-11-LABX-0020-01`

Ph.D. Grant

Three years, Università di Bologna **2009, 2010, 2011**

SELECTED CONFERENCES ATTENDED

Summer School on Current Topics in Mathematic Physics **July 17th-21st, 2017**
`Zürich, Switzerland`

Champ moyen quantique et problèmes liés **July 5th-7th, 2017**
`Villetaneuse, France`
Invited speaker

Spectral Days 2017 **April 3rd-7th, 2017**
`Stuttgart, Germany`
Contributed speaker

Journées mesures en dimension infinie et applications **November 17th-18th, 2016**
`Reims, France`
Invited speaker

Mathematical quantum field theory and related topics **June 6th-8th, 2016**
Fukuoka, Japan
Invited speaker

Mathematical Challenges in Quantum Mechanics **February 8th-13th, 2016**
Bressanone, Italy
Contributed speaker

Meeting SQFT 2015 **June 11th-13th, 2015**
Île de Porquerolles, France
Invited speaker

Rencontre LODIQUAS 2014 **December 8th-10th, 2014**
Saint-Malo, France
Invited speaker

Dispersive equations with nonlocal dispersion - III **October 6th-10th 2014**
Wolfgang Pauli Institute Vienna, Austria
Invited speaker

GDR DynQua annual meeting 2014 **February 5th-7th, 2014**
Roscoff, France
Invited speaker

Fourth School and Workshop on Mathematical Methods in Quantum Mechanics **February 14th-19th, 2011**
Bressanone, Italy

LANGUAGE SKILLS

Italian	Mother Tongue
English	Fluent
French	Very good knowledge
Spanish	Basic knowledge

Zürich, 27/12/2017.