Marco Falconi — Curriculum Vitæ

CONTACTS

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DATE DE NAISSANCE Le 5 octobre 1983 à Faenza, Italie.

NATIONALITÉ Italienne

EMPLOI

- **Institut für Mathematik – Universität Zürich**
  Postdoc. **depuis avril 2017**
- **Dipartimento di Matematica e Fisica — Università di Roma Tre**
  Cond-math postdoc. **avril 2016 - mars 2017**
- **Institut für Analysis, Dynamik und Modellierung — Universität Stuttgart**
  ATER. **octobre 2015 - mars 2016**
- **Centre Henri Lebesgue — Université de Rennes I**
  Postdoc. **janvier 2014 - septembre 2015**
- **Dipartimento di Matematica — Università di Bologna**
  Postdoc. **juin 2012 - décembre 2013**
- **Dipartimento di Matematica — Università di Bologna**
  Doctorant. **janvier 2009 - mai 2012**

FORMATION UNIVERSITAIRE

Alma Mater Studiorum - Università di Bologna, Bologna (Italie)

Dottorato (Doctorat) en Mathématiques. **janvier 2009 - mai 2012**

- Soutenance : 8 juin, 2012
- Thèse : `Classical limit of the Nelson model`
- Directeur : Prof. Giorgio Velo
- Jury : Prof. Piero D'Ancona, Prof. Alberto Parmeggiani, Prof. Marco Peloso

Laurea Specialistica (Master), Physique théorique **2005 - 2007**

- Summa cum Laude
- Thèse : `On the regularization of phase-space path integral in curved manifolds`
- Directeur : Prof. Fiorenzo Bastianelli

Laurea Triennale (Licence), Physique **2002 - 2005**

- Summa cum Laude
- Thèse : `Sulla nozione di distinguibilità e degenerazione (en italien)`
- Directeur : Prof. Loris Ferrari

DOMAINES D'INTÉRÊT

Analyse semiclassique en dimension infinie, Physique Mathématique, Analyse Fonctionnelle

- Mesures de Wigner et Théorèmes d'Egorov en dimension infinie
- Dérivation rigoureuse de théories efficaces en matière condensée
- Théorie de la diffusion pour les systèmes d'évolution linéaires et nonlinéaires
- Calcul pseudodifferentiel projectif
- Renormalisation non-perturbative en Théories Quantiques de Champ

PUBLICATIONS

Concentration of cylindrical Wigner measures

Commun. Contemp. Math. (2017) 1750055
arXiv:1704.07676
doi: 10.1142/S0219199717500559

Résumé : 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 (en collaboration avec M. Correggi) **Prépublication (2017)**
arXiv:1701.01317

Résumé : We study the *quasi-classical limit* of a quantum system composed of finitely many non-relativistic particles coupled to a quantized field in Nelson-type models. We prove that, as the field becomes classical 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 with an additional potential, depending on the state of the field. Moreover, we explicitly derive the expression of such a potential for a large class of field states and show that, for certain special sequences of states, the effective potential is trapping. In addition, 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.

Cylindrical Wigner measures

Prépublication (2016)
arXiv:1605.04778

Résumé : 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 (en collaboration avec 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

Résumé : We study scattering theory for a quantum-mechanical system consisting of a particle scattered off a dynamical target that occupies a compact region in position space. After taking a trace over the degrees of freedom of the target, the dynamics of the particle is generated by a Lindbladian acting on the space of trace-class operators. We study scattering theory for a general class of Lindbladians with bounded interaction terms. First, we consider models where a particle approaching the target is always re-emitted by the target. Then we study models where the particle may be captured by the target. An important ingredient of our analysis is a scattering theory for dissipative operators on Hilbert space.

Bohr's correspondence principle in quantum field theory and classical renormalization scheme : the Nelson model (en collaboration avec Z. Ammari) **Prépublication (2016)**
arXiv:1602.03212

Résumé : In the mid Sixties Edward Nelson proved the existence of a consistent quantum field theory that describes the Yukawa-like interaction of a non-relativistic nucleon field with a relativistic meson field. Since then it is thought, despite the renormalization procedure involved in the construction, that the quantum dynamics should be governed in the classical limit by a Schrödinger-Klein-Gordon system with Yukawa coupling. In the present paper we prove this fact in the form of a Bohr correspondence principle. Besides, our result enlighten the nature of the renormalization method employed in this model which we interpret as a strategy that allows to put the related classical Hamiltonian PDE in a normal form suitable for a canonical quantization.

On the rate of convergence for the mean field approximation of Bosonic many-body quantum dynamics (en collaboration avec Z. Ammari and B. Pawilowski) **Commun. Math. Sci. 14 (2016) No.5, 1417-1442**
arXiv:1411.6284
doi:10.4310/CMS.2016.v14.n5.a9

Résumé : We consider the time evolution of quantum states by many-body Schrödinger dynamics and study the rate of convergence of their reduced density matrices in the mean field limit. If the prepared state at initial time is of coherent or factorized type and the number of particles n is large enough then it is known that $1/n$ is the correct rate of convergence at any time. We show in the simple case of bounded pair potentials that the previous rate of convergence holds in more general situations with possibly correlated prepared states. In particular, it turns that the coherent structure at initial time is unessential and the important fact is rather the speed of convergence of all reduced density matrices of the prepared states. We illustrate our result with several numerical simulations and examples of multi-partite entangled quantum states borrowed from quantum information.

Self-Adjointness criterion for operators in Fock spaces **Math. Phys. Anal. Geom. 18, No.1 (2015)**
arXiv:1405.6570

doi:10.1007/s11040-015-9173-x

Résumé : In this paper we provide a criterion of essential self-adjointness for operators in the tensor product of a separable Hilbert space and a Fock space. The class of operators we consider may contain a self-adjoint part, a part that preserves the number of Fock space particles and a non-diagonal part that is at most quadratic with respect to the creation and annihilation operators. The hypotheses of the criterion are satisfied in several interesting applications.

Wigner measures approach to the classical limit of the Nelson model : Convergence of dynamics and ground state energy (en collaboration avec Z. Ammari) **J. Stat. Phys. 157, No.2 330-364 (2014)**

arXiv:1403.2327
doi:10.1007/s10955-014-1079-7

Résumé : We consider the classical limit of the Nelson model, a system of stable nucleons interacting with a meson field. We prove convergence of the quantum dynamics towards the evolution of the coupled Klein-Gordon-Schrödinger equation. Also, we show that the ground state energy level of N nucleons, when N is large and the meson field approaches its classical value, is given by the infimum of the classical energy functional at a fixed density of particles. Our study relies on a recently elaborated approach for mean field theory and uses Wigner measures.

Global Solution of the Electromagnetic Field-Particle System of Equations

J. Math. Phys. 55, 101502 (2014)

arXiv:1311.1675
doi:10.1063/1.4897211

Résumé : In this paper we discuss global existence of the solution of the Maxwell and Newton system of equations, describing the interaction of a rigid charge distribution with the electromagnetic field it generates. A unique solution is proved to exist (for regular charge distributions) on suitable homogeneous and non-homogeneous Sobolev spaces, for the electromagnetic field, and on coordinate and velocity space for the charge ; provided initial data belong to the subspace that satisfies the divergence part of Maxwell's equations.

Mean field limit of bosonic systems in partially factorized states and their linear combinations

arXiv e-Print (2013)

arXiv:1305.5699

Résumé : We study the mean field limit of one-particle reduced density matrices, for a bosonic system in an initial state with a fixed number of particles, only a fraction of which occupies the same state, and for linear combinations of such states. In the mean field limit, the time-evolved reduced density matrix is proved to converge : in trace norm, towards a rank one projection (on the state solution of Hartree equation) for a single state ; in Hilbert-Schmidt norm towards a mixed state, combination of projections on different solutions (corresponding to each initial datum), for states that are a linear superposition.

Classical limit of the Nelson model with cut off **J. Math. Phys. 54 012303 (2013)**

arXiv:1205.4367
doi:10.1063/1.4775716

Résumé : In this paper we analyze the classical limit of the Nelson model with cut off, when both non-relativistic and relativistic particles number goes to infinity. We prove convergence of quantum observables to the solutions of classical equations, and find the evolution of quantum fluctuations around the classical solution. Furthermore we analyze the convergence of transition amplitudes of normal ordered products of creation and annihilation operators between different types of initial states. In particular the limit of normal ordered products between states with a fixed number of both relativistic and non-relativistic particles yields an unexpected quantum residue : instead of the product of classical solutions we obtain an average of the product of solutions corresponding to varying initial conditions.

Mode Regularization for $N = 1, 2$ SUSY Sigma Model (en collaboration avec R. Bonezzi)

J. High Energy Phys. 10 (2008) 019

arXiv:0807.2276
doi:10.1088/1126-6708/2008/10/019

Résumé : 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.

ACTES DES SÉMINAIRES

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

Résumé : 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.

COMMUNICATIONS ORALES

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

Universität Stuttgart, Stuttgart (Allemagne)
- *External Potentials Generated by the Interaction with a Semiclassical Field.* — **5 avril, 2017**
  Spectral Days 2017

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

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

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

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

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

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

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

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

Dipartimento di Matematica e Fisica, Roma (Italie)
- *Bohr's correspondence principle and renormalization : linking the Nelson model and the Schrödinger-Klein-Gordon system* — **5 novembre, 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* — **11 juin, 2015**
  ANR SQFT 3rd Meeting

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

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

Institut Élie Cartan de Lorraine, Metz (France)
- *Vitesse de convergence vers la dynamique de Hartree pour des états généraux* **6 mars, 2015**
  `Séminaire EDP, Analyse et Applications`

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

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

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

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

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

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

Séjours scientifiques

Séjours de courte durée

- *IRMAR Rennes (invité par Zied Ammari)* **13-17 Mars, 2017**
- *Kyushu University (invité par Fumio Hiroshima)* **6-17 Juin, 2016**
- *Ludwig-Maximilians-Universität München (invité par Peter Pickl)* **2-4 février, 2016**
- *Stuttgart Universität (invité par Marcel Griesemer)* **1-3 juin, 2015**
- *Institut Élie Cartan de Lorraine (invité par Jérémy Faupin)* **6-14 mars, 2015**
- *Università di Milano-Bicocca (invité par Diego Noja)* **24-28 novembre, 2014**

Enseignement

Università La Sapienza

Minicorso (Cours doctoral) **Novembre 2016**
- *An introduction to semiclassical analysis in infinite dimensions, and its applications to mean and quantum field theories*

Universität Stuttgart

Fachbereich Mathematik, Assistant d'enseignement **octobre 2015-mars 2015**
- Analysis I, Lehramtsstudiengang Mathematik.

IRMAR - Université de Rennes I

Cours doctoral **janvier-février 2015**
- *Relations de commutation canoniques : représentations en systèmes fini ou infini-dimensionnels*

Alma Mater Studiorum - Università di Bologna

École d'architecture, Assistant d'enseignement **2009-2013**
- Istituzioni di Matematica, CdL Architettura e Processo Edilizio
- Istituzioni di Matematiche I e II, Cdl Architettura

École d'ingénieurs, Assistant d'enseignement **2010**
- Analisi Matematica per l'Ingegneria Informatica, CdL in Ingegneria Informatica

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**

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**

HONNEURS, PRIX ET BOURSES

Contrat de Postdoc

6 months, Universität Zürich — **avril - septembre 2017**
`ATER`

12 mois, Università di Roma Tre — **avril 2016 - mars 2017**
`Assegnista di Ricerca --- FIR project Cond-Math`

6 mois, Universität Stuttgart — **octobre 2015 - mars 2016**
`ATER`

12 mois, Centre Henri Lebesgue — **octobre 2014 - septembre 2015**
`programme "Investissements d'avenir" --- ANR-11-LABX-0020-01`

9 mois, Centre Henri Lebesgue — **janvier - septembre 2014**
`programme "Investissements d'avenir" --- ANR-11-LABX-0020-01`

Bourse de doctorat

3 ans, Università di Bologna — **2009, 2010, 2011**

CONFÉRENCES ET WORKSHOPS

Journées mesures en dimension infinie et applications — **17-18 Novembre, 2016**
`Reims, France`

Mathematical quantum field theory and related topics — **6-8 Juin, 2016**
`Fukuoka, Japon`

Meeting SQFT 2016 — **23-27 Mai, 2016**
`Île de Porquerolles, France`

Mathematical Challenges in Quantum Mechanics — **8-13 février, 2016**
`Bressanone, Italie`

Meeting SQFT 2015 — **11-13 Juin, 2015**
`Île de Porquerolles, France`

Mathematical physics (GDR DynQua—ANR Nosevol) — **2-6 février, 2015**
`Nantes, France`

Rencontre LODIQUAS 2014 — **8-10 décembre, 2014**
`Saint-Malo, France`

Dispersive equations with nonlocal dispersion - III — **6-10 octobre 2014**
`Wolfgang Pauli Institute Vienna, Autriche`

Workshop SQFT 2014 — **5-7 juin 2014**
`Île de Porquerolles, France`

Rencontre Nosevol #3 — **7-9 avril 2014**
`IRMAR Rennes, France`

GDR DynQua annual meeting 2014 **5-7 février, 2014**
Roscoff, France

Perspectives in Phase Space Analysis of PDE's **27-30 septembre, 2011**
Bertinoro, Italie

Asymptotic Properties of Solutions to Hyperbolic Equations **21-25 mars, 2011**
Imperial College London, Royaume-Uni

Fourth School and Workshop on Mathematical Methods in Quantum Mechanics **14-19 février, 2011**
Bressanone, Italie

Seminal Interactions between Mathematics and Physics **22-25 septembre, 2010**
Accademia Nazionale dei Lincei Roma, Italie

LANGUES

Italien	Langue maternelle
Anglais	Très bon niveau
Français	Bon niveau
Espagnol	Niveau scolaire

Dernière mise à jour : 10 juillet 2017.