Marco Falconi — Curriculum Vitæ

CONTACT INFORMATIONS

Institut für Analysis, Dynamik und Modellierung
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BIRTH

October 5^{th} 1983 in Faenza, Italy.

NATIONALITY

Italian

EMPLOYMENT

- **Institut für Dynamik, Analysis und Modellierung — Universität Stuttgart**
  Research assistant. **October 2015 - Present**
- **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**

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 *Mathematical Physics, Nonlinear Partial Differential Equations*

- Classical and mean field limit of quantum systems
- Scattering theory for quantum fields
- Rigorous aspects of Quantum ElectroDynamics
- Renormalization of Quantum Field Theories
- Dispersive PDEs
- Functional integration

PUBLICATIONS

Bohr's correspondence principle in quantum field theory and classical dressing renormalization: the Nelson model. (with Z. Ammari) **In preparation**

Abstract: In this paper we prove that Bohr's principle of correspondence between quantum and classical formulations of a physical theory holds for a renormalized system of quantum fields in interaction. In particular, it is shown that the renormalized Nelson dynamics converges, in the limit of large quantum numbers, towards the solution of a Schrödinger and Klein-Gordon system with Yukawa-type interaction. The dressing transformation is classically implemented by a symplectomorphism of the phase space. In virtue of this classical dressing, we can develop a new perspective on the renormalization procedure, that is founded exclusively on manipulations at the classical level.

On the rate of convergence for the mean field approximation of many-body quantum dynamics (with Z. Ammari and B. Pawilowski) **Submitted to Comm. Math. Sci. (2015)**
arXiv:1411.6284

Abstract: 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

Abstract: 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 (with Z. Ammari) **J. Stat. Phys. 157, No.2 330-364 (2014)**
arXiv:1403.2327
doi:10.1007/s10955-014-1079-7

Abstract: 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

Abstract: 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

Abstract: 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

Abstract: 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 (with R. Bonezzi)
J. High Energy Phys. 10 (2008) 019
arXiv:0807.2276
doi:10.1088/1126-6708/2008/10/019

Abstract: 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 world- line 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.

Latest Oral Communications

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 23th, 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

- *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 Stuttgart

Fachbereich Mathematik, Teaching Assistant **October 2015-March 2015**
- 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)

Qualifications

Maître de Conferences

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

Affiliations

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

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

European Mathematical Society (EMS) **2015**

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

Honors, Awards, Fellowships

Postdoc Fellowships

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	*Meeting SQFT 2015* Île de Porquerolles, France	**June 11th-13th, 2015**
	Mathematical physics (GDR DynQua—ANR Nosevol) Nantes, France	**February 2nd-6th, 2015**
	Rencontre LODIQUAS 2014 Saint-Malo, France	**December 8th-10th, 2014**
	Dispersive equations with nonlocal dispersion - III Wolfgang Pauli Institute Vienna, Austria	**October 6th-10th 2014**
	Workshop SQFT 2014 Île de Porquerolles, France	**June 5th-7th 2014**
	Rencontre Nosevol #3 IRMAR Rennes, France	**April 7th-9th 2014**
	GDR DynQua annual meeting 2014 Roscoff, France	**February 5th-7th, 2014**
	Perspectives in Phase Space Analysis of PDE's Bertinoro, Italy	**September 27th-30th, 2011**
	Asymptotic Properties of Solutions to Hyperbolic Equations Imperial College London, United Kingdom	**March 21st-25th, 2011**
	Fourth School and Workshop on Mathematical Methods in Quantum Mechanics Bressanone, Italy	**February 14th-19th, 2011**
	Seminal Interactions between Mathematics and Physics Accademia Nazionale dei Lincei Roma, Italy	**September 22nd-25th, 2010**
LANGUAGE SKILLS	*Italian*	Mother Tongue
	English	Fluent
	French	Very good knowledge
	Spanish	Basic knowledge

INFORMATION TECHNOLOGY SKILLS

Good knowledge of *MS Windows*, *Apple Mac OS X* and other *UNIX*/*LINUX OS*. Basic knowledge of *C*, *Objective-C*, *SAGE*, *MATLAB*/*Octave* and *Mathematica*/*Maxima* languages. Good knowledge of *MS Office*, *Libre Office*, *iWork*, *LaTeX* and *HTML*. Good knowledge of *GIMP*, *Adobe Photoshop* and *Adobe Illustrator*.