Training school for graduating students, PhD students and young researchers. Are spin-statistics connection and quantum theory exact? The endeavor for the theory beyond the standard quantum mechanics. FQT2016

Report of Contributions

https://agenda.infn.it/e/FQT2016

Contribution ID: **0** Type: **not specified**

Lecture 1: Spontaneous wave function collapse models: an introduction

Monday, 19 December 2016 11:30 (1 hour)

I will present the basic features of the GRW model of spontaneous wave function collapse: the collapse of the wave function, the amplification mechanism, which states are affected by it. Eventually, the picture which emerges is that of a unified description of microscopic (quantum) and macroscopic (classical) systems, in terms of a wave function evolving according to a modified Schrödinger equation. I will give present a short introduction to the different ontologies, which can be attached to a spontaneously collapsing wave function. I will explain how these models can be tested experimentally, and will give an overview of the state of the art from the experimental point of view.

Presenter: Dr BASSI, Angelo (University of Trieste and INFN)

Contribution ID: **17** Type: **not specified**

Lecture 2: Properties, statics and the identity of quantum particles

Monday, 19 December 2016 12:30 (1 hour)

In this talk I will present some of the considerations that philosophers make concerning the identity and individuality of material objects, and discuss the way in which the peculiar features of (non-relativistic) quantum entities can be brought to bear on these issues. In particular, I will look at the 'Received View' that quantum particles are non-individuals, and at possible alternatives. Special attention will be devoted to the various ways in which one may account for the properties and statistical behaviour of quantum systems.

Presenter: Dr MORGANTI, Matteo (University of Rome TRE)

Contribution ID: **18** Type: **not specified**

Lecture 3: The Galileo principle for general dynamical systems: Lorentz transformations from Quantum Theory and a little bit more (homogeneity, isotropy, and locality)

Monday, 19 December 2016 14:46 (59 minutes)

Free Quantum Field Theory (QFT) can be derived without quantization rules as a quantum ab initio theory of numerable systems, with general assumptions as homogeneity, isotropy, locality and linearity of the interactions. What follows is a theory of quantum walks on the Cayley graph of a group G. Virtually abelian G corresponds to QFT in Euclidean space, whereas relaxing linearity leads to interacting QFTs. The purely mathematical adimensional theory contains the standards for mass, space, and time through the nonlinearities intrinsic to the theory (maximum wave-vector, frequency, and mass, the latter from unitarity). The small wave-vector regime connects these standards to the speed of light and to the Planck constant, whereas at the maximum value for the particle mass the dispersion relation becomes flat, with interpretation as a mini-black hole, thus setting the scale at Planck's. The Galilean relativity principle can be semantically translated for a general dynamical system, and for the case of a quantum walk it corresponds to the invariance of the walk with the representation. The Lorentz transformations make a nonlinear group (the theory is a model for doubly special relativity), whereas the usual linear transformation are recovered in the small wavevector regime, corresponding to the whole physical domain experimented so far. The particle is still the Poincaré invariant. A new emerging feature is that for Planckian boosts/masses also the rest-mass get involved in the transformations, leading to a De Sitter covariance.

Presenter: Prof. D'ARIANO, Giacomo (PV)

Contribution ID: **19** Type: **not specified**

Lecture 4 From exotic atoms to impossible atoms – t.b.c.

Monday, 19 December 2016 16:15 (1 hour)

Presenter: Dr CURCEANU, Catalina Oana (LNF)

Contribution ID: **20** Type: **not specified**

Lecture 5: Neutrino as a messenger of breaking of the spin-statistics relation

Tuesday, 20 December 2016 09:01 (59 minutes)

A possibility that the spin-statistics theorem is broken in neutrino hysics is discussed. The impact of such violation on double beta decay, big bang nucleosynthesis, and the cosmological dark matter problems are considered. A possible transition of the statistics breaking from the neutrino sector to other particles is estimated.

Presenter: Prof. DOLGOV, Alexander (FE)

Contribution ID: **21** Type: **not specified**

Students talks : Heat beackflow in non-Markovian open quantum systems

Tuesday, 20 December 2016 10:00 (15 minutes)

"We characterize the time behavior of the energy exchange between an open quantum system and its environment in a non-Markovian dynamical regime using the full counting statistics formalism. In particular we focus on the occurrence of energy backflow from environment to system, to which we introduce a suitable condition and measure. We study in detail this quantifier in two paradigmatic open quantum systems, namely the spin-boson model and the quantum brownian motion, drawing a connection with recently introduced notions of non-Markovianity. Results show that, while Born-Markov semi-group limiting case and, more in general, Markovian regime prevent the occurrence of energy backflow, non-Markovianity allows for its observation and quantification".

Presenter: GUARNIERI, Giacomo (MI)

Contribution ID: **22** Type: **not specified**

Students talks : CP reduced dynamical maps, initial correlations and commutativity

Tuesday, 20 December 2016 10:15 (15 minutes)

It is well known that a closed and isolated quantum system evolves through unitary transformations. When a quantum system of interest is not closed and isolated, but interacts with other degrees of freedom (the environment), we refer to it as an open quantum systems: in general its evolution is non unitary because of the coupling with external degrees of freedom. The mathematical framework of the reduced dynamical maps will be outlined, while the difficulties arising in the definition and construction of these mappings will be pointed out. The aim of this talk is to show the main results of (https://arxiv.org/abs/1605.04159 [arxiv.org]).

Presenter: AMATO, Giulio

Contribution ID: **23** Type: **not specified**

Students talks : Analysis of decoherence in Marshall et al. experiment by means of a quantum-classical hybrid theory

Tuesday, 20 December 2016 10:30 (15 minutes)

We re-analyse the optomechanical interferometer experiment proposed by Marshall, Simon, Penrose and Bouwmeester with the help of a recently developed quantum-classical hybrid theory. This leads to an alternative evaluation of the mirror induced decoherence. Surprisingly, we nd that it behaves essentially in the same way for suitable initial conditions and experimentally relevant parameters, no matter whether the mirror is considered a classical or quantum mechanical object. We discuss the parameter ranges where this result holds and possible implications for a test of spontaneous collapse models, for which this experiment has been designed.

Presenter: Mr LAMPO, Aniello (ICFO)

Contribution ID: **24** Type: **not specified**

Students talks : Quantum to Classical transition in Bohmian mechanics

Tuesday, 20 December 2016 10:45 (15 minutes)

I want to present a general scheme for the classical limit within the framework of Bohmian mechanics (BM). The choice of BM follows from the following consideration: classical mechanics (CM) has a realistic and objective ontology, that is, particles that follow Newtonian trajectories in 3D space. In order to recover CM, it seems therefore preferable to start with a quantum theory that is presented in terms of trajectories of individual particles, i.e., with BM.
In a Bohmian framework, the problem of the classical limit reduces to the following main questions:
1. Why do we not perceive the existence of the wave function in the classical world?
2. Why do the Bohmian trajectories become Newtonian in the macroscopic regime?
My paper aims to present an answer to the first question. The answer is essentially due to the mechanism of effective factorization of the wave function, which generally emerge in the decoherence regime. Indeed, interaction with the environment produces effective wave functions (EWFs) for the Bohmian subsystems, and it is possible to show that systems described by EWFs loose the typical quantum non-locality and describe a "local"dynamical regime.
In the final part, I will sketch a possible new approach for deriving the Newtonian trajectories from the Bohmian ones in the classical limit. The approach is based on the use of the quantum potential and decoherence.

References:
- Bohm & Hiley (1987): An ontological basis for the quantum theory, Physical Report.
- Romano (2015): Bohmian classical limit in bounded regions, SILFS proceedings.
- Zurek, Habib, Paz (1993): Coherent states via decoherence, Physical Review Letters.

Presenter: Mr ROMANO, Davide (University of Lausanne)

Contribution ID: **25** Type: **not specified**

Lecture 6: A review of the conceptual problems in tests of the Pauli exclusion principle

Tuesday, 20 December 2016 11:30 (1 hour)

: The Pauli Exclusion Principle has a surprisingly rigid structure within the theoretical framework of modern physics. This rigidity leads to difficulties in formulating a comprehensive theory of possible violations, and also to many problems in setting up experiments and in the interpretation of their results. In this seminar, I shall review both kinds of difficulties, and I shall sketch possible solutions.

Presenter: MILOTTI, Edoardo (TS)

Contribution ID: **26** Type: **not specified**

Lecture 7: Experimental test of spin-statistics and the CPT symmetry

Tuesday, 20 December 2016 12:30 (1 hour)

The spin-statistics theorem is a pillar of quantum theory and together with CPT symmetry it is fundamental for the relativistic quantum field theory. Up-to now no violations of spin statistics and CPT were found. Nevertheless, experimental attempts were and are performed to proof or falsify these concepts with experiments at extremely high sensitivity. This lecture will discuss the spin statistics theorem (which is connected to the Pauli Exclusion Principle) and the CPT symmetry in connection to recent experiments

Presenter: Dr MARTON, Johann (Stefan Meyer Institute)

Contribution ID: **27** Type: **not specified**

Lecture 8: Quantum Theory Beyond !?

Tuesday, 20 December 2016 14:46 (59 minutes)

Quantum theory is a very successful theory since no experiments are in contradiction with its predictions. I will discuss some main principles of quantum theory and discuss how they can be questioned very deeply, both from the theoretical and experimental point of view

Presenter: Dr HIESMAYR, Beatrix (University of Vienna)

Contribution ID: **28** Type: **not specified**

Lecture 9 Exploring boundaries of quantum mechanics

Wednesday, 21 December 2016 09:01 (59 minutes)

: I will begin by recalling how I met the late Nikola Buric and how our friendship developed in a short time. Motivated by quite different interests in the transition between quantum and classical mechanics, at first, we both were studying possibilities for a theory of quantum-classical hybrid systems, which became the focus of our discussions. - This has recently led me to explore cellular automata (CA) which, quite surprisingly, show well known features of quantum mechanics (QM). Such as a linear updating rule resembling a discretized form of the Schroedinger equation together with its conservation laws. In particular, a whole class of natural Hamiltonian CA, which are based entirely on integer-valued variables and couplings and derived from an action principle, can be mapped reversibly to
continuum models with the help of sampling theory [Shannon's Theorem]. This results in "deformed" quantum mechanical models with a finite discreteness scale l, which for l-> 0 reproduce the familiar continuum limit. Such CA can form multipartite systems consistently with the tensor product structures of many-body QM, while maintaining linearity. Interestingly, discreteness necessitates a many-time formulation reminding of relativistic dynamics. We conclude that the
superposition principle is fully operative already on the level of such primordial discrete deterministic automata, including the essential quantum effects of interference and entanglement and might offer a primitive understanding of the Born rule. - Time permitting, I will relate these findings to the Cellular Automaton Interptetation of QM, recently proposed by G. 't Hooft.

Presenter: Prof. ELZE, Hans-Thomas (Univesita di Pisa)

Contribution ID: **29** Type: **not specified**

Lecture 10 Evaluation of the energy shift for the Pauli-forbidden X-ray transitions

Wednesday, 21 December 2016 10:00 (1 hour)

Abstract: We describe how the energy shift for the Pauli-forbidden X-ray transitions is calculated within the Dirac-Fock theory. We start from the general expression for the cross-section of usual, Pauli-allowed, X-ray transitions and then explain what changes should be considered in the Pauli-forbidden case. The specific cases of copper (the material of choice for VIP experiment), lead and gold are described.
We finish the presentation with a brief methodological and philosophical discussion about the role of the time in these calculations and the role of the time in the antisymmetrization of the electrons

Presenter: Dr DI MATTEO, Sergio (Institute de Physique de Rennes - IPR)

Contribution ID: **30** Type: **not specified**

Lecture 11 ”Distribution function of extremely rare events from Bayesian reasoning

Wednesday, 21 December 2016 11:30 (1 hour)

Presenter: Mr PISCICCHIA, Kristian (LNF)