



SCUOLA
NORMALE
SUPERIORE

RELAZIONE ATTIVITA' ANNUALE DEI PERFEZIONANDI/DOTTORANDI – TERZO/QUARTO ANNO
REPORT ON THE PHD ACTIVITY – THIRD/FORTH YEAR

NOME E COGNOME NAME AND SURNAME	DONATO FARINA
DISCIPLINA PHD COURSE	NANOSCIENCE

CORSI FREQUENTATI CON SOSTENIMENTO DI ESAME FINALE ATTENDED COURSES (WITH FINAL EXAM)	VOTAZIONE RIPORTATA MARK	NUMERO DI ORE HOURS

CORSI FREQUENTATI SENZA SOSTENIMENTO DI ESAME FINALE ATTENDED COURSES (ATTENDANCE ONLY)	NUMERO DI ORE HOURS
Ciclo di seminari - Fisica della materia condensata	2
Quantitative Finance	10



ALTRE ATTIVITÀ FORMATIVE (SEMINARI, WORKSHOP, SCUOLE ESTIVE, ECC.) – DESCRIZIONE OTHER PHD ORIENTED ACTIVITIES (SEMINARS, WORKSHOPS, SUMMER SCHOOLS, ETC) – DESCRIPTION	NUMERO DI ORE HOURS
Partecipazione attiva (2 talks sui miei argomenti di ricerca) ai seminari settimanali interni al gruppo di nanoscienze “Theoretical Physics Talks on Quantum Information & Materials Science”.	40
Partecipazione attiva (poster dal titolo ‘Recovering positivity of the Redfield equation via the partial secular approximation’) alla <i>Summer School on Engineered Quantum Systems</i> , ad Helsinki (Finlandia), 28-30 giugno 2019.	15
Partecipazione attiva (poster dal titolo ‘Recovering positivity of the Redfield equation via the partial secular approximation’) alla <i>Quantum ThermoDynamics conference QTD2019</i> , ad Espoo (Finlandia), 23-28 giugno 2019.	40
Partecipazione attiva (contributed talk dal titolo ‘Quantum bath statistics tagging’) alla <i>Italian quantum information science conference IQIS2019</i> , a Milano (Italia), 9-12 settembre 2019.	32



ATTIVITÀ DI RICERCA SVOLTA (MAX. 8.000 CARATTERI)*

RESEARCH ACTIVITY (MAX. 8000 CHARACTERS)

My field of research is open quantum system dynamics and its applications to quantum nanotechnology.

My research during the third year has mainly concerned the following points:

- I concluded two works that I started during the second year on open [D. Farina, G.M. Andolina, A. Mari, M. Polini, V. Giovannetti, *Physical Review B* 99 (3), 035421 (2019), *Charger-mediated energy transfer for quantum batteries: An open-system approach*] and closed [G.M. Andolina, D. Farina, A. Mari, V. Pellegrini, V. Giovannetti, M. Polini, *Physical Review B* 98 (20), 205423 (2018), *Charger-mediated energy transfer in exactly solvable models for quantum batteries*] quantum batteries, being mainly involved in the first project.
- With Vittorio Giovannetti, I studied how to recover the positivity of the Redfield equation via a partial implementation of the secular approximation [Donato Farina and Vittorio Giovannetti, *Phys. Rev. A* 100, 012107 (2019), *Open-quantum-system dynamics: Recovering positivity of the Redfield equation via the partial secular approximation*].
More specifically, we showed how to recover complete positivity (and hence positivity) of the Redfield equation via a coarsegrained averaging technique. We derived general bounds for the coarse graining timescale above which the positivity of the Redfield equation is guaranteed. It turns out that a coarse grain timescale has strong impact on the characteristics of the Lamb shift term and implies, in general, noncommutation between the dissipating and the Hamiltonian components of the generator of the dynamical semigroup. Finally, we specify the analysis to a two-level system or a quantum harmonic oscillator coupled to a fermionic or bosonic thermal environment via dipolelike interaction.
- With Vittorio Giovannetti and Vasco Cavina, we proposed and studied a protocol aimed to tag the statistics of a quantum thermal bath - supposed to be either of bosonic or fermionic nature - by monitoring a probe system (indirect measurements) out of equilibrium and by using quantum state discrimination methods [D. Farina, V. Cavina, V. Giovannetti, *arXiv preprint arXiv:1907.04704*, *Quantum bath statistics tagging. Accepted on Physical Review A*].

The scheme relies on the fact that, when weakly coupled with the environment of interest, the transient evolution of the probe toward its final thermal configuration, is strongly affected by the fermionic or bosonic nature of the bath excitations. Using figures of merit taken from quantum metrology such as the Holevo-Helstrom probability of error and the Quantum Chernoff bound, we discussed how to achieve the greatest precision in this statistics tagging procedure, analyzing different models of probes and different initial preparations and by optimizing over the time of exposure of the probe.



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- I am testing the effectiveness of different master equations for thermalization processes of multipartite systems, using as benchmark exactly solvable models [[In preparation](#)].
- With the purpose of analyzing in the future (and eventually propose) solid state-based superradiating systems, I studied in detail the literature concerning the realization of effective Dicke models (e.g. using multilevel atoms and cavity-mediated Raman transitions, see “Dimer et al., PHYSICAL REVIEW A 75, 013804 2007”) and the open dynamics of Dicke-like systems.

*se si intende sottoporre una relazione di ricerca più estesa, utilizzare il campo per una descrizione sintetica e allegare il documento in formato .pdf

If you are going to submit a longer report, please fill the box with a synthetic abstract and attach a document in pdf format

EVENTUALI PUBBLICAZIONI
PUBLICATIONS (IF AVAILABLE)

D. Farina, V. Cavina, V. Giovannetti, arXiv preprint arXiv:1907.04704, *Quantum bath statistics tagging*. Accepted in Physical Review A.

Donato Farina and Vittorio Giovannetti, Phys. Rev. A 100, 012107 (2019), *Open-quantum-system dynamics: Recovering positivity of the Redfield equation via the partial secular approximation*.

D. Farina, G.M. Andolina, A. Mari, M. Polini, V. Giovannetti, Physical Review B 99 (3), 035421 (2019), *Charger-mediated energy transfer for quantum batteries: An open-system approach*.

G.M. Andolina, D. Farina, A. Mari, V. Pellegrini, V. Giovannetti, M. Polini, Physical Review B 98 (20), 205423 (2018), *Charger-mediated energy transfer in exactly solvable models for quantum batteries*.

NOME DEL RELATORE
THESIS ADVISOR

VITTORIO GIOVANNETTI, MARCO POLINI

DATA

02/10/2019

DATE

FIRMA

SIGNATURE