SCUOLA NORMALE SUPERIORE

RELAZIONE ATTIVITA' ANNUALE DEI PERFEZIONANDI/DOTTORANDI – SECONDO ANNO
REPORT ON THE PHD ACTIVITY – SECOND YEAR

NOME E COGNOME NAME AND SURNAME	Marco Fanizza
DISCIPLINA PHD COURSE	Nanoscienze

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**

ALTRE ATTIVITÀ FORMATIVE (SEMINARI, WORKSHOP, SCUOLE ESTIVE, ECC.) – DESCRIZIONE OTHER PHD ORIENTED ACTIVITIES (SEMINARS, WORKSHOPS, SUMMER SCHOOLS, ETC) – DESCRIPTION	**NUMERO DI ORE HOURS**
Masterclass on Quantum Computation and Communication with Continuous Variables - Copenaghen	35
Quantum Information workshop - Benasque	35

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ATTIVITÀ DI RICERCA SVOLTA (MAX. 8.000 CARATTERI)*
RESEARCH ACTIVITY (MAX. 8000 CHARACTERS)

My research project lies in the field of quantum statistical inference, and it is focused on two main themes: the first is the generalization of learning tasks with quantum systems and processes, and the second is the the use of symmetries in inference problems, where the lack of knowledge can be modeled absence of asymmetry. These two themes shows a very powerful interplay, making possible to obtain analytical results on the optimal performances of many important tasks in quantum information processing.

In the context of classical statistical inference and machine learning one can adopt a probabilistic setting where an algorithm trains a machine to perform a task optimally, starting from a situation of relative ignorance and acquiring information through repeated sampling from a probability distribution. Drawing an analogy between probability distributions and quantum states, quantum machine learning tasks can be characterized as those problems where an agent is asked to perform an operation on partially unknown quantum objects (states, processes, maps on processes…) requiring to extract information from the sample.

I have explored this theme in a project on quantum learning machines for state discrimination, and in a work on optimal subtracting machines (with my colleague Farzad Kianvash), which we completed during this year. Working further on these ideas with Kianvash, we ended up studying depolarizing channels channels with quantum flags, which are a type of noise acting on a quantum system where some side information about which error happens is memorized in an ancillary system, as a quantum state. Using this additional information to correct the noise requires proper quantum processing. Besides the interest in these channels as toy models for realistic quantum communication scenarios, these channels let us to prove new tight bound on the quantum capacity of the depolarizing channel, its exact expression being one of the most important unsolved problems in quantum information theory.

In the field of quantum Shannon theory I also collaborated with my colleague Stefano Chessa on a work about bounds to the capacity of spin-network channels based on diamond norm distance between channels.

A considerable portion of my activity this year has involved the problem of estimating the overlap (OvE) between two unknown states, a project done in collaboration with the quantum information group of Universitat Autonoma de Barcelona (UAB). We characterized the optimal estimation protocol, giving quantitative results about the optimal precision attainable by any quantum measurement, and illustrating how to realize it. We compared the optimal strategy with previous proposals and other intuitive strategies based on the estimation of one or both states. We also considered the the effect of noise. OvE is a fundamental primitive, appearing in many quantum algorithms, especially quantum machine learning algorithms, and our work puts a definitive and exact answer to the problem.

I have presented and will present these results in several workshops and conferences, with posters, contributed talks (QTML 2018, IQIS 2018, QTML 2019), and an invited talk at UAB.

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*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)
Donà, Fanizza, Sarno, Speziale, *SU(2) graph invariants, Regge actions and polytopes* Classical and Quantum Gravity 35 (4), 045011
Fanizza, Mari, Giovannetti, O*ptimal learning machines for quantum state discrimination* IEEE Transactions on Information Theory Volume 65 Issue 9 • Sept.-2019
Donà, Fanizza, Sarno, Speziale, *Numerical study of the Lorentzian EPRL spin foam amplitude* Accepted in Physical Review D, arXiv:1903.12624
Kianvash, Fanizza, Giovannetti, *Optimal quantum subtracting machine* Physical Review A 99 (5), 052319
Chessa, Fanizza, Giovannetti, *Quantum-capacity bounds in spin-network communication channels* Physical Review A 100 (3), 032311
Fanizza, Rosati, Skotiniotis, Calsamiglia, Giovannetti, *Beyond the swap test: optimal estimation of quantum state overlap* arXiv:1906.10639

NOME DEL RELATORE THESIS ADVISOR
Vittorio Giovannetti

DATA DATE	06/10/2019	FIRMA SIGNATURE	Marco Fanizza