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

NOME E COGNOME NAME AND SURNAME	Andrea Iorio
DISCIPLINA PHD COURSE	Nanoscience

CORSI FREQUENTATI CON SOSTENIMENTO DI ESAME FINALE ATTENDED COURSES (WITH FINAL EXAM)	VOTAZIONE RIPORTATA MARK	NUMERO DI ORE HOURS
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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
Virtual Science Forum – Long Range Colloquium Series of 15 online talks on condensed matter physics and quantum information topics sponsored by the Kavli Institute of Nanoscience (Delft). https://virtualscienceforum.org/#/long_range_colloquium	20+
Qiskit Seminar Series Series of 24 online talks on quantum computing and quantum information topics organized by IBM Research. https://qiskit.org/	30+

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

My research project is mainly focused on the study of superconducting circuits in the radio frequency (RF) GHz regime. A consistent part of the project consists in building *completely from scratch* the RF cryogenic setup necessary for these delicate measurements. Another part is using the assembled setup to perform experiments on superconducting circuits with application on a) *quantum computing*-like technologies b) *fast superconducting digital electronics* devices. In parallel, during the year I had the chance to work on an experiment that saw the first realization of a quantum phase battery. Lastly, I am also carrying out theoretical explorations on systems that well match my research project and that find themselves at the border of quantum computation and quantum thermodynamics (for instance, qubits interacting with thermal and photonic baths).

- **Cleanroom activity**
  Being trained to the most of the cleanroom instruments I need, I carried out the first fabrication tests on prototypical devices to be measured on the new RF setup like superconducting resonators. In parallel to the design and fabrication of the devices, I also conducted electromagnetic simulation by means of high frequency EM software analysis.

- **Cryogenic RF setup**
  The cryogenic RF setup is actively being developed and is a consistent part of my daily bread. I personally designed very delicate components such as the printed circuit boards (PCBs) and the sample holder that will host the chips by using CAD softwares. Realizing cryogenic GHz measurements is extremely challenging due to the need of facing different issues and conditions (for instance thermal noise, impedance mismatches, parasitics modes, material choices, etc.). The new dilution refrigerator cryostat devoted to the RF experiments is being tested after a period of maintenance and the assembling of the active/passive components is now taking place (filters, attenuators, amplifiers). Implementation of all the new hardware electronics in our instrument control system is being conducted in parallel by means of LabVIEW & Python programming.

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- **Quantum phase battery**
  In parallel to the RF setup, during the year I also have been able to work and complete an experiment which saw the realization of the first quantum phase battery. The experiment saw my participation as a major actor having conducted part of the DC transport measurements, performed all the data analysis and co-written the manuscript. The work, published on *Nature Nanotechnology*, also raised a considerable interest in the international press. The experiment is also well connected with my main research line since it can pave the way to the investigation of similar devices by means of RF spectroscopy or can be implemented as a phase-shifter for quantum computing superconducting circuits.

- **Theoretical investigations**
  Lastly I am carrying out theoretical exploration of systems that also well match my research project. My interest is specifically focused at the border of quantum computation and quantum thermodynamics. For instance, I have investigated the photonic heat transport between two thermal baths mediated by two interacting qubits. I found out that a quantum enhancement of the thermal rectification properties takes place due to the coherent coupling of the qubits. A manuscript is now being written and will be sent for peer-review in the next weeks.

*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

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EVENTUALI PUBBLICAZIONI PUBLICATIONS (IF AVAILABLE)
Guarcello, C., Citro, R., Durante, O., Bergeret, F. S., ***Iorio, A.****, Sanz-Fernández, C., Strambini, E., Giazotto, F., & Braggio, A.* (2020). **Rf-SQUID measurements of anomalous Josephson effect.** ***Physical Review Research, 2(2), 023165.*** https://doi.org/10.1103/PhysRevResearch.2.023165
Strambini, E., ***Iorio, A.****, Durante, O., Citro, R., Sanz-Fernández, C., Guarcello, C., Tokatly, I. V., Braggio, A., Rocci, M., Ligato, N., Zannier, V., Sorba, L., Bergeret, F. S., & Giazotto, F.* (2020). **A Josephson phase battery.** ***Nature Nanotechnology.*** https://doi.org/10.1038/s41565-020-0712-7
Iorio, A.*, Strambini E., Hack G., Campisi M., Giazotto F. (2020)* **Quantum enhancement of heat rectification in coupled qubits system** ***Soon available on arXiv.***

NOME DEL RELATORE THESIS ADVISOR
Dr. Francesco Giazotto

DATA DATE	18/10/20	FIRMA SIGNATURE