PROPOSTA DI CORSO INTERNO per l'A.A. 2025-2026

TIPOLOGIA DI CORSO: CORSO SPECIALISTICO (destinatari: allievi/e III, IV, V e VI anno)

Ambito: Scienze e Tecnologie (Classe delle Scienze Sperimentali)

Cognome e nome proponente/coordinatore	**SSD e Dipartimento di afferenza**	**Indirizzo email**	**Recapito telefonico**
Di Liberto Marco Fedele	PHYS-04/A - Dipartimento di Fisica e Astronomia, Università di Padova	marco.diliberto@unipd.it	+393296064419

Titolo del Corso in Italiano: **Informazione Quantistica con Atomi e Fotoni**

Titolo del Corso in Inglese: **Quantum Information with Atoms and Photons**

SETTORE/I SCIENTIFICO-DISCIPLINARE/I DI RIFERIMENTO DEL CORSO: PHYS-04/A

STRUTTURA DEL CORSO

Durata: 36 ore oltre verifica finale apprendimento

Numero di CFU (Crediti Formativi Universitari) del Corso unitario: 6 (6 ore per CFU)

Corso suddiviso in moduli formativi: Sì

Modulo: 1
Titolo: **Atoms in optical lattices**
Durata in ore: **13**
SSD: PHYS-04/A
Testi consigliati: Gardiner, Zoller "The Quantum World of Ultra-Cold Atoms and Light", Imperial College Press, 2015
Calendario di massima: 1 semestre
Docente: **Di Liberto Marco Fedele**
Cittadinanza:
Istituzione di afferenza: Dipartimento di Fisica e Astronomia, Università di Padova
Ruolo: Professore Associato
E-mail: marco.diliberto@unipd.it
Tel. Cellulare: +39 3296064419

Link a pagina web istituzionale: https://sites.google.com/site/mardiliberto/home

Breve Bio: Prof. Di Liberto is Associate Professor at the Physics Department of the University of Padova. He graduated in Physics at the University of Catania in 2011 where he was also a student of the Scuola Superiore di Catania and obtained the Diploma. He obtained his PhD at Utrecht University in 2015 working on quantum phases of ultracold atoms in optical lattices and subsequently worked as a postdoctoral research at the Pitaevski BEC Center (Trento, Italy), at Université Libre de Bruxelles (Belgium) and at the Institute for Quantum Optics and Quantum Information (Innsbruck, Austria). In 2022 he obtained a Montalcini grant fellowship and started working as a faculty researcher at the University of Padova where he became Associate Professor in 2025. His interests are the theoretical study of quantum simulators based on atoms, many-body quantum systems and topological phases of matter.

Modulo: 2

Titolo: **Trapped ions**

Durata in ore: **10**

SSD: PHYS-04/A

Testi consigliati: Gardiner, Zoller "The Quantum World of Ultra-Cold Atoms and Light", Imperial College Press, 2015

Calendario di massima: 1 semestre

Docente: **Silvi Pietro**

Cittadinanza:

Istituzione di afferenza: Dipartimento di Fisica e Astronomia, Università di Padova

Ruolo: Ricercatore Tenure Track (RTT)

E-mail: pietro.silvi@unipd.it

Tel. Cellulare: +39-353-4362657

Link a pagina web istituzionale: https://quantum.dfa.unipd.it/people/

Breve Bio: Pietro Silvi is a faculty researcher, with tenure track, in quantum information and correlated quantum matter. He graduated at the university of Pisa and the school of excellence Scuola Normale Superiore in 2007, then achieved his PhD degree at SISSA/ISAS Trieste in 2011. He then spent several years doing research in Germany, then in Austria, as a Postdoc. In his academic career, Dr. Silvi was Coordinator and/or PI of various national (Germany, Austria,Italy) and international (EU) project grants. He’s one of the most prominent promoters of Tensor Network methods for Lattice Gauge Theories, as means to reach our full understanding of the Standard Model. His academic interests also encompass Trapped Ion quantum processing strategies, as well as open quantum systems and entanglement characterization.

Modulo: 3

Titolo: **Rydberg atoms**

Durata in ore: **13**

SSD: PHYS-03/A

Testi consigliati: Haroche - Raimond "Exploring the quantum: Atoms, Cavities, and photons"

Calendario di massima: 1 semestre
Docente: **Marinelli Matteo**
Cittadinanza:
Istituzione di afferenza: Università di Trieste, CNR-IOM
Ruolo: Ricercatore Tenure Track (RTT)
E-mail: Matteo.marinelli@units.it
Tel. Cellulare: +39-353-4703738
Link a pagina web istituzionale: https://sites.units.it/arquslab/index.html
Breve Bio: Matteo Marinelli holds a tenure track position at the University of Trieste since October 2024. He received his PhD in 2020 from ETH Zurich under the supervision of Jonathan Home, working with trapped ions. After graduation he served as the Trapped-ion experimental leading scientist at the newly founded ETH-PSI quantum computing hub where led a team of engineers and scientist to create the first experimental platform working with more than 50 qubits. In 2022 he received the SNS Postdoc Mobility fellowship and moved to JILA in Boulder (CO) where he worked together with Adam Kaufman and Cindy Regal at the realization of a novel platform using neutral atoms trapped in optical tweezers in a cryogenic environment. His academic interests span the domain of quantum information science, with a focus on technologies towards scalable architectures.

Struttura del Corso

Lingua/e dell'insegnamento: Italiano/Inglese

Eventuali prerequisiti degli/lle allievi/e frequentanti: Meccanica quantistica ed elementi di fisica atomica e interazione luce-materia.

Obiettivi formativi: Comprensione delle piattaforme atomiche per la simulazione e il calcolo quantistici. Conoscenza dei principali fenomeni e processi fisici accessibili.

Contenuti del Corso Introduction to quantum simulators. Floquet driven systems. Atoms in optical lattices for analog quantum simulation. Single-particle physics, AC-Stark shift, optical potential and bands. Tight-binding regime, quantum walk. Atom-atom interactions and scattering theory. Bose-Hubbard model and Mott insulator-superfluid quantum phase transition. Three level systems, Raman coupling. Trapped ions, vibrational modes, Lamb-Dicke regime Elements of quantum information and computation. Cirac-Zoller and Molmer-Sorensen gates. Analog quantum simulation with trapped ions. Magneto-optical traps in 2D and 3D. Optical tweezers. State dependent potentials: magic trapping, cooling and detection. Rydberg atoms. Circular rydberg states. Two-qubit operations mediated by Rydberg gates. The Levine-Pichler gate. Simulation of spin models with Rydberg atoms. Experimental requirements and imperfections: decoherence, atom loss, heating rates. Atom-photon entanglement, modular computing and quantum networks with atom arrays.

Metodologia didattica: Didattica frontale e seminari

Modalità della verifica finale di apprendimento: Esame orale

Calendario programmato: I Semestre (da fine novembre 2025 al marzo 2026)