

QUANTUM-NEST SUMMER SCHOOL 2026

INTERNATIONAL SCHOOL
OF PHYSICS "ENRICO
FERMI" - ITALIAN
PHYSICAL SOCIETY



JUNE 22-28, 2026



VILLA MONASTERO, COMO
LAKE, ITALY

EVENT BOOKLET

https://www.sif.it/corsi/scuola_fermi/2026/218



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PRESENTATION OF THE SCHOOL

The 2026 edition of the **Quantum-NEST School** (Quantum Network for Education and Scientific Training) is organized in collaboration with the **International School of Physics “Enrico Fermi” of the Italian Physical Society** (*Course 218 – Quantum Dynamics and Communication*). The school aims to provide an overview of the **most recent developments in quantum science and technology** through lectures delivered by leading researchers in the field. Primarily intended for master’s and PhD students, it offers participants both a broad vision of current challenges in quantum technologies and valuable networking opportunities with established scientists from around the world. Founded in 1953 by the Italian Physical Society, the Enrico Fermi School has become an internationally renowned summer school and an important meeting place for young physicists and researchers.

Organizers

Marino Marsi (University Paris-Saclay)

Rinaldo Trotta (Sapienza University of Rome)

SIF – Società Italiana di Fisica

Webpage

https://www.sif.it/corsi/scuola_fermi/2026/218

PRACTICAL INFORMATION

Event dates: 22-28 June 2026

Event venue:

Villa Monastero
Viale Giovanni Polvani, 4,
23829 Varenna
Italy



Varenna is one of the most charming villages on the eastern shore of Lake Como. Villa Monastero, one of the oldest and most famous villas in the region, is well known for its impressive botanical garden. Originally a monastery and later turned into a private residence, it is now managed by the Province of Lecco and is a popular attraction for visitors from all over the world. The School "Enrico Fermi" has its institutional seat in the Villa.

How to reach Varenna?

- By Train: Milano Centrale → Varenna-Esino
(Bookings on <https://www.trenord.it/> – €7.40)
Trains run every hour, and the journey takes about 1 hour.

Villa Monastero is then a 10/15-minute walk from Varenna-Esino station:
<https://maps.app.goo.gl/dW1NLKNmC5ZQAZV79>

Accommodation for Quarmen & Arteq students:

Residence Brezza del Lario

Via Valvarrone, 17B, 23824 Dervio, Italy

<https://maps.app.goo.gl/3CH1vLXNopxAi7mXA>

<https://brezzadellario.com/en/>



Rooms are booked from Monday, 22 June to Sunday, 28 June (6 nights).

Trains from Dervio to Varenna:

Bookings on <https://www.trenord.it> – €2.00

Trains run every hour, and the journey takes about 10 minutes.

 REG 10315	 07:54 - Dervio  08:05 - Varenna Esino
BIGLIETTO FERROVIARIO	
 REG 10317	 08:54 - Dervio  09:05 - Varenna Esino

No parties or loud gatherings should take place at the residence. Please note that the program holds responsibility for ensuring that these rules are respected. As there are other clients, we ask for your cooperation to maintain a peaceful environment.

Catering:

Lunches will be served at Villa Monastero.

Dinners will take place at Blanco Lounge Bar & Restaurant:

<https://maps.app.goo.gl/YnnEoryfnxzARqhR9>

SPEAKERS & LECTURES

Philippe Grangier, Paris-Saclay University, France
"Quantum Communications with Gaussian and Non-Gaussian Light"

Georgios Katsaros, Institute of Science and Technology Austria (ISTA), Austria,
"Spin Qubits in Ge/SiGe heterostructures"

Enrico Perfetto, University of Rome Tor Vergata, Italy
"Introduction to exciton quantum dynamics"

Jean-François Roch, ENS Paris-Saclay, France
« The NV Color Center in Diamond as a Solid-State Artificial Atom for Quantum Technologies »

Fabio Sciarrino, University of Rome La Sapienza, Italy
"Quantum information processing via integrated photonics"

Dvira Segal, University of Toronto, Canada
"Open Quantum Systems: From standard to advanced tool"

Pascale Senellart, Paris-Saclay University, France
"Introduction to single-photon-based quantum computing"

Nuno Silva, University of Porto, Porto
"Analogue Quantum Simulations with Paraxial Fluids of Light"

ALUMNI

Jean-Paul Nohra, PhD at Laboratoire Kastler Brossel, CNRS/Ecole Normale Supérieure, *"Quantum Simulation of Fermionic Matter: Correlation Imaging for Strongly Correlated Fermions"*.

Claire Roussy, PhD at ENS Paris-Saclay - LuMIn, *"Quantum sensor-based spectroscopies for the study of quantum materials under high pressure"*

André Soares, PhD at University of Porto/University of Minho/University of Southern Denmark Odense, *"Quantum and topological plasmonics in 2D materials and nanostructures"*

PROGRAMME & ABSTRACTS

Attendance at all lectures is mandatory. You will be required to sign an attendance sheet in the morning each day. Please note that no attendance certificate will be issued to students who miss any part of the scheduled classes.

ALL LECTURES TAKE PLACE AT VILLA MONASTERO

	Monday June 22th
15:00 - 19:00	School Registration at Villa Monastero (<i>can also be done on Tuesday morning before the start of the lectures</i>)

	Tuesday June 23th
8 :30 – 9 :15	School Registration
9:30-10:30	J-F. Roch <i>"The NV Color Center in Diamond as a Solid-State Artificial Atom for Quantum Technologies"</i>
10:30 - 10:50	Coffee break
10:50 - 11:50	P. Senellart <i>"Introduction to single-photon-based quantum computing"</i>
11:50 - 13:10	P. Grangier <i>"Quantum Communications with Gaussian and Non-Gaussian Light"</i>
13:15 - 14:15	Lunch
14:15- 15:15	P. Senellart <i>"Introduction to single-photon-based quantum computing"</i>
15:15 - 16:15	D. Segal <i>"Open Quantum Systems: From standard to advanced tool"</i>
16:15- 16:30	Break
16:30 - 17:00	Alumni (J-P. Nohra)
17:30 - 19:30	Poster session (<i>program requirement for Arteq students ; not compulsory for other participants</i>)
20:00 - 22:00	Welcome Party at Blanco Lounge Bar & Restaurant

	Wednesday June 24th
9:30-10:30	J-F. Roch <i>"The NV Color Center in Diamond as a Solid-State Artificial Atom for Quantum Technologies"</i>
10:30 - 10:50	Coffee break
10:50 - 11:50	F. Sciarrino <i>"Quantum information processing via integrated photonics"</i>
11:50 - 13:10	P. Grangier <i>"Quantum Communications with Gaussian and Non-Gaussian Light"</i>
13:15 - 14:15	Lunch
14:15- 15:15	P. Senellart <i>"Introduction to single-photon-based quantum computing"</i>
15:15 - 16:15	D. Segal <i>"Open Quantum Systems: From standard to advanced tool"</i>
16:15- 16:30	Break
16:30 - 17:30	F. Sciarrino <i>"Quantum information processing via integrated photonics"</i>
20:00 - 22:00	Dinner at Blanco Lounge Bar & Restaurant

	Thursday June 25th
9:30-10:30	J-F. Roch <i>"The NV Color Center in Diamond as a Solid-State Artificial Atom for Quantum Technologies"</i>
10:30 - 10:50	Coffee break
10:50 - 11:50	F. Sciarrino <i>"Quantum information processing via integrated photonics"</i>
11:50 - 13:10	P. Grangier <i>"Quantum Communications with Gaussian and Non-Gaussian Light"</i>
13:15 - 14:15	Lunch
14:15- 15:15	E. Perfetto <i>"Introduction to exciton quantum dynamics"</i>
15:15 - 16:15	D. Segal <i>"Open Quantum Systems: From standard to advanced tool"</i> P.
16:15- 16:30	Break
16:30 - 17:30	Alumni (C. Roussy/ A. Soares)
20:00 - 22:00	Dinner at Blanco Lounge Bar & Restaurant

	Friday June 26th
9:30-10:30	E. Perfetto <i>"Introduction to exciton quantum dynamics"</i>
10:30 - 10:50	Coffee break
10:50 - 11:50	G. Katsaros <i>"Spin Qubits in Ge/SiGe heterostructures"</i>
11:50 - 13:10	N. Silva <i>"Analogue Quantum Simulations with Paraxial Fluids of Light"</i>
13:15 - 14:15	Lunch
14:15- 15:15	E. Perfetto <i>"Introduction to exciton quantum dynamics"</i>
15:15 - 16:15	G. Katsaros <i>"Spin Qubits in Ge/SiGe heterostructures"</i>
16:15- 16:30	Break
16:30 - 17:30	N. Silva <i>"Analogue Quantum Simulations with Paraxial Fluids of Light"</i>
20:00 - 22:00	Farewell Party in Villa Monastero

	Saturday June 27th
9:30-10:30	N. Silva <i>"Analogue Quantum Simulations with Paraxial Fluids of Light"</i>
10:30- 10:50	Coffee break
10:50 - 11:50	G. Katsaros <i>"Spin Qubits in Ge/SiGe heterostructures"</i>
11:50 - 12:30	Closing address by Prof. Angela Bracco, SIF President School closing remarks.
12 :30 - 14:00	Lunch. End of the school.
Afternoon	Free afternoon to discover the Como Lake

Quantum Communications with Gaussian and Non-Gaussian Light

Philippe GRANGIER

Institut d'Optique Graduate School, CNRS, Université Paris-Saclay, F79126 Palaiseau

These lectures will be centered on quantum continuous variables, which are typically implemented as the quadrature components of a quantum light field. We will introduce the Wigner function, which is equivalent to the density matrix, and is a very convenient way to display the quantum features of light. This will allow us to define Gaussian and non-Gaussian light fields, and to explore their many applications for quantum cryptography, quantum communications and quantum computing. Illustrative examples are given in the references below and will be discussed during the lectures.

- [1] A. Ourjoumteev, R. Tualle-Broui, J. Laurat, and Ph. Grangier, "Generating Optical Schrödinger Kittens for Quantum Information Processing", *Science* 312, 83 (2006).
- [2] E. Bimbard, R. Boddeda, N. Vitrant, A. Grankin, V. Parigi, J. Stanojevic, A. Ourjoumteev, and P. Grangier, "Homodyne tomography of a single photon retrieved on demand from a cavity-enhanced cold atom memory", *Phys. Rev. Lett.* 112, 033601 (2014)
- [3] V.C. Usenko et al, Continuous-variable quantum communication, *Rev. Mod. Phys.* 98, 015003 (2026). <https://doi.org/10.48550/arXiv.2501.12801>

Spin Qubits in Ge/SiGe heterostructures

Georgios Katsaros

While Ge was used to realize the first transistor at Bell Labs in 1947, only recently has it come into focus for its potential in quantum information [1]. In the past few years, impressive progress has been achieved: Ge hole spin qubits are now considered promising contenders for creating quantum processors. They offer significant advantages, such as a small effective mass that mitigates fabrication limitations, intrinsic protection from magnetic noise, and robust spin–orbit coupling, enabling rapid electric control.

In this lecture, I will begin by providing a historical overview of how the field of semiconductor spin qubits has evolved since the realization of the first spin qubits in 2005 and 2006 [2,3]. I will then focus on hole spin qubits, explain the difference from electron spin qubits, and discuss the current state of the art. Also, challenges involved in scaling up to larger devices for quantum processors will be addressed. Finally, I will also offer a glimpse into the potential of Ge spin qubits when coupled to superconductors.

- [1] G. Scappucci et al., *Nat. Rev. Mater.*, 6, 926 (2021).
- [2] J. Petta et al., *Science* 309, 2180 (2005)
- [3] F. Koppens et al., *Nature* 442, 766 (2006)

Introduction to exciton quantum dynamics

Enrico PERFETTO

In these lectures I will introduce the concept of the exciton as the key quasiparticle that dominates the optical properties of many materials. In order to achieve a complete understanding and control of these properties, it is essential to clarify how excitons are generated and how they evolve in time. I will therefore introduce the Bethe–Salpeter equation as the theoretical framework to predict the energy and the wavefunction of excitons in materials at equilibrium, and show how this equation naturally encodes the physics underlying photoabsorption experiments.

We will then move to the non-equilibrium regime, which describes the state of materials when they are driven by electromagnetic radiation. In this context, I will discuss how excitons evolve in time and how these dynamical changes can be probed in time-resolved photoabsorption and photoemission experiments.

In the final part, I will address more advanced topics, focusing on the interaction between excitons and lattice vibrations, and ultimately, I will discuss the microscopic mechanism through which an electron and a hole bind together to form an excitonic bound state.

The NV Color Center in Diamond as a Solid-State Artificial Atom for Quantum Technologies

Jean-François ROCH
ENS Paris-Saclay

The study of color centers in solids began nearly a century ago with pioneering investigations of vacancies and impurity-related defects in alkali halide crystals. These point defects, which can be created through irradiation or controlled doping, give rise to localized electronic states within the host material's bandgap and exhibit optical transitions that are similar to those found in isolated atoms. The nitrogen-vacancy (NV) center in diamond is one of the most remarkable solid-state quantum systems. First identified in the 1960s as a luminescent defect associated with a nitrogen impurity adjacent to a carbon vacancy, considerable interest in the NV center followed the 1997 discovery that it could be isolated, optically detected, and manipulated at the single-defect level.

The NV center combines several unique properties that make it particularly attractive for quantum science and technology. Its photoluminescence is exceptionally stable, even at room temperature, enabling efficient single-photon sources to be realized. Additionally, its electronic spin-triplet ground state can be initialized, manipulated and read out using a combination of optical and microwave fields. The NV center has established itself as a versatile platform for quantum technologies thanks to its long spin coherence times and operation under ambient conditions.

In the first lecture, I will provide an overview of the optical and spin properties of the NV center, describing how these properties enable the detection of magnetic fields in environments where conventional sensors are ineffective. This capability has led to a wide range of applications, from nanoscale magnetometry to industrial sensing, and several commercial devices are already available. I will also discuss the crucial role played by advances in plasma-assisted chemical vapor deposition (CVD) diamond growth and defect engineering in developing these technologies.

The second lecture will address the fundamental physics of the NV center, explaining why it can be considered an atomic system within a solid-state environment. The interplay between localized electronic states and the host crystal will be emphasized, highlighting the similarities to isolated atomic systems and the features unique to the solid-state matrix.

The third lecture will focus on the spin Hamiltonian of the NV center and the mechanisms underlying optical spin polarization and readout. Building on this framework, I will demonstrate how to exploit coherent spin manipulation techniques for quantum sensing applications, particularly high-sensitivity magnetic field measurements.

Quantum information processing via integrated photonics

Fabio SCIARRINO

Dipartimento di Fisica, Sapienza Università di Roma

Quantum information processing is nowadays an established branch of quantum mechanics applications. Recent results in different areas, ranging from communications to computing, show that quantum technologies are advancing towards being mature platforms with substantial advantages over traditional classical protocols. Quantum optics and photonic apparatuses are one of the best candidates for the realization of quantum processors. In this context, integrated photonic technologies are essential components towards miniaturisation of such complex optical systems. Integrated optical devices enabled an important improvement in the level of complexity in the generation and processing of quantum states of light. The lectures aim at providing an exhaustive framework of the advances of integrated quantum photonic platforms, for what concerns the integration of sources, manipulation, and detectors, as well as the contributions in quantum computing, cryptography and simulations.

T. Giordani, F. Hoch, G. Carvacho, N. Spagnolo and F. Sciarrino. Integrated photonics in quantum technologies. *La Rivista del Nuovo Cimento* 46, 71–103 (2023).

E. Pelucchi, G. Fagas, I. Aharonovich, D. Englund, E. Figueroa, Q. Gong, H. Hannes, J. Liu, C.-Y. Lu, N. Matsuda, J.-W. Pan, F. Schreck, F. Sciarrino, C. Silberhorn, J. Wang, K.D. Jöns. The potential and global outlook of integrated photonics for quantum technologies, *Nature Reviews Physics*, 4, 194-208 (2022).

J. Wang, F. Sciarrino, A. Laing, M. G. Thompson, Integrated photonic quantum technologies, *Nat. Photonics*. (2019).

D.J. Brod, E. F. Galvao, A. Crespi, R. Osellame, N. Spagnolo, F. Sciarrino, Photonic implementation of Boson Sampling: a review, *Adv. Phot.* 1, 034001 (2019).

Open Quantum Systems: From standard to advanced tool

Dvira Segal

Talk 1: Introduction to Open Quantum Systems: Standard frameworks

Talk 2: Open quantum systems: What Happens When Standard Frameworks Break Down?

Research talk: Anomalous Quantum Dissipative Dynamics

In Talk #1, I will introduce and motivate the field of Open Quantum Systems. I will present the derivation of “standard” quantum master equations, both from microscopic principles (leading to the Redfield equation) and from a mathematical characterization of completely positive dynamics (the Lindblad equation). Physical examples and practical applications will also be discussed.

In Talk #2, I will discuss strong coupling, memory effects, and advanced methods in open quantum systems. Topics will include Markovian embedding approaches, reaction-coordinate and polaron methods, as well as path-integral techniques based on the Feynman–Vernon Influence Functional.

In Talk #3, I will focus on examples and applications of anomalous quantum dynamics. Examples include manifestations of the Mpemba effect in open quantum systems, hierarchical relaxation dynamics in disordered systems, and counterintuitive relaxation phenomena, such as the slowing down of relaxation due to decoherence.

Introduction to single-photon-based quantum computing

Pascale SENELLART

University Paris-Saclay, Centre de Nanosciences et de Nanotechnologies, CNRS, 10
Boulevard Thomas Gobert, 91120, Palaiseau, France

In this lecture, we will introduce the fundamentals of photon-based quantum technologies. We will begin with a brief overview of the quantum description of light, including second quantization, single-photon states, and methods for quantum state characterization.

We will then present the two main approaches for generating single photons: heralded photon sources based on nonlinear frequency-conversion processes, and on-demand single-photon sources based on quantum emitters. The objective is to provide an understanding of the underlying physical principles, the main experimental techniques, and the current state of the art in photonic quantum light sources.

The final part of the lectures will be devoted to an introduction to optical quantum computing. We will introduce the circuit-based approach, which relies on quantum interference between indistinguishable photons. We will present the first photonic quantum computing prototypes and examples of first applications. We will then present the measurement-based approach, in which large entangled states of light are generated and processed through adaptive measurements.

Analogue Quantum Simulations with Paraxial Fluids of Light

Nuno AZEVEDO SILVA

Paraxial fluids of light are emerging as a versatile experimental setting to investigate quantum-like many-body and hydrodynamic phenomena. Indeed, building on the similarity between the mathematical model for the propagation of an optical beam through a nonlinear medium and the model for the time-evolution of a two-dimensional quantum fluid, these platforms offer an experimentally accessible counterpart to systems such as ultracold atomic gases and superfluid helium, acting as an analogue tabletop quantum simulator. In this lecture, we will introduce the main theoretical ideas behind paraxial fluids of light, starting from the nonlinear Schrödinger equation and its connection to an effective Gross-Pitaevskii description in two spatial dimensions plus propagation. The hydrodynamic formulation will then be discussed, highlighting how concepts such as density, phase, flow velocity, interactions, and collective excitations emerge in optical media, and relating with some of quantum-like properties these display. Particular attention will be given to the similarities and differences between fluids of light and atomic quantum fluids, including the relevant physical parameters, regimes of validity, and experimental figures of merit. Shifting the focus to experimental work, we will survey current experimental implementations of paraxial fluids of light, with emphasis on platforms based on photorefractive materials and atomic media. Finally, we will discuss some of the open challenges and future perspectives, ranging from fundamental studies of topological or nonequilibrium quantum-fluid behavior to applications in optical computing and emerging quantum technologies.

- [1] Glorieux, Q., Piekarski, C., Schibler, Q., Aladjidi, T., & Baker-Rasooli, M. (2025). *Paraxial fluids of light*. *Advances In Atomic, Molecular, and Optical Physics*, 74, 157-241.
- [2] Ferreira, Tiago D., Ariel Guerreiro, and Nuno A. Silva. "Digital feedback loop in paraxial fluids of light: a gate to new phenomena in analog physical simulations." *Physical Review Letters* 133, no. 24 (2024): 243802.