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2026

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CHAIRE PHOTONIQUE

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RESEARCH & DISCUSSIONS

PhD students, researchers

Guest speaker

Discover

Present

Connect

March 31st

9 AM

CS Amphitheater

31 MARCH 2026

Time		Doctoral students
08:45 -09:00	Breakfast	
09:00 – 09:40	Systems	D'heib Vall Khier
09:40 – 10:05	Photonics	Draupath Umesh
10:05 –10:15	Break	
10:15 – 10:50	Invited Speaker	Jean Paul Salvestrini
10:50 – 11:15	Photonics	Itisha
11:15 – 11:30	Photonics	Yohann Sanvert
11:30 – 11:40	Group Photo	
11:40 – 13:00	Lunch-break (Cafétéria)	
13:15 – 13:30	Materials	Clara MEFO-SOP
13:30 – 14:15	Materials	Krishna Lone
14:15 – 14:30	Break	
14:30 – 14:45	Systems	Gerald Kobi
14:45 – 15:00	Photonics	Theo Creola-Chivers
15:00 – 15:15	Systems	Eric Gomes
15:15 – 15:25	Invited speaker	Kamenan N'Gadi

(green)	1st year (10 + 5 min)
(blue)	2nd year (15+10 min)
(yellow)	3rd year (30+15 min)

BREAKS
INVITED SPEAKER
PHOTOS

Performance and constraints of a power converter with wideband-gap semiconductor components for residential photovoltaic deployment more resilient to critical usage constraints

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Partial shading poses a major challenge for residential photovoltaic systems, where the lack of overlapping strategies amplifies their vulnerability. This phenomenon leads to significant drops in generated power, the emergence of multiple maximum power points (MPPT) [1], as well as dynamic and thermal stresses on electronic components. These effects impact not only the efficiency of solar panels but also the performance and reliability of interface power converters. While existing research primarily focuses on large-scale installations, leveraging advanced strategies to mitigate these impacts, our study focuses on residential photovoltaic systems. Due to their smaller scale and the absence of such strategies, these systems are particularly susceptible to the dynamic and thermal stresses caused by partial shading.

Faced with the limitations of photovoltaic systems exposed to partial shading, several studies have explored technological solutions to mitigate the effects of partial shading, particularly through the use of advanced converter topologies such as DC-DC interface converters integrated into photovoltaic panels [2]. These converters enable each panel to operate independently at its maximum power point (MPP), thereby reducing losses caused by irradiance disparities. However, traditional silicon (Si)-based converters exhibit significant limitations in terms of power density and energy efficiency, especially under fluctuating irradiance conditions. Gallium nitride (GaN) transistors offer an innovative solution due to their ability to operate at high switching frequencies, enabling better management of irradiance variations. They reduce switching losses, increase power density, and extend the efficient operating range, while minimizing thermal stresses on components [3].

This work addresses the reduction of the adverse effects of partial shading on photovoltaic (PV) systems by analyzing its consequences on both solar panels and power converters. Through numerical simulations conducted in MATLAB/Simulink©, the impacts of partial shading on the electrical performance of the PV system and power converter, such as power reduction, efficiency losses, and electrothermal stresses on components, are examined in detail. To address these challenges, the use of a power converter based on gallium nitride (GaN) transistors is explored. The results highlight the significant advantages of GaN components, including their ability to enhance system efficiency, minimize losses due to partial shading, and strengthen converter resilience against irradiance fluctuations.

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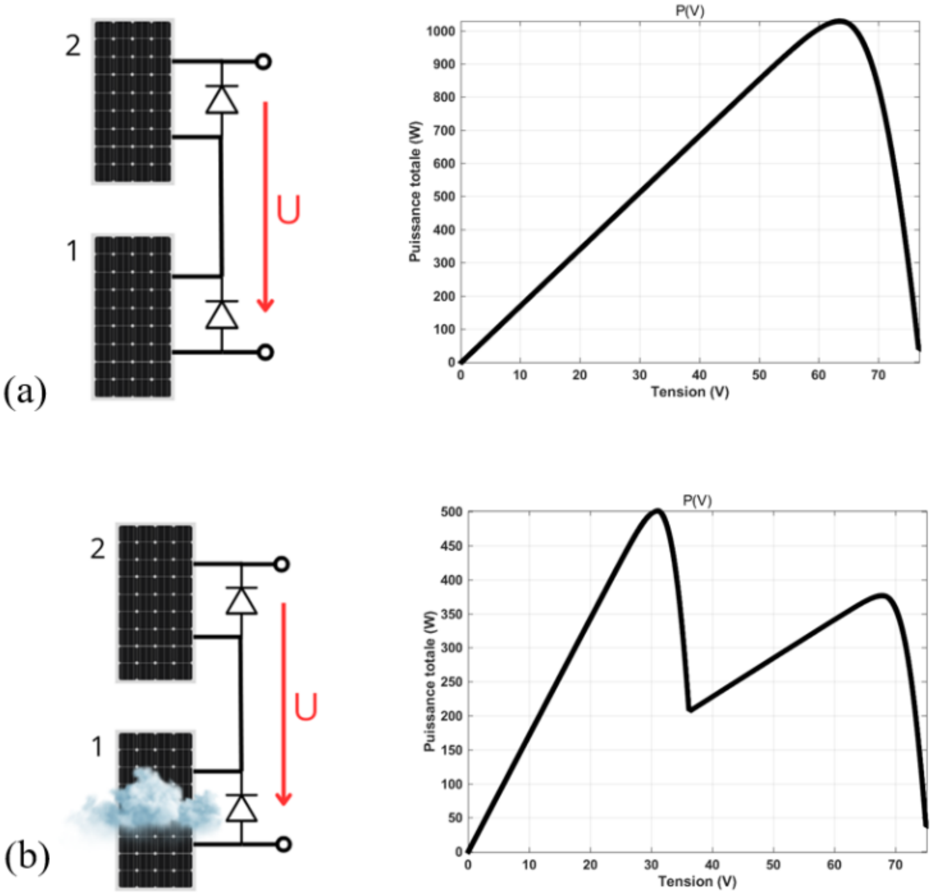

Figure 1: Impact of shading on a simplified string composed of only two photovoltaic (PV) panels: (a) Output power of the PV string when both panels are unshaded and receive uniform irradiance, and (b) With one shaded panel (represented as a function of the total voltage U).

Design of broadband nonlinear frequency converter using chirped directional coupler

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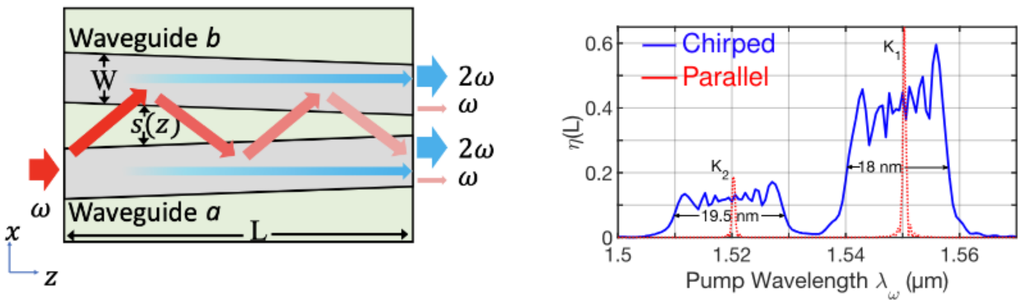
The robustness in an optical system manifests itself by increased tolerances with respect to potential fabrication errors, and more specifically to variations in temperature. The most evident source of error is the use of wavelength different than those at which the optical system is designed. In this case robustness is associated to a broadband operation. In this work I study classical optical systems and aim at increasing their robustness taking advantage of analogies with quantum dynamics.

The matter of my recent investigations concern nonlinear frequency conversion in coupled optical waveguides. Specifically, I am evaluating Second Harmonic generation (SHG) in such kind of waveguides from a theoretical point of view to analyze the influence of light coupling between the two waveguides in the SHG process. Coupling-length phase matching (CLPM), a technique reported in the literature [1], is used to facilitate phase matching between the interacting waves involved in the nonlinear process. CLPM is a quasi-phase-matching scheme for guided nonlinear optical frequency conversion. Here, instead of a longitudinal variation of any material parameter or propagation constant, the spatial modulation of the intensities in coupled waveguides is used to compensate for the phase mismatch.



(a) (b)

Figure 1: (a) Schematic diagram of the CLPM principle in chirped symmetric planar coupled waveguides illustrated with SHG. The pump beam (at frequency ω) is injected in waveguide a. The evanescent coupling between the two waveguides causes the power to oscillate between the two waveguides. Waveguides a and b are identical with a width *W*. The waveguide separation at the location *z* is given by *s(z)*, for a total interaction length *L*. The evolution of *s(z)* gives an evolution of the CLMP condition leading to broadband behavior. (b) Efficiency spectrum $\eta(L)$ at the output as a function of the pump wavelength λ_ω for chirped waveguides with *s(z)* evolving from 0.74 to 0.57 μm (input intensity of approx. 645 MW/cm2) (blue line) and comparison with parallel waveguides with s_0=0.66 μm

To enhance the operational bandwidth, we exploit an analogy with the population dynamics in a two-level quantum system, specifically Rapid Adiabatic Passage (RAP). A schematic principle of the method is shown in Fig.1 (a) for SHG. In RAP, efficient and complete population transfer is achieved by adiabatically sweeping the detuning through the resonance frequency [2]. Analogously, we vary the phase mismatch slowly along the propagation direction through the phase matching condition, to enable broadband nonlinear conversion. Fig.1 (b) shows the increased bandwidth of the spectra satisfying $K_1 = 0$ and $K_2 = 0$ for the chirped configuration with a range spanning 18 nm and 20 nm, respectively (compared to the parallel case where a bandwidth of 0.7 nm is obtained for both CLMP conditions).

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Hexagonal Boron Nitride, a key player for optoelectronics and microelectronics

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The mechanical release of semiconductor devices using 2D layer assisted lift-off and transfer technique is a promising approach for heterogeneous integration of devices on a host substrate. Upscaling this technology for industrial level requires solutions that allow a simple pick-and-place technique of selected devices for integration while preserving device performance. In this presentation I will first describe recent works we led towards this purpose using an approach combining the use of hBN as the 2D material and, selective area growth to define the shape of the devices during their epitaxy. I will then highlight how the amazing physical properties of hBN can be used to fabricate new kind of electronic and optoelectronic devices.

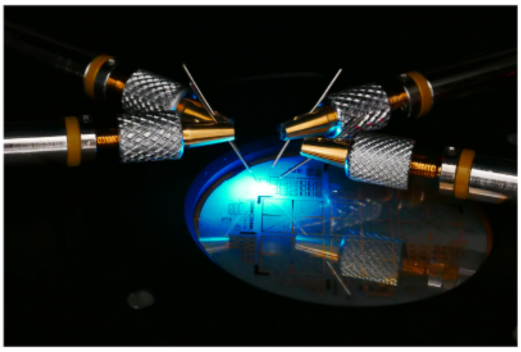

Figure 2: III-N based blue LEDs fabricated on hBN/Al_2O_3 template substrate

Efficient tuning of non-linear dynamics in multimode fibers for optical reservoir computing

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Reservoir computing is a machine learning framework that utilizes the intrinsic dynamics of a complex system to transform input signals into a high-dimensional feature space. The internal structure of the reservoir remains fixed and only the output layer is trained, which makes it computationally efficient and suitable for physical implementations.[1] Multimode optical fibers provide a natural platform for reservoir computing due to their rich spatiotemporal dynamics. Light propagation in MMFs involves modal interference, dispersion, and Kerr nonlinearity, which together generate complex transformations of the input signal, enabling the fiber to act as a physical reservoir where nonlinear mode coupling enhances feature diversity.

Simulation. The propagation of the optical field in the multimode fiber is modeled using a nonlinear time-domain beam propagation method (TBPM) based on the nonlinear Schrödinger equation[2]. Input data is encoded onto the optical field and injected into the fiber, where nonlinear interactions generate complex output intensity patterns. Two fiber architectures, step-index and graded-index (GRIN), are considered, and the output intensity is spatially sampled to form feature vectors used for classification. The role of optical power is investigated to understand the influence of nonlinearity on reservoir performance.

Acknowledgment. Co-funded by the European Union under the Marie Sklodowska-Curie Grant Agreement No 101081465 (AUFRANDE). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the Research Executive Agency. Neither the European Union nor the Research Executive Agency can be held responsible for them

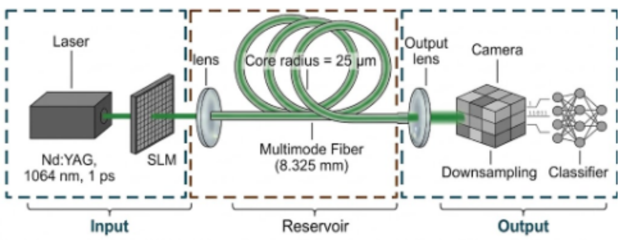

Figure 3: Setup

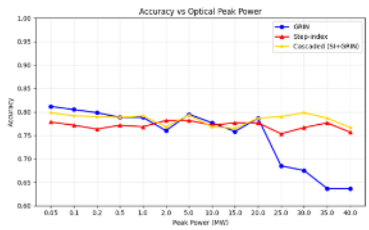

Figure 4: Power vs Accuracy

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Investigating the chaotic properties of a multimode (MM-)VCSEL for random number generation

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The intrinsic polarization competition in vertical-cavity surface-emitting lasers (VCSELs) enables the generation of complex chaotic dynamics even in free-running operation, i.e., without optical injection or feedback [1]. Such polarization chaos has attracted strong interest for applications including chaos-based cryptography and physical random number generation (RNG). In particular, MM-VCSELs exhibit a rich variety of nonlinear behaviors arising from transverse-mode competition and polarization switching. Here, we study a VCSEL supporting two transverse modes to investigate how the presence of an additional mode modifies these dynamics [2, 3].

In Figure 5, the bifurcation diagram of the fundamental mode illustrates the evolution of optical intensity extrema with injection current. This diagram reveals different dynamical regimes, including several chaotic regions and an unexpected restabilization absent in single-mode VCSELs, highlighting the strong impact of multimode interactions on the system's dynamics. Such intrinsic chaos can be directly harnessed for high-speed physical RNG. Combined with validation via NIST statistical tests [4], the generated sequences exhibit high-quality randomness, enabling extraction rates up to 150 Gb/s. These results demonstrate the potential of multimode VCSELs as compact, high-performance RNG sources operating without external feedback.

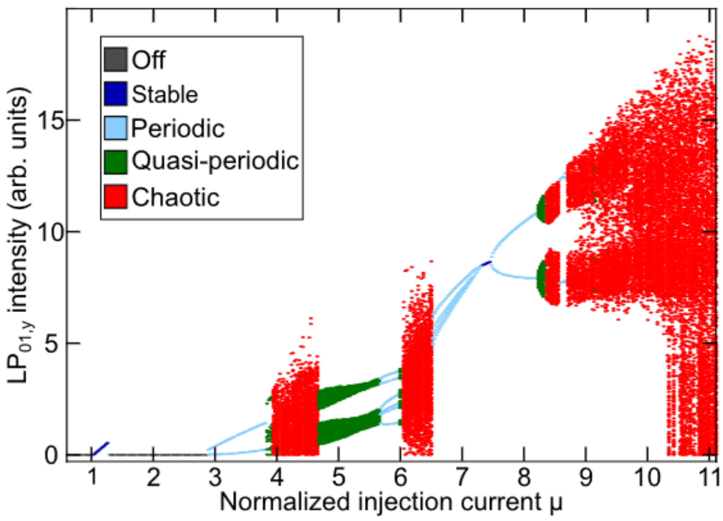

Figure 5: Bifurcation diagram of the fundamental y polarization mode ($LP_{01,y}$) showing minima and maxima of the optical intensity for different injection current μ.

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SYNTHESIS OF INHERENTLY FLAME-RETARDANT AND IONIC CONDUCTIVE POLYMER

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In 2022, the road transport sector, operating internal combustion engine vehicles, accounted for 17% of greenhouse gas emissions. Replacing conventional thermal vehicles with electric vehicles, therefore, appears promising for reducing greenhouse gas emissions. However, electric vehicles rely on flammable liquid electrolytes, which raises safety concerns [1].

To address flammability issues, previous studies have explored the use of flame-retardant additives [2], which, upon incorporation, increase both the oxygen concentration required for ignition and the ignition induction time [3]. Another alternative involves the use of solid polymer electrolytes. However, in both cases, lithium-ion mobility becomes significantly lower than in liquid electrolytes [4], [5]. Moreover, flame retardants are often considered toxic and/or may release toxic compounds upon decomposition [6].

Here, we describe a strategy to combine phosphorus-containing molecules and ionic polymers to obtain inherently flame-retardant, ion-conducting solid electrolytes. The approach relies on thermally activated radical polymerization between a phosphorus-substituted acrylate derivative, poly(ethylene glycol) methacrylate, and poly(ethylene glycol) dimethacrylate.

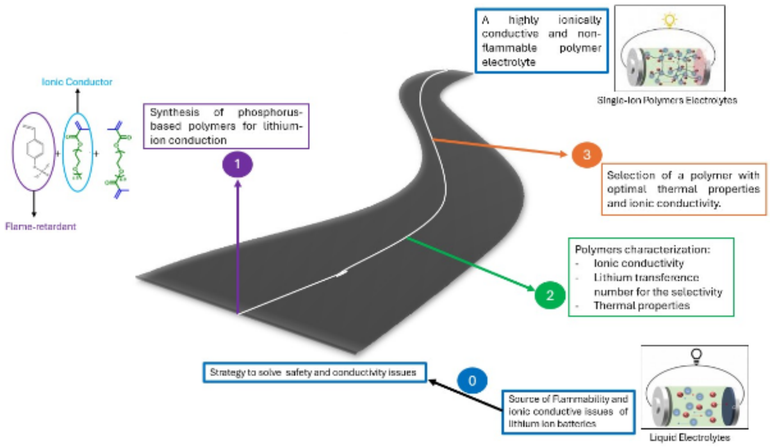

Figure 6: Incorporation of phosphorus containing moieties into lithium-ion conducting polymers

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Modelling and Study of All-oxide heterostructure for efficient and low cost solar-cell

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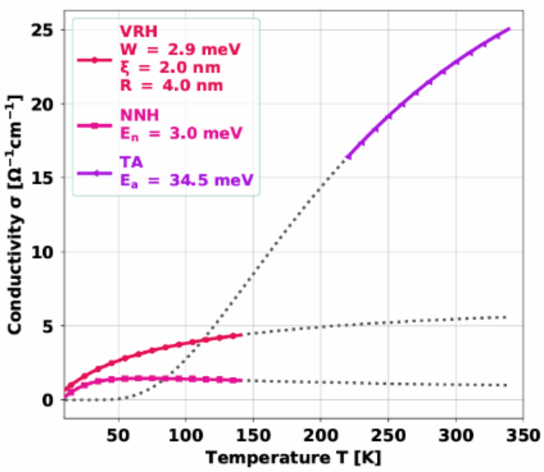
All-oxide-based heterostructures are emerging as promising candidates for next-generation photovoltaic devices due to their earth abundance, non-toxic nature, and tunable opto-electrical properties. These devices offer an environmentally friendly alternative to conventional silicon-based solar cells and typically consist of a transparent conducting oxide (TCO) layer, an n-type zinc magnesium oxide (ZnMgO) window/buffer layer, and a p-type cuprous oxide (Cu_2O) absorber layer forming a heterostructure.

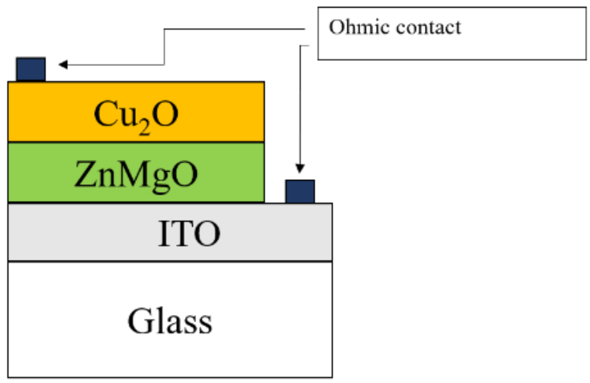
The objective of this work is to investigate conduction mechanisms in ZnMgO and Cu_2O thin films and to develop a functional all-oxide heterostructure with optimized electrical contacts. ZnMgO thin films deposited by ultrasonic spray pyrolysis were electrically characterized over a temperature range of 40–320 K. The results reveal a composition-dependent transition from variable range hopping (VRH) at low temperatures to nearest-neighbor hopping (NNH), followed by thermally activated conduction at higher temperatures, highlighting the role of defect states and carrier localization [1, 2].

Building on these insights, a three-step fabrication strategy was implemented, including the realization of Schottky contacts on ZnMgO and Cu_2O, followed by the fabrication of a complete Au/Cu_2O/ZnMgO/ITO heterostructure. The photoelectrical response was investigated using modulated photocurrent spectroscopy, enabling the extraction of quantum efficiency and identification of defect-related recombination pathways.

These results provide a comprehensive understanding of transport and recombination mechanisms in oxide semiconductors and establish a pathway toward scalable, low-cost, and environmentally sustainable all-oxide photovoltaic devices.



(a) Illustration of the three conduction mechanisms in ZnO-based alloys



(b) All-oxide heterostructure transverse design

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Scalable integrated photonic neural network for ultrafast analog processing of multimedia and telecom signals

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Reservoir Computing (RC) is an efficient machine learning framework for training large-scale recurrent neural networks by optimizing only the readout weights while keeping the internal "reservoir" fixed. Originally proposed by Herbert Jaeger [1] through Echo State Networks (ESNs), this architecture uses a randomly initialized reservoir to model complex dynamical systems with minimal training overhead. This approach has demonstrated exceptional capabilities in processing temporal data, particularly in tasks involving chaotic time-series prediction and complex dynamical system modeling. A key evolution is Time Delay Reservoir Computing (TDRC), pioneered by Appeltant et al. [2], which moves away from spatially distributed networks in favor of a single nonlinear node with a delayed feedback loop. By time-multiplexing the signal, this architecture creates a large set of computational nodes within the temporal domain. This paradigm shift has paved the way for robust physical implementations, particularly in photonics, where a single high-speed component can replace complex physical interconnections while maintaining state-of-the-art performance in time-series processing.

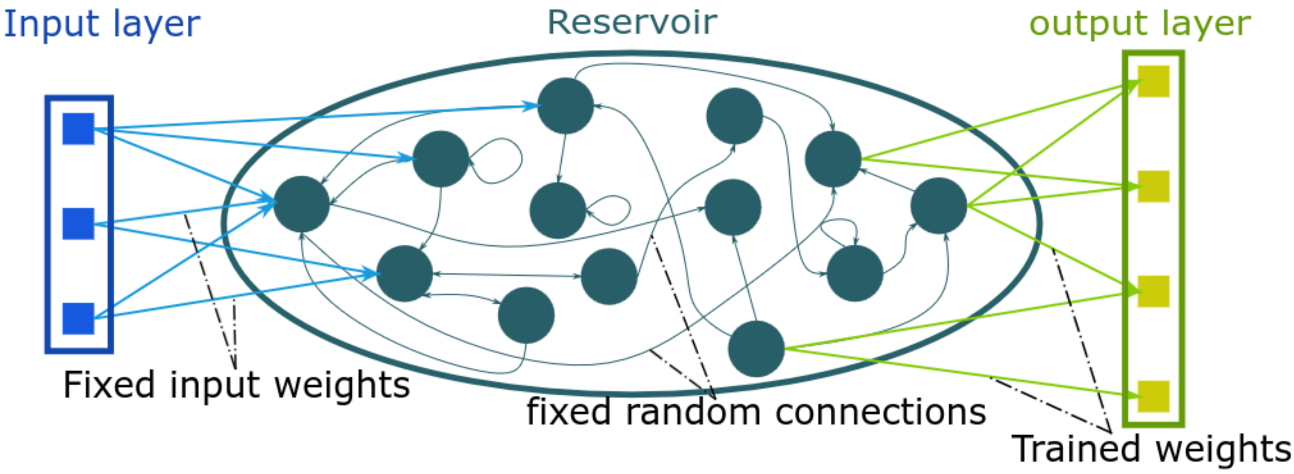

Figure 7: Representation of a Echo State Network (ESN)

References

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Pattern Dynamics Control via Orbital Angular Momentum and Airy Phase Engineering in Airy–Gaussian–Vortex Beams

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Since their first demonstration by Siviloglou *et al.* in 2007 [1], Airy beams have attracted interest for their non-diffractive, self-healing, and accelerating properties. The inclusion of orbital angular momentum (OAM) [2] led to the development of Airy–vortex beams [3]. In photorefractive (PR) crystals, the intensity distribution modulates the refractive index, controlling the evolution of spontaneously formed patterns [4], with OAM further influencing the dynamics [5]. We simulate counter-propagating Airy–Gaussian–Vortex (AiGV) beams through a PR crystal, as shown in Fig. 8**a**. Figure 8**b** shows that varying the OAM induces a tunable rotation of the patterns around the vortex singularity, with direction set by the sign of the topological charge.

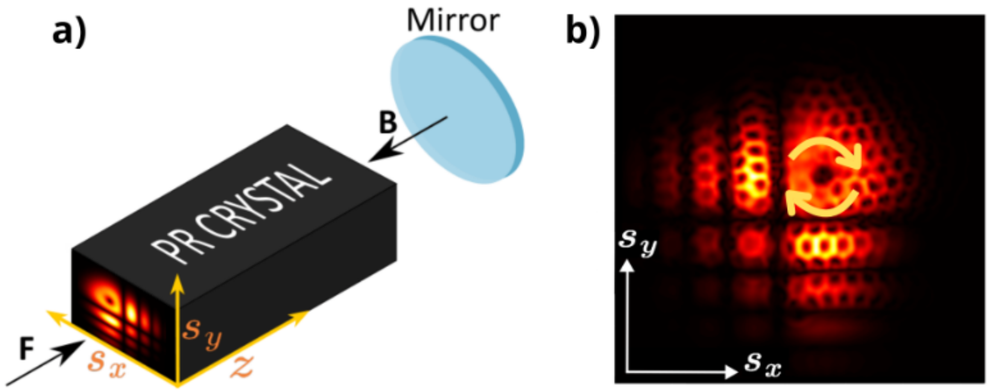

Figure 8: **a)** Schematic of the simulated interaction setup between a PR crystal and counter-propagating AiGV beams. F denotes the forward-propagating beam, and B the backward-propagating beam reflected from the mirror (reflected F beam). We denote s_x and s_y as the normalized spatial coordinates. **b)** Simulated transverse intensity profile of an AiGV beam with rotating patterns.

Our simulations demonstrate precise all-optical control of pattern dynamics in a photorefractive crystal. The topological charge regulates both rotation direction and speed. These patterns act as precursors to localized, erasable, and reconfigurable structures, offering potential for optical memory applications.

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Asynchronous networks of nonlinear electronic oscillators implemented on FPGA and FPAA platforms for information processing and NP-hard optimization

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Different challenges in computing motivate the search for fundamentally new computing architectures. In particular, NP-hard problems, a class of computational problems for which no polynomial-time solutions are known, often become intractable due to their unfavorable scaling. Similarly, the growing computational demands of modern machine learning models drive the need for more efficient information processing approaches. Among emerging paradigms, Ising machines have demonstrated the ability to address NP-hard combinatorial optimization problems by mapping them onto an Ising model and identifying its minimum-energy state, which corresponds to the optimal solution [1]. In parallel, alternative architectures for machine learning have been proposed, leveraging non-digital systems to achieve low-energy, high-throughput computation.

In this work, we investigate the use of autonomous Boolean networks for efficient information processing, with a focus on their application to the development of Ising machines and the solution of machine learning tasks. Autonomous Boolean networks consist of interconnected logic elements that operate continuously without a clock signal. These systems can exhibit complex, high-speed dynamics, such as chaotic behavior [2], that are inaccessible to conventional synchronous digital circuits. A network architecture capable of exhibiting chaotic dynamics, as proposed by Rosin et al. [2], is illustrated in Figure 9.

In particular, we aim to implement such networks using Field-Programmable Gate Arrays (FPGAs), which are widely available reconfigurable digital devices commonly used for prototyping and signal processing. Hence, FPGAs offer a promising pathway toward low-cost, flexible information processing systems. In parallel, the potential of Field-Programmable Analog Arrays (FPAAs), that is, devices that extend FPGA concepts with analog capabilities, will also be explored [3].

Initially, we aim to design novel building blocks suitable for constructing Ising machines on FPGA platforms, as well as modules applicable to machine learning tasks. Based on these building blocks, we seek to develop efficient methods for mapping problems onto physically realizable autonomous Boolean architectures. Finally, the proposed system will be evaluated on benchmark NP-hard optimization and machine learning tasks, enabling comparison with existing approaches.

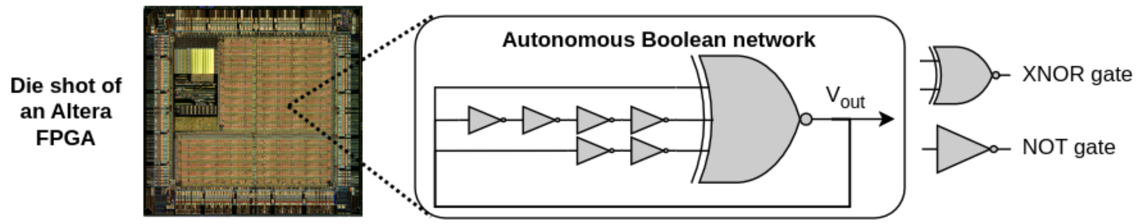

Figure 9: Architecture of an autonomous Boolean network designed to exhibit chaotic dynamics.

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