

# Photoniques

LIGHT AND APPLICATIONS | EOS &amp; SFO JOINT ISSUE

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Fresnel-Arago

**BUYER'S GUIDE**

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In optics and photonics

**FOCUS**

## PHOTONICS AND ARTIFICIAL INTELLIGENCE

- Microlasers for neuromorphic computing
- Free annotated data for deep learning in microscopy? A hitchhiker's guide
- Optical Neural Networks: The 3D connection
- Silicon Photonics for Artificial Intelligence Applications
- Photonic Reservoir Computing using Delay Dynamical Systems



**Artificial Intelligence:  
From electronics to Optics**

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## Editorial



NICOLAS BONOD

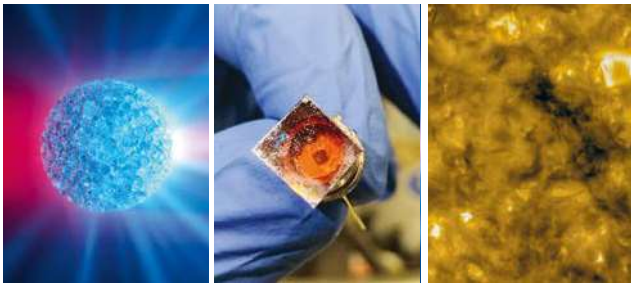
Editor-in-Chief

## Photonics and AI: from the software to the hardware

Advances during the 19<sup>th</sup> century in optical microscopy, together with the discovery of silver nitrate staining of nerve cells, allowed Santiago Ramón y Cajal to prove in the 1880s that nerve cells are single entities transferring impulses through nerve synapses. This discovery forged a solid link between neural networks and optics. The 20<sup>th</sup> century saw the rise of artificial neural networks with pioneering works by McCulloch & Pitts in the 1940s followed by the development of perceptrons by Frank Rosenblatt in the 1950s. While artificial intelligence has now become ubiquitous in a wide range of scientific fields thanks to the development of deep learning, photonics has retained this privileged link with artificial intelligence: not only are deep learning techniques revolutionizing many areas of optics such as imaging or inverse design, but photonics is now addressing the development of all-optical artificial neural networks. Photonic technologies aim at creating a new paradigm in computing and data processing by designing optical processors no longer based on von Neumann's architecture, as computing has been for the last 70 years, but on neuroinspired architectures. This issue of *Photoniques* is thus dedicated to one of the greatest scientific challenges of the 21<sup>st</sup> century and shows us how photonics will be at the centre of future breakthroughs in computing and data processing.

The finalization of this issue was marked by the announcement of the 2020 Nobel Prize Laureates. The Physics Prize celebrates theoretical advances in the formation of black holes (Roger Penrose) and the discovery of a super-massive black hole at the centre of our galaxy (Reinhard Genzel, Andrea Ghez). This latter prize builds on an impressive list of Nobel prizes related to optics or rewarding discoveries made possible thanks to optical techniques and technologies. The observation of this super-massive black hole has been made possible by the combination of several optical techniques such as interferometry and adaptive optics to compensate in real-time atmospheric turbulences. The implementation of these techniques in telescopes, including the European Southern Observatory's Very Large Telescope, has allowed precise tracking of stellar orbits from which the presence of black holes are deduced.

As we can see, optical techniques and technologies are solidly to the fore in the greatest scientific adventures of this 21<sup>st</sup> century, from the exploration of the universe by our giant telescopes to the design of optical perceptrons that will revolutionize tomorrow's computing. *Photoniques* will have so many topics to report on due to the exciting scientific adventures of photonics in the 21<sup>st</sup> century.



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Highlights & news from our 7 partners!

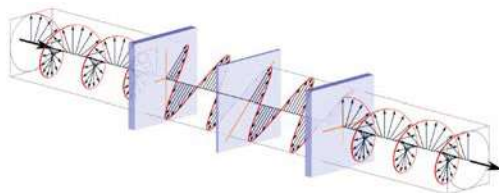


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# EOS/SFO forewords

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**PHILIPPE ADAM**

President of the French Optical Society

**S**ix months since our last issue of our magazine in English. What's up since then?

The period leading up to the holidays was intense; it was mainly devoted to managing the agendas in order to ensure the continuity of the SFO's activities and to interface them with our communities, at the national and European level, in order to avoid possible "traffic jams" in the events agendas, caused by multiple postponements all around. Now after rescheduling our activities, we hope to come back to a normal situation... as far as the COVID will let us serenely work in the upcoming months! An important issue since that time is the change at the head of the European Optical Society. First, SFO would like to thank Umberto MICHINEL for his strong involvement and supporting activities for the benefit of the European optical community. Secondly, SFO would like to warmly congratulate Gilles PAULIAT for his election at the head of EOS. Of course, SFO and Gilles PAULIAT know each other very well over the years. It is a great pleasure to cross his path again: we have common plans for the years to come and a lot of exciting tasks to achieve. One of them is the organisation of the EOS Annual Meeting in France in 2021. SFO and EOS will work closely together.

Maybe another workshop to take care of in this somewhat disturbed period: the overall landscape could be a bit unstable; we are all aware about the consequences of the pandemic situation on our activities. A bit of concern is for the PhD students who should achieve their works in a fixed period. We will do our best to help them, at the national and maybe international level.

At the scientific level, I am happy the current issue is devoted to AI. The links with photonics are clear and the summary is quite promising, important as such for scientific knowledge and future developments, but crucial as well for many applications with strong social impacts: diagnosis and processing, population protection and crisis management, global resilience enhancement ... I am really looking forward to reading this magazine.

Now back to school time. It will be surely chugging along and the balances to work in serenity have to be implemented. So good luck to you all!



**GILLES PAULIAT**

President of the European Optical Society

**T**he present health condition worldwide strongly affects our social and working relationships. Our learned societies had to learn how to serve the optics and photonics communities under these news constraints.

Initially EOS planned to celebrate the European Optical Society (EOS) Annual international conference and industrial exhibition, EOSAM, under the warm sun of Porto, on 7-11 September 2020, organized together with the Portuguese Society for Optics and photonics, SPOF. However, to ensure the safety of our attendees, EOS made the difficult decision to move the onsite event into online. The organizers, all presenters made a considerable effort to provide high quality presentations. During EOSAM, 12 topical meetings, 4 plenary live sessions and a special project session were held, including the esteemed Emmy Noether distinction awarded by the European Physical Society to Hatice Altug. With more than 300 live attendees during the plenary talks and more than 350 replay views of sessions, this first time ever online event in the history of EOS was a great success.

The situation thus prompted us to learn new ways for remote working with some positive facets: from an ecological point of view of course but also because the possibility to pause and play videos gives additional insight in the scientific content. Once the crisis is over, we should continue to use these tools to strengthen our ties. Do not hesitate to contact and share your ideas with your learned societies in which you are the real players. From this year on, EOSAM becomes a yearly event. It moves around Europe to better interact with the local communities and create a unique experience for the attendees. Next EOSAM will be held in Paris on 6-10 September 2021. EOS will organize it jointly with the French Optical Society, SFO. Save already the date to contribute to EOSAM2021, to meet in-person and to make this event our next big common success! Apart from meetings, we have many other ways to keep in touch and stimulate the imagination. "Photoniques" is the journal of the French Optical Society. This special SFO/EOS issue about "Photonics and Artificial intelligence" is a nice way of sharing our thoughts. Let's invent the world of tomorrow. I wish you an insightful reading.

## AGENDA



■ **OPTIQUE Dijon 2021,**  
**5 au 9 juillet 2021**  
**Congress of the SFO**  
**Congrexpo - Dijon - France**

ATTENDEE REGISTRATION  
IS NOW OPEN

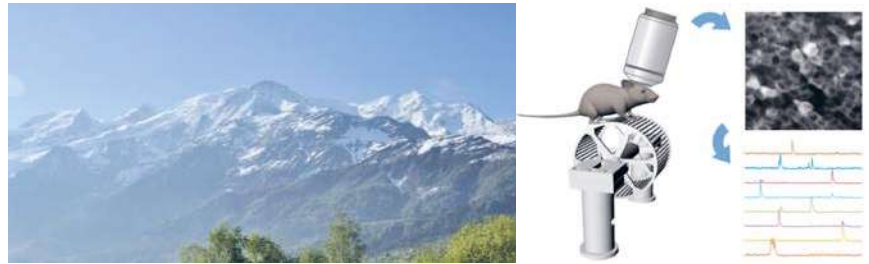
RESERVATION IN THE  
INDUSTRIAL EXHIBITION  
IS NOW OPEN

**OPTIQUE Dijon 2021** covers a wide range from the fundamental to the applied research, industrial developments and pedagogical innovations. An exhibition area for photonics industry, including start-ups, will be set up at the heart of the congress. This congress provides fertile ground for beneficial exchanges between the actors of optics and photonics.

**Professor Gérard Mourou,** Nobel Prize in Physics 2018, will deliver the keynote opening plenary speech in this congress. OPTIQUE Dijon also includes plenary sessions led by guest speakers renowned internationally for their expertise, several thematic conferences and poster sessions.

■ **PHOTONICS EXCELLENCE DAYS 2020,**  
**November 26 - 2020**  
**Proposing of the SFO**  
**IOGS - PALAISEAU**

**All the events of the SFO:**  
[www.sfoptique.org/agenda/](http://www.sfoptique.org/agenda/)



## SCHOOL IN LES HOUCHES, 25–30 APRIL 2021

### ALL-OPTICAL INTERROGATION OF NEURONAL NETWORKS IN VIVO

Thanks to the development of optogenetics, activity of neural networks can be recorded and modulated using optical methods. Thereby, these methods have become major tools for studying the neural mechanisms underlying perception, memory and behavior in animal models.

In this school, we will describe the different fluorescence microscopy techniques that have been developed and used to record neuronal activity in vivo, as well as the methods that enable modulating activity according to precise spatio-temporal patterns. We will first discuss the theoretical bases of these methods, and then we will present recent advances that have improved their speed, depth of penetration, field of view (2D and 3D), and applicability to the awake animal, both in head-fixed and unconstrained configurations. We will also give an overview of the palette of optogenetic tools available and the associated targeted labeling technologies. Finally, we will discuss the methods for analysis of raw functional signals, showing the wealth of information that these experiments can provide. The school is designed for students and researchers in neurophysiology using optical methods and for physicists participating in their development.

#### CONTACT

Cathie VENTALON et Laurent BOURDIEU From IBENS – The ENS Institute of Biology  
 Schedule – Submission campaign : November 26th, 2020 – February 1st, 2021

**For more information:** <https://www.sfoptique.org> – section "Écoles thématiques de la SFO"

## FREEFORM OPTICS: ISSUES & CHALLENGES IS NOW OPEN

*5<sup>th</sup> edition of days of the SFO "Club Calcul Optique"*

*19–20 november 2020 • IOGS – Institut d'Optique Graduate School • Palaiseau – France*

The SFO "Club Calcul Optique" is organizing its 5th edition of days of discussion around the issues and challenges of "freeform" optics, a technology that is now spreading very quickly in the world of photonics and our daily lives. The 2020 edition of these days will bring together many academic and industrial players involved in the design, production, metrology, and integration of freeform optical components.

#### CONTACT

Yan CORNIL (LIGHTTEC)

Yvan SORTAIS (Group of Industrial Photonics – CHARLES FABRY Laboratory - IOGS)

For more information: <https://www.sfoptique.org> – section "Conférences des clubs SFO"