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Thursday,

October 13th, 2022

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Photonics

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Plenaries 1 Auditorium, 9:15 – 12:15

Chairs: Carmelo Bastos Filho and
Anderson S. L. Gomes

9:15 Opening Ceremony

9:30 The world of optical solitons in ultrafast fiber lasers (Philippe Grelu): I will provide a short introduction about the milestones that led to the generalized use of fiber lasers, from the research lab to the industry. Then, I will focus on the generation of short and ultrashort pulses from fiber lasers. The fiber cavity medium involves in general a substantial participation of nonlinear and dispersive effects. That is why soliton concepts have always been closely related to mode-locked fiber laser operation. I will show how the goings and comings between experiments and theoretical considerations have made these concepts evolve, toward the generalized notion of a dissipative soliton, which made scientists move beyond conventional laser stereotypes. I will illustrate how the fiber laser platform allows us to experiment vivid signatures of the complex nonlinear dynamics of temporal solitons, such as soliton molecules and complexes, which turn out to manifest some analogies with their matter molecule counterparts.

10:45 Metal-Nanostructures for Nonlinear Photonics (Cid Bartolomeu de Araújo): Nonlinear optical experiments with metal-nanoparticles and metal-nanoclusters hosted in liquids and glasses will be reported. The metal-dielectric nanocomposites were produced by selecting the nanostructures compositions, shapes, densities, and spatial arrangements, as well as by choosing appropriate hosts. Optical nonlinearities beyond the third-order were observed and characterized. The stable propagation of spatial-solitons was studied along with the guiding of gaussian light beams using optical vortices. A procedure for optimization of all-optical switches, the upgraded operation of optical amplifiers in the shortwave infrared region (SWIR), the optical modulation based on the dynamic control of gold nanorods driven by an external electric field, and the study of the nonlinear behavior of a metal-metasurface in the SWIR, will be described to illustrate proof-of-principle applications of nanocomposites.

11:30 Understanding the optics of the retina and photoreceptors with ballistic photons (Brian Vohnsen): The photoreceptors of the retina are highly directional in their sensitivity to light. This shows in visual optics via the classical Stiles-Crawford effect of the first kind and in retinal imaging by

highly directional backscattering of light. In this contribution we review our work on understanding the optics of the photoreceptors in both healthy eyes and in eyes affected by retinal degenerations combining psychophysical optics measurements with optical imaging and eye modelling. Finally, we discuss how the optics principles may be involved in the process of emmetropization that hinders myopia onset and in detecting the sign of defocus in the process of accommodation and on how the knowledge gained may be used in the development of new ophthalmic lenses.

Optical Communication 1

Auditorium, 14:00 – 15:30

Chair: Joaquim Ferreira Martins Filho

14:00 **(Invited) Wideband Amplification for the Next Generation of Optical Transport Networks (Marcionilo José da Silva):** The data transmission over optical channels in wideband systems is an important alternative to increase the capacity of the current optical transport networks without a significant increase in implementation and operational costs. However, to allow these systems to achieve long-reach transmissions, the development of appropriate optical amplifiers to provide high gain with low noise insertion in each new optical band to be explored is a crucial step. This work briefly describes the main technological alternatives with suitable performance and complexity for high-capacity optical links in the extended C+L band, including fiber-doped, Raman-based, and semiconductor optical amplifiers. The amplifiers' characteristics, most common use cases, design and optimization methodology based on Artificial Intelligence techniques, as well implementation and commercial challenges are discussed in this paper.

14:30 **Routing Traffic Distribution and the Performance Correspondence for Optical Networks (Kelly Costa Fábio Della Nina and Luiz H. Bonani):** In this article, we analyze the performance of optical networks according to some scenarios of routing traffic distribution that include a strategy based on the population served by the network nodes. Blocking probability and the average utilization are evaluated for the National Science Foundation (NSFNET) and the Pan-European (PANEUR) topologies. Moreover, statistics on the routing traffic distribution are achieved and discussed to establish a correspondence between the characteristics of routing traffic distribution and the respective network performances.

14:50 **FE-OCDMA applied to C-RAN fronthaul in future mobile networks (Arthur G Bueno and Andrea Chiuchiarelli):** An optical access link, based on Frequency Encoding Orthogonal Code Division Multiple Access (FE-OCDMA) for mitigation of Rayleigh backscattering crosstalk, is presented and analyzed. The proposed system supports up to 7 users, all sharing the same optical wavelength through a bidirectional fiber, allowing for full-duplex transmission. Results show that FE-OCDMA coding shows higher resilience to optical crosstalk compared to uncoded NRZ-OOK, allowing a data rate per user of 1 Gbps with BER lower than 10−3 at 7 dB signal-to-crosstalk ratio.

15:10 **Estimating Amplifier Cascade Output Signal Using an Artificial Neural Network and Considering Tilted Signals (José C. Pinheiro, Erick A. Barboza, Marcionilo José da Silva, Carmelo Bastos-Filho, Joaquim F. Martins-Filho):** We adapt and optimize an output power estimator based on an artificial neural network (ANN) to work in a scenario with multiple amplifiers (cascade). The optimization is made considering the ANN number of hidden layers and the number of neurons in these layers. The optimized ANN is applied in three link scenarios with a different number of amplifiers and different power tilt profiles. Results show that the model achieved less than 2.5 dB of absolute error median considering the scenario with 20 amplifiers and the worst power tilt profile.

Optics and Instrumentation

Room 2, 14:00 – 15:30

Chair: Marcio Miranda

14:00 **(Invited) Scattering evaluation in nanoparticle liquid suspensions using Z-scan-thermal-lens configuration (Georges Boudebs):** The understanding of nanoparticles scattering is very important, especially for the medical area where the majority of imaging techniques and photothermal therapeutic applications are subject to this phenomenon. Also, distinguishing thermal lens effect from electronic third-order nonlinear response could help to better understand fundamental physics. In this talk, the main characteristics of the thermal lens effect is studied as a time-resolved Z-scan configuration using cw-single Gaussian beam. We will focus on the evaluation of the measurement error from statistical calculations also to check the linearity of the response and the way to extract the thermo-optical characteristics of different absorbing liquids. The results will be

applied to demonstrate the feasibility of absorption and scattering efficiencies determination on gold nanoparticles of 5 and 50 nm diameters.

14:30 **Anomalous diffusion on a two-particle quantum walk (Rodrigo Barbosa, Igor de Oliveira, Pedro de Figueirêdo and José Ferraz:** In this work, we theoretically investigate a one-dimensional bosonic and fermionic discrete quantum walk, affected by a temporal disorder. Specifically, we study how the wave-function symmetry and the phase disorder distribution affect the final coincidence probability and transport properties of a 100-step quantum walk. The degree of randomness is suitably adjusted by the disorder distribution width and different diffusion exponents of quantum state regimes are achieved, ranging from the classical diffusion ones to the ballistic propagation.

14:50 **Chemical sample classification using autoencoder-based spectroscopy (José Paulo G. de Oliveira, Carmelo Bastos-Filho, Sergio C. Oliveira):** We present a Proof of Concept of a chemical sample classifier. Instead of spectrometer, we use autoencoders, which are machine learning models that try to reconstruct at their output images presented at their input. The autoencoder is trained with spectrograms generated from optical signals detected after propagating through the sample. The signal shape is specifically designed and the emitted wavelength varies as a function of time. Over propagation through the sample, the signal is partially absorbed. Since absorption depends on sample's transmittance, the detected signal represents a signature. Hence, based on reconstruction error, the autoencoder performs classification with 100% accuracy.

15:10 **Characterization of nonlinear optical constants in turbid media using the Scattered Light Imaging Method (Kelly Jorge, Anderson M. Amaral, Albert Reyna, Cid Araujo and Leonardo Menezes:** Scattering is an intrinsic characteristic of several relevant media, as biological materials or the atmosphere. While the retrieval of nonlinear optical constants inside such media is challenging, the Scattered Light Imaging Method has been recently proposed as a tool to characterize the nonlinear optical constants using single laser shots. Theoretical and experimental results show that the SLIM signal can not only determine the optical constants, but it is also able to distinguish nonlinear absorption from elastic nonlinear scattering (an often ignored phenomenon). The present discussion shall be particularly relevant for biological samples or colloids containing metallic or high-index materials.

Nanophotonics and Plasmonics 1 Room 3, 14:00 – 15:30

Chair: Luis Arturo Gómez Malagón

14:00 **(Invited) Illuminating materials: The materials science of light emitting diodes (Rachel Oliver):** About a quarter of the electricity generated worldwide is used for lighting. Energy efficient light bulbs based on light emitting diodes (LEDs) are about five times more efficient than traditional incandescent bulbs, and hence have the potential to allow enormous energy savings. The key material used in LEDs which emit white light is gallium nitride, a human-made compound, which has never been observed to occur in nature. Optimising this new material to make LEDs which are efficient, long-lived and reasonably affordable has been a huge challenge, and despite the undoubted commercial success of these devices many aspects of their operation remain mysterious. Materials scientists can take LEDs apart, literally atom by atom, to understand their structure and how this controls their properties. The relevant techniques emerged from traditional metallurgy, but are now being used to understand materials for cutting edge optoelectronic devices, illustrating how the basic principles of materials science are vital to the development of the technologies of tomorrow.

14:30 **Solar Harvesting Application with Gold Nanospheres: the Influence of Particle Size (Túlio L. Pedrosa, Caio V. P. Vital, Diego Rativa, Luis Malagon and Renato Evangelista de Araujo:** Plasmonic nanoparticles have been applied to solar energy harvesting devices to improve their performance. In this work, we propose to evaluate the effects of gold nanosphere size on solar harvesting for thermal applications. The nanoparticle absorption spectrum is obtained using Mie Theory, and the spectral match with the sun is evaluated. Moreover, the temperature variation in the particle neighborhood is analyzed. Results show that the amplitude of the absorption peak decreases with size, but its broadness increases. Furthermore, the dimensions of nanospheres that maximize solar energy absorption and temperature increase in the surroundings of nanoparticles are determined.

14:50 **Aminolevulinic acid-based metallic nanoparticles: Applications in Agriculture (Isabela Lopes, Marcia Franzolin, Susana Barreto, Carla Lopes and Lilia Courrol):** Aminolevulinic acid is a plant growth regulator and essential precursor for chlorophyll biosynthesis; besides, its photodynamic activity can be used to exterminate microorganisms in plants and soil. In

this study, silver and gold nanoparticles capped with aminolevulinic acid (ALANPs) were synthesized by the photoreduction method and characterized by UV-Vis, transmission electron microscopy, and Zeta potential. The effect of ALANPs was evaluated on stalks of E. densa by measuring the fluorescence of chlorophyll extracted from the plants after incubation with nanoparticles. The antimicrobial activities were obtained. The results suggested that ALANPs could be suitable for applications as nanopesticides and nanostimulants simultaneously.

15:10 **Study of Interferents of a Plasmonic Sensor for Uremic Toxins (Elberth Manfron Schiefer, Andressa Santos, Marcia Muller,Andréa Stinghen, Lucas H Negri and José L Fabris:** This work shows the selectivity of a colorimetric sensor based on albumin bound to citrate-capped silver nanoparticles. The sensor capability of quantifying protein-bound uremic toxins, such as indoxyl sulfate, and uremic toxins that do not bind to proteins, such as creatinine and urea, is demonstrated. Furthermore, optimal sensor outputs were obtained independently of the silver nanoparticles concentration, indicating that smaller nanoparticles are possibly responsible for the sensing of below-uremic concentrations of uremic toxins.

Lasers 1 — Auditorium, 16:00 – 17:50

Chair: Carlos Jacinto

16:00 **(Invited) Flexible, Stretachable, Plasmonically Enhanced Random Lasers and Random Fiber Lasers (Anderson S. L. Gomes):** Random Lasers (RLs) and Random Fiber Lasers (RFLs) are coherent optical sources whose optical feedback mechanism to sustain oscillation in the gain material comes from scattering in a disordered media, rather than from two static mirrors. Even though they are cavityless, they are not modeless, and generally behave as multimode lasers. The subject was first theoretically introduced in 1967, has been recently reviewed. In this talk, I will briefly review the state-of-the-art in RLs and RFLs and focus on one of the main advantages of this photonic device, which is their ability to be flexible and stretchable, yet emitting coherent radiation, besides being able to take advantage of plasmonic enhancement due to its interaction with metallic materials. Examples for biomaterials host for RLs will be emphasized.

16:30 **Numerical solution of atmospheric laser beam propagation using artificial compressibility and pseudo-spectral methods (Paulo Jorge de Morais and Rubens Cavalcante da Silva, Wagner de Rossi and Claudio C. Motta):** In order to analyze the thermal blooming on wireless power transmission and remote recharge of batteries this study proposes a coupled numerical solution. The Navier-Stokes, Energy and Paraxial equations to a laser beam propagation through the atmosphere are solved by artificial compressibility and pseudo-spectral methods. Changes in refractive index due to asymmetric temperature variations are the cause of this optical phenomenon. Numerical results are compared with reference studies and good agreement is obtained. The conditions: laser beam, power density and absorptivity are constants; flow regime of Re=1000, Ri=10.e (4), laser wavenumber k=10.e(5), and Stanton number St=1/30.

16:50 **Solution of an YDFA in Tandem-Pumping configuration with ASE using the RK4 method (Pedro Bernardo S. Melo, Ricardo E. Samad and Claudio C. Motta:** The formulation of a tandem amplifier using a 30/250 µm doped fiber was improved by the use of the rate equations solution for the amplification of the spontaneous emissions in these multikilowatt systems. The model precisely describes the behavior of a fiber amplifier with a 5986kW, 1018nm pumping, and a signal seed of 75W at 1080nm, and solves the propagation and rate equations using the fourth-order Runge-Kutta method, also using the relaxation method as a convergence criterion for the integrations.

17:10 **Ultrafast laser micromachining of submillimetric de Laval nozzles in alumina for laser electron acceleration (Armando V. F. Zuffi, Fabio Tabacow, Nilson Vieira and Ricardo E. Samad):** We have explored the fabrication of submillimetric de Laval nozzles by ultrashort laser pulses micromachining in alumina, a dielectric ceramic, to generate supersonic gas jets in vacuum. The nozzles were manufactured in a home-built trepanning setup, and their geometry and surface quality dependence on the laser and machining parameters was investigated, aiming to control the jet spatial density to produce optimal gaseous targets for laser electron acceleration.

17:30 **(Technical Talk) Sensores FBG em aplicações de SHM - Structural Health Monitoring (Danilo Ginez, Hottinger Brüel and Kjær A/S)**

Integrated Photonics 1 Room 2, 16:00 – 17:50

Chair: Cid. B. de Araújo

16:00 **A Finite-Difference Time-Domain analysis of Fiber Bragg Gratings (Davi P. Nacaratti, Ricardo E. Samad and Claudio C. Motta):** An analytical formulation and modeling of optical fiber Bragg gratings has been developed, and is reported in this paper. Supported by the Finite-Difference Time-Domain (FDTD) method, it was possible to set a 1018nm Bragg grating and simulate an electromagnetic field going through its periodic refractive-index structure, obtaining its reflectivity, transmittivity, and bandwidth. Moreover, the model was applied to analyze the influence of structural parameters of fiber gratings, such as length, grating period and refractive index modulation on its spectral response.

In this talk, we show a particular scatterometry technique, in which a coherent light beam is focused by a lens on a surface to be inspected and the scattered light is collected and detected in the far field. This technique has been successfully used for characterization of nanostructures and contamination detection for the semiconductor industry.

16:30 **Fabrication of Rib Waveguides with 3D printing and their Characterization (Fábio G Borges and Bruno Denadai, Andréia Macedo, Juan Pérez, Neri Volpato and Alexandre Pohl):** This work describes the fabrication of optical rib waveguides with the Vat photopolymerization technique. Results of surface roughness and material absorption, which impact the quality of the fabricated structures are presented and discussed.

16:50 **Role of the ZnO crystallinity on the Er3+ Optical Emissions (Camila Ianhez-Pereira, Marcio Godoy and Ariano Rodrigues):** We report on the correlations between optical emissions of Er3+ and structural properties of ZnO host thin films. The films were deposited by spray pyrolysis using high and low precursor dilution (molarity) conditions, which influence the crystal order. Structural and optical measurements correlate the use of a lower molarity with a transparent film texturized in c-axis and strong Stark effect in infrared emission. In contrast, emissions in visible range are present only in high molarity film.

17:10 **Spatial coherence mapping using NV centers in diamond (Lucas N. S. de Andrade, Charlie O. Oncebay Segura and Sergio R. Muniz):** The nitrogen-vacancy (NV) centers in diamond became, in recent years, an excellent solid-state spin system for quantum sensors due to their electronic spin properties. Especially for their easy manipulation and optical initialization

at room temperature. Works have reported its use as a sensor for temperature, strain, electric fields, and mainly a sensor of magnetic fields. This work demonstrates another use of NV centers, reconstructing a coherence map using an engineered sample of ultra-pure diamond and a CCD camera.

17:30 **Numerical simulation on modified chemical vapor deposition (MCVD) thermal flow field (Rubens Cavalcante da Silva and Paulo Jorge de Morais, A Carvalho, Wagner de Rossi, and Claudio C. Motta):** To modeling the SiCl4 oxidation reaction in the modified chemical vapor deposition (MCVD), this study determines the hydrodynamic and thermal properties of flow field using a CFD steady-state simulation. The Navier-Stokes, continuity, energy and species equations were solved by the Finite Volume Method over a cylindrical domain rotating at 45rpm, 24mm diameter and a flow regime of Re=900. User defined functions were developed on STAR-CCM+ code to modeling SiCl4 oxidation, which occurred in the zones with the highest temperatures (1800K) determined by the torch heating profile. The numerical results were compared with a reference study and good agreement was obtained.

Sensors, Image and Illumination 1

Room 3, 16:00 – 17:50

Chair: Eduardo Fontana

16:00 **(Invited) Optical and Fiber Optic Sensors – Theory and Applications (Marcelo Martins Werneck):** Prepared by a top expert in the field, with many developments, real applications and patents, this lecture will be an invaluable resource for physicists, electronic engineers and will be well accepted by teachers, students, technicians and those working in the sensor area. This lecture discloses the advantages and capabilities of optical fiber sensors in research and industry, including two technologies, the plastic optical fiber (POF) and the silica fiber. Apart from presenting several technologies applying the POF as a sensor, this tutorial will also deal with another kind of technology, the Fiber Bragg Grating (FBG). FBGs can be found in many industrial applications and I will show our experience in applying FBGs in many types of sensors for the electric energy industry. The tutorial starts with the theory of optical fiber sensors applying both POF and FBG. Then it focuses on several practical uses of sensors including successful field applications designed by our laboratory in areas such as Oil & Gas, Biotechnology and Electrical Energy. The following topics are presented and

discussed throughout the lecture: Optical Fiber Sensors technologies; Temperature Sensing; Strain & Force Sensing; Refractive Index Sensing; High voltage switch monitoring; Current & Voltage Sensing; Gas Sensing; Chemical & Biological Sensing; Oil Leaking Sensing; High voltage and high current measurements; Gas flow velocity measurements.

16:30 **Application of optical microsphere in fiber optic sensors for measurement of electrochemical processes: Paulina Listewnik):** Examination of chemical phenomena is crucial in sensing and detection of bisphenol A in waste. In this paper, the investigation of the electrochemical processes using micro-sphere fiber-optic sensor with a zinc oxide (ZnO) coating applied by Atomic Layer Deposition method (ALD) is presented. To perform the measurements, a three electrode setup was used. During the process, the decomposition of a bisphenol A solution in 1M KNO3 was observed.

16:50 **Computational Modeling of D-shaped Optical Fiber Nitrate and Sulfate Sensor (Thales H. Castro de Barros, Henrique Patriota Alves, Renato Evangelista de Araujo and Joaquim F. Martins-Filho:** Sulfates and nitrates are ions that are present in many important chemical processes such as the manufacture of fertilizers. This work proposes the use of single-mode D-shaped optical fiber (SMF-D) as an optical sensor platform to measure the concentration of these ions. Computational modeling, exploring the finite element method, was explored in the evaluation of the fiber sensor performance, considering ammonium nitrate and ammonium sulfate, with 10%, 25% and 40% concentrations, in water solution. The proposed optical sensor presents a sensitivity of 0.0016 dB/% for ammonium nitrate solutions and 0.00151 dB/% for ammonium sulfate solutions.

17:10 **Polarizing fiber temperature sensor powered remotely by circularly polarized light (Martin Kyselak, David Grenar, Jiri Vavra, Zdenek Vylezich and Karel Slavicek:** From their conception, optical fibers have been primarily used in telecommunications technology to transmit data using non-polarized light. Nowadays, however, the development of fibers has advanced considerably and new applications have been discovered. One application is utilizing optical fibers as sensors, predominantly polarizing fiber sensors working with polarization-preserving fibers. Their use thus extends to the temperature/pressure sensor used in this work. This article deals with the issue of temperature measurement using a single-mode sensory polarization maintaining fiber. Since this fiber is not circularly symmetrical, or rather, the stress elements inserted into this fiber are utilized, birefringence occurs in its core.

17:30 **Hollow-core fibers for curvature sensing (Jonas H Osório, William M Guimarães, Marcos A. R. Franco and Cristiano MB Cordeiro:** We develop on an approach for assessing curvature variations by using hollow-core photonic crystal fibers. The sensing method described herein relies on an azimuthally asymmetric tubular-lattice hollow fiber and explores the bend-induced spectral shifts of the cladding tubes' resonances. By numerically analyzing the transmission properties of such fiber architecture, we show that this platform can detect both curvature magnitude and angle. We understand that this study widens the framework for hollow-core fibers applications within the sensing scenario.

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Plenaries 2 Auditorium, 9:00 – 12:30

Chairs: Diego Rativa and Renato E. de Araujo

9:00 **Microwave Photonics and Application to 6G systems (Arismar Cerqueira Sodré Junior):** This seminar is going to concisely and comprehensively covers all-important aspects of diverse 5G optical-wireless communications (OWC), including the fundamentals and state-of-the-art of free space optical (FSO), visible light communication (VLC) and radio over fiber (RoF). Moreover, implementations of 5G New Radio (5G-NR) Fiber/Wireless (FiWi) systems based on FSO, VLC, RoF and power over fiber (PoF) towards the sixth generation of mobile networks (6G) are going to be reported into details. Deployments of 5G-NR FiWi systems operating in the 26 GHz frequency band at dozens of Gb/s throughput, as well as the concept and implementation of machine learning (ML)-based pre- and post-distortion schemes for RoF systems are going to be demonstrated and properly discussed. All OWC experiments have been carried at the Laboratory WOCA (Wireless and Optical Convergent Access) from Inatel in the city of Santa Rita do Sapucaí-MG, Brazil.

9:45 **Exploring spontaneous emission for building up global quantum networks (Daniel Felinto):** The quantum internet is emerging as an extension of the protocols for quantum communication, incorporating local processing of information together with distribution of quantum entanglement among multiple sites. Even though quantum communication initially developed with a focus on local networks, in the last years large steps were given in the distribution of quantum entanglement through sattelites, stablishing the first quantum networks of truly global reach. Behind this trajectory of technological development, there has been also conceptual developments in the last decades about the ubiquitous nature of quantum entanglement and its presence in various natural phenomena routinely occurring around us. Here I will discuss this arch of ideas that goes from the observation of quantum entanglement is ever simpler phenomena, up to its control and application in quantum communication of growing distance and complexity. I will focus on the work of our group and in the recent perspectives of integrating this work in the global effort to develop technologies for a quantum internet.

11:00 **Status of Luminescence Nanothermometers for Biomedicine (Carlos Jacinto da Silva):** In recent years, there has been an increasing interest in luminescent nanoparticles (LNPs) as biocompatible optical probes for diagnostic, therapy and fluorescent probes. Special attention has been given to the use of nanoparticles as luminescent nanothermometers (LNThs) because the temperature is a fundamental parameter in a variety of areas. In biomedicine, for example, the temperature is one of the most critical parameters affecting the dynamics of living specimens due to the strong temperature dependence of cellular dynamics, since abnormal temperatures could induce irreversible effects. Furthermore, small temperature anomalies could indicate many diseases or health dysfunctions such as tumors, inflammation, so on. Therefore, the local temperature monitoring can be used as an effective early detection procedure and for therapy as well. Unfortunately, recent results have raised some concerns about the reliability of "classical LNThs" due to the presence of non-negligible tissue-induced spectral distortions. The scientific community is, in fact, looking for a straightforward solution to this problem that would allow continue to consider LNThs as a reliable and robust technique for intratumoral thermal reading. In this talk, it will be presented in a well-summarized form what has been done on fluorescence and thermal images applied to biological systems.

11:45 **From machine learning for photonics to photonics for machine learning in fiber-based and integrated devices (Roberto Morandotti):** AI and Machine learning (ML) find increasing applications in the field of photonics. On one hand, ML can assist photonics via the use of evolutive algorithms that can be used to optimize the response of a given device or process. As an example, the straight-forward on-chip design of an unbalanced Mach-Zehnder interferometer cascade (UMIC) can be used for either custom-tailoring the spectrum of supercontinuum generation, or to perform efficient pulse shaping in the (tens of) picosecond(s) regime via temporal coherence synthesis. On the other hand, photonics can assist ML. Specifically, artificial neural networks (ANNs) are capable to classify different sets of data and are of significant interest for machine learning tasks such as computer vision, speech recognition, playing board games and medical diagnosis, to name only a few. Optical-based neural networks are especially attractive as they have the capability to dramatically accelerate the computing speed of ANNs and thus overcome the intrinsic bottleneck in bandwidth that currently limits the performance of electronics-based

approaches. Furthermore, a specific class of ANNs, namely Convolutional Neural Networks (CNNs), is capable to greatly reduce network complexity without affecting the accuracy of the predictions by a fully connected neuronal network. In this talk, I will give an overview of some of these approaches and will discuss both advantages and limitations.

Optical Communication 2

Auditorium, 14:10 – 15:30

Chair: Daniel Augusto Ribeiro Chaves

14:10 **(Invited) Integrated photonics in access networks: the challenges (António Teixeira):** In this work we will address the specific field of access networks and FTTH. The particularities of this field and context make all developments more demanding. In one hand the players see the opportunities that this brings, like billions of subscribers eager for bandwidth, and on the other the same see the challenge of the cost/maturity point that each service or interface has to reach in order be able to be mass deployed. These challenges will be addressed by comparing the existing bulk approaches being partitioned today and how the integrated photonics world is developing its ecosystem and techniques to surpass the challenges.

14:30 **Performance Evaluation of Elastic Optical Networks under Scenarios with Unequal Distribution of Service Types per Route Length (Fábio Della Nina and Kelly Costa and Luiz H Bonani):** This paper addresses the problem of heterogeneously distributed service types according to the route lengths and the impact on the EON performance. Blocking probability in different aspects of the network, such as network-related, inter-service, and considering specific route lengths, is evaluated according to a methodology that changes the percentage of services in the routes with specific lengths, keeping a fixed network load. A 4-node bidirectional ring topology is used to present the methodology and evaluate the initial scenarios. However, this strategy can be generalized to other scenarios, standing as a helpful tool to assess the coexistence of diverse modulation formats.

14:50 **Design of a coherent optical receiver on a silicon nitride platform for mode multiplexed systems (Ítalo Albuquerque Araújo, João Gadelha and Adolfo Fernandes Herbster):** Current coherent optical systems carry information at high bit rates over long distances in single-mode optical fibers. However, expanding data traffic is increasingly demanding higher transmission rates which could be employed by spatial mode multiplexing. In this work, an

optical hybrid for C-band on a silicon nitride platform is proposed. The hybrid is composed by a 2x2 and 1x2 multimode interferometers, and a mode converter. Losses less than 0.5 dB and 0.75 dB for TE0 and TE1 modes are achieved and common mode rejection ratio near 50 dB, and phase error below 0.5°.

15:10 **Theoretical Analysis of the Transmission Efficiency of a (6 + 1)×1 Pump-Signal Combiner (Lucas Mendes, Ricardo E. Samad and Claudio C. Motta:** An analytical formulation for the transmission efficiency of a (6 + 1)×1 pump-signal combiner has been developed and is reported in this paper. The formulation is supported by the Coupled Mode Theory (CMT), and the Finite Difference Beam Propagation Method (FD-BPM). Within this scope, the characteristics of the commercial fibers FG200AEA, GDF20/200, P-20/400DC were considered for building a combiner computational model. Thus, the CMT was used to estimate the adiabatic length of the input bundle fibers, and the combiner efficiency was analyzed based on FD-BPM.

Optics and Instrumentation — Room 2, 14:00 – 15:30

Chair: Marcelo Martins Werneck

14:00 **(Invited) Optical metrology of structures and surfaces (Silvania Pereira):** Optical scatterometry is a method that can be used for the characterization of unknown properties of a medium by measuring some parameters or properties of the scattered light, such as its intensity distribution, polarization and coherence. The scattered field is usually detected or observed at a distance of many wavelengths from the medium, in the so called far field region. Far field detection is convenient in terms of data acquisition, but the drawback is that, in the far field, high spatial frequency information contained in the near field is lost. By measuring the scattered far field one does not obtain a direct image, but instead by means of solving an inverse electromagnetic model and taking a priori knowledge into account, one can infer some parameters of interest of the medium/scatterer.

In this talk, we show a particular scatterometry technique, in which a coherent light beam is focused by a lens on a surface to be inspected and the scattered light is collected and detected in the far field. This technique has been successfully used for characterization of nanostructures and contamination detection for the semiconductor industry.

14:30 **Temperature artifacts on two-dimensional thermal imaging of upconverting microcrystals via hyperspectral scanning (Jefferson Augusto de Oliveira Galindo, Allison Pessoa, Anderson M Amaral, Leonardo Menezes, Sidney JL Ribeiro and York Serge-Correales):** Lanthanide-doped upconverting particles are among the main subjects of interest for luminescence thermometry in micro/nanoscale. Despite their outstanding performance, the investigation of spatially varying effects related to internal dynamics and/or interaction with the surrounding medium is still a challenge. This work reports on thermal imaging measurements performed through hyperspectral scanning technique on single NaYF4: Yb3+/Er3+ microparticles. The results show that the thermal response of the microparticle depends on the laser incidence position, which may induce temperature misreadings. Also, this work reports instrumental-related thermal artifacts, suggesting important corrections for building spatially-resolved thermal maps with direct implications on lanthanide-based luminescent thermometry.

14:50 **A Software-Based Lock-in Amplifier for Optical Spectroscopy Applications (Hugo A. Fonsêca, Ricardo Ataide Lima and Diego Rativa):** This works describes the development of a low computing software capable of applying the lock-in amplifier signal correlation technique. These amplifiers can obtain the measured signal immersed in noise which has superior signal amplitude. The software was developed in C#. The software is capable of processing all 2050 points that compose the optical spectrum simultaneously. Two performance tests were conducted to recover the spectral profile of a yellow LED, submitted to two different emulated optical noises. Preliminary results show its efficacy and its viability of embed platform prototyping, allowing the application of optical spectroscopy techniques without needing external luminosity control.

15:10 **LED-POF Compound as Current Sensor for High-Voltage Transmission Lines (Marcelo Werneck, Paulo Henrique S Pinto and Renato Bellini, Juan D Lopez and Regina Allil):** Transmission line operators need to know the electrical currents to control energy demands, excess heating, and impulsive surges. Nevertheless, current transformers are bulk, heavy with a large footprint, and difficult to install. We describe a high-voltage current sensor applying a LED and a plastic optical fiber. This system was tested in two applications: A current transformer for in-field surveys at 13.8 kV lines and to measure leakage currents in insulators. The systems are portable, cheap, and easy to install, presenting advantages: do not require

energization, electromagnetic immunity, electrical isolation and the possibility to install in live-line.

Nanophotonics and Plasmonics 2 Room 3, 14:00 – 15:30
Chair: Albert Stevens Reyna Ocas

14:00 **(Invited) Combining pulsed lasers and photothermal nanoparticles for delivering functional molecules in living cells and beyond (Kevin Braeckmans):** Point of need testing has tremendous value in sensing (medical and non-medical) in resource-poor areas. The ideal point-of-need device is a portable 'sample-in-answer-out' system, which requires simplicity in operation. However, most sensing technologies require quantitative, diagnostic-level performance, and necessitate specialized instrumentation, limiting their use in point-of-need applications. To adapt biosensors to resource-poor locations, device miniaturization for portability, cost-effectiveness, and easy sample processing needs to be considered while maintaining their efficacy. Consequently, incorporating photonic technologies into biosensing platforms is needed to address this issue. I will present our work on integrating sample handling (the microfluidic component), biosensor chemistry (the assay), and data recording (the reader) into one single device. This approach leverages recent developments in the semiconductor industry where CMOS devices are manufactured at scale for low cost (<$1) and achieve high performance such as improved efficiency in converting photons to electrons (close to 90%) for improved sensitivity, small pixel size (<1 micrometer) leading to high spatial resolution, and large active area (>3x2mm) to accommodate several microfluidic channels.

14:30 **Detection of Glyphosate in Water with Photonic-Tailored Silver Nanoparticles (Lays C. Seixas Costa, Elberth Manfron Schiefer, José L Fabris and Marcia Muller:** This work describes an approach towards the detection of glyphosate levels in liquid compatible with standards for drinking water. Prismatic nanostructures were produced from spherical silver nanoparticles by photoinduced shape conversion, leading to an enhanced interaction between the nanoparticles and the analyte, inferred by both ultraviolet-visible and surface enhanced Raman spectroscopy. The role of the silver nanoparticles' shape and charge in the interaction with glyphosate was investigated. SERS spectra revealed fingerprint bands that provide an unambiguous identification of this herbicide. The obtained limit of

detection was 0.11 mg/L, which is almost 8.2 times smaller than the health-based reference value.

14:50 **Selecting silver nanoshells for colorimetric sensors (Raphael Baltar, Renato Evangelista de Araujo and Sajid Farooq:** In this work the use of silver nanoshell as a starting point for the establishment of colorimetric sensor platforms, under solar illumination, was evaluated. Mie theory was explored on the analysis of the nanosensor linearity and sensitivity, considering 4 different color spaces and the influence of the nanoshell geometry. A high performance plasmonic nanoplatform was identified. The nanosensor platform based on nanoshells, with 35 nm SiO2 core radius and 25 nm Ag shell thickness, showed sensitivity values up to 2.78/RIU and linearity higher than 0.96, considering the Hue parameter of the HSV color space. The identification of optimized plasmonic nanoplatforms may extend the use naked-eye colorimetric applications in low-resource environments.

15:10 **Effect of the addition of thermoxidized soybean oil on the fluorescence spectra of silver nanoparticles synthesized with extract of Mimusops coriacea (Carla Lopes and Lilia Courrol):** Silver nanoparticles were synthesized using the aqueous extract of Mimusops coriacea leaves. This extract emits intense fluorescence at approximately 364, 450 and 510 nm when excited at 280, 368 and 432 nm, respectively. After the formation of the nanoparticles, there is a significant reduction in the emission intensity. The addition of soybean oils heated at ~180 °C to the nanoparticles increased the emission intensity, varying with the degree of oxidation of the oil. This result indicates the potential of developing a nanosensor to determine the degree of thermoxidation of soybean oils.

Biophotonics — Auditorium, 16:00 – 17:50

Chair: Renato E. de Araujo

16:00 **(Invited) Novel photonic technologies for biosensing at the point of need (Sebastian Wachsmann-Hogiu):** Intracellular delivery of bioactive compounds, such as proteins and nucleic acids, into living cells is a generic requirement for many applications in the life sciences. Although substantial effort has gone into developing viral and non-viral nanocarriers, they each come with their limitations, including safety concerns and limited efficiency. Physical delivery methods offer an interesting alternative solution. Electroporation is a notable example but is often associated with high cell

toxicity. Laser technology combined with photothermal nanoparticles has emerged as a promising intracellular delivery method combining high delivery efficiency with flexibility and good cell viability. Cells are first incubated with photothermal nanoparticles which are adsorbed to the cell membrane. Local heating effects upon laser irradiation create pores in the membrane through which compounds in the surrounding cell medium can then enter the cell. Using this so-called 'photoporation' technology, we have demonstrated that many cell types can be efficiently transfected, including primary neurons, macrophages and T-cells. Compounds that can be delivered include nucleic acids (siRNA, mRNA, pDNA, …), proteins (e.g. nano- and antibodies), gene editing complexes (e.g. CRISPR/Cas9) and contrast agents (e.g. for MRI). Applications range from fundamental biological investigations to the engineering of therapeutic cells for cell-based therapies. In addition, we have demonstrated that the same principle can be used to disrupt bacterial biofilms or to destroy vision-impairing 'floaters' in eyes in vivo. In summary, pulsed lasers and nanoparticles offers the possibility to interfere with biological tissues in a highly controlled manner, thus opening up unique biomedical applications with plenty of room for further exploration and development.

16:30 **Identifying enamel demineralization using high performance convolutional neural network (Amanda Caramel-Juvino, Sajid Farooq, Mariana Romano and Denise M. Zezell):** Here, we traces use segmentation and convolutional neural network (CNN) to to trace, diagnose and quantify enamel demineralization for research. The preprocessing, histograms based methods are used to enhance the contrast and equalize the brightness through the scanning electron microscope images. Our result evidence that the deep learning based CNN model is highly efficient to process the dental image to achieve high accuracy of enamel demineralization and presents promising outcomes with optimal precision.

16:50 **Correlation Between Human Skin Optical Properties and Colorimetry Using Individual Typology Angle (Luismar Barbosa da Cruz Junior, Carlos Eduardo Girasol, Pedro Coltro, Rinaldo Guirro and Luciano Bachmann):** This work aims to correlate the human skin phototype through the individual typology angle (ITA) values with the human skin optical characterization (absorption and scattering coefficients) for different phototypes. We used a colorimeter to group 10 fresh human skin samples according to their phototype. This study demonstrates the importance of considering skin colors in optical analysis but also takes into consideration

an absolute quantitative metric to evaluate skin color. Melanin is a strong modifier of optical properties and using the ITA quantitative analysis it is possible to characterize its optical properties correlating with a non-subjective color scale.

17:10 **Superior Machine Learning Method for breast cancer cell lines identification (Sajid Farooq, Amanda Caramel-Juvino, Matheus del Valle, Sofia dos Santos, Emerson Bernardes and Denise M. Zezell:** We propose here an artificial intelligence platform based on machine learning (ML) algorithm using Neighborhood Component analysis and K-Nearest Neighbors for breast cancer cell lines recognition. Our model presents up to 97% accuracy for identification of breast can cell lines.

17:30 **Aminolevulinic acid-based metallic nanoparticles: Applications in Agriculture (Isabela Lopes, Marcia Franzolin, Susana Barreto, Carla Lopes and Lilia Courrol:** Aminolevulinic acid is a plant growth regulator and essential precursor for chlorophyll biosynthesis; besides, its photodynamic activity can be used to exterminate microorganisms in plants and soil. In this study, silver and gold nanoparticles capped with aminolevulinic acid (ALANPs) were synthesized by the photoreduction method and characterized by UV-Vis, transmission electron microscopy, and Zeta potential. The effect of ALANPs was evaluated on stalks of E. densa by measuring the fluorescence of chlorophyll extracted from the plants after incubation with nanoparticles. The antimicrobial activities were obtained. The results suggested that ALANPs could be suitable for applications as nanopesticides and nanostimulants simultaneously.

Lasers 2

Room 2, 16:10 – 17:50

Chair: Marcio Miranda

16:10 **Tunable diode laser surface plasmon spectroscopy (Gabriel F Fernandes, Raoni F Gois, Ernande Melo and Eduardo Fontana):** In this paper, we propose use of temperature tuning of distributed feedback lasers in conjunction with metal coated diffraction gratings in the near infrared for interrogation of the surface plasmon resonance spectrum, at a fixed angle. The approach allows using traditional techniques for spectral analysis of the SPR effect, such as wavelength modulation spectroscopy. Case studies are simulated to demonstrate the feasibility of the approach, based on thermal response curves of commercially available DFB lasers.

16:30 **Thermodynamic measurement of non-equilibrium stochastic processes in optical tweezers (Thalyta T. Martins, Lucas Kamizaki and Sergio R. Muniz):** Due to their versatility in investigating phenomena in microscopic scales, optical tweezers have been an excellent platform for studying stochastic thermodynamics. In this context, this work presents experimental measurements of the energetic cost of driven finite-time protocols using colloidal Brownian particles in harmonic potentials. For this simple model system, there is an exact optimal solution. Our results compare the optimal and (sub-optimal) linear protocol for a time-dependent trap, controlling the trap stiffness with different modulation amplitudes and protocol times. We also calculate the Jarzynski relation for the stochastic trajectories as an independent consistency check.

16:50 **Power analysis of a microstructured vector light beam composed of a continuous superposition of zeroth order ideal Bessel beams (Vinicius de Angelis and Leonardo Ambrosio):** In this paper, we derive an expression for the power of a nondiffracting microstructured vector light beam characterized by a continuous superposition of zeroth order ideal Bessel beams, known in the literature as Frozen Wave. Our final result expresses the power in terms of the spectrum of the Frozen Wave in the spatial frequency domain. The power evaluated from our final result is in accordance with that obtained by numerically integrating the average energy flux associated with the beam. Besides, our expression is less computationally demanded, which facilitates the determination of the optical forces produced by this vector light beam.

17:10 **Numerical simulation tool and experimental set-up for measuring the modal structure of a broad area semiconductor laser diode (Fernando Carlos Romano and Niklaus Wetter):** A computer simulation model for a single stripe, multimode laser diode of the type broad area semiconductor diode (BALD) was built and compared to the transversal mode structure measured in an experimental set-up as a function of the forward current in its heterojunction. A set up was built with the objective of identifying the lateral modes by using the frequency beat technique in the RF spectrum. A spectrum analyzer measured the signals emitted by the BALD using the fast Fourier transform (FFT) method.

17:30 **Technical Talk Reserved**

Sensors, Image and Illumination 2 Room 3, 16:00 – 17:30

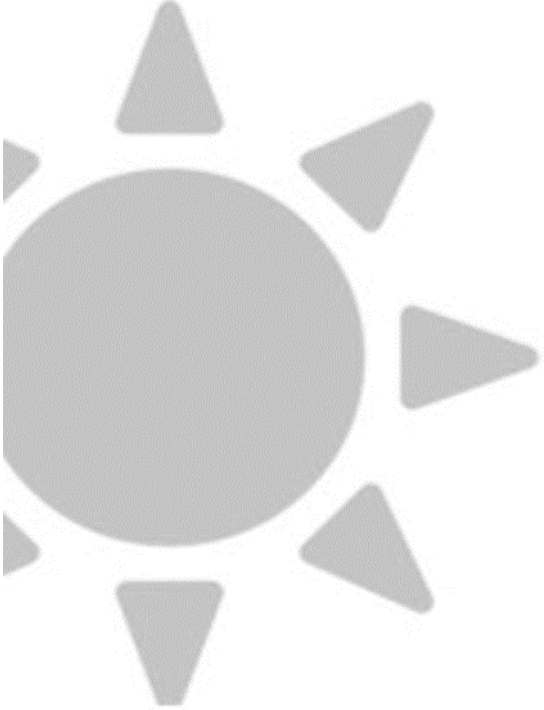
Chair: Brian Vohnsen

16:00 **(Invited) New-generation hollow-core photonic crystal fibers and their outstanding possibilities (Jonas H Osório):** The recent breakthroughs in hollow-core fiber technology have granted new enthusiasm to the fiber optics community and consolidated this family of special optical fibers as building blocks for the next developments in photonics. In this talk, we will review the fundamentals of hollow-core fibers by delving into the light guidance mechanisms, the different fiber architectures, and fabrication methods. Moreover, we discuss the latest advances and the bright scenario of hollow-core fibers applications ranging from beam delivery devices to sensing opportunities.

16:30 **Analysis of 3-D waveguides in a cylindrical lens solar concentrator (Marcos C. Ramos, Caio V. P. Vital, Hugo A. Fonsêca, Renato Evangelista de Araujo and Diego Rativa):** High-efficiency solar cells use waveguides for concentration and greater capture of sunlight, reducing the physical area of solar panels and the cost of this technology. Therefore, this study intends to simulate and analyze a solar concentrator that will consist of 3 cylindrical lenses and 3 waveguides. The model simulation was performed using the Comsol Multiphysics software. The results showed a maximum optical efficiency of 77% and a concentration ratio approximately equal to 3.5. The set of lenses and waveguides were developed in a unique structure. The model demonstrates potential for photovoltaic and photothermal applications from concentrated sunlight.

16:50 **A study comparative between Magnetic Field Sensors Based on in-Fiber Fabry-Pérot cavity Interferometer and on etched side-hole Fiber (Larissa Beserra Soares, Juan D Lopez, Alex Dante, Regina Allil and Marcelo Werneck):** This paper presents a study comparative between two types of in-fiber Fabry-Pérot interferometers (FPI) and a commercial fiber Bragg grating (FBG) for magnetic field sensing. The first FPI sensor (FP1) was manufactured with a 273 µm section of capillary fiber. The other FPI sensor (FP2) was manufactured by etching the tip of a telecom SMF (germanium-doped) in hydrofluoric acid. The FPI sensors manufactured plus a commercial fiber Bragg grating (FBG), were bonded on a Terfenol-D piece. The results show that the FP2 sensor presented a sensitivity of 2.02 times higher than FP1 and 3.4 times higher than the FBG sensor.

17:10 **Ti/Au layers impact in prism-based plasmonic sensing of ethanol-fuel purity detection (Jorge R Fernández and Vitor Freire and Hugo Enrique Hernandez-Figueroa):** In this work, the impact of a Titanium adhesion layer for the deposition of gold on the performance of an SPR sensor based on the Kretschmann configuration is analyzed. The theoretical and numerical analysis of the SPR from the multilayer structure Fresnel reflection coefficient point of view was taken and experimental results for ethanol purity detection with a setup based on angular interrogation with a 632nm He-Ne laser, one theta-2*theta stage, a photodetector, a BK7 prism, a PDMS microfluidic system and two different Titanium/Gold layers with different thicknesses were acquired.



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October 15th, 2022

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Hands-On Optics Workshop I — Room 1, 9:00 – 12:00

9:00 **(Talk) Adaptive Optics Systems (Brian Vohnsen and Denise Valente)**
9:30 **(Talk) Optical Tweezers (Adriana Fontes and Diógenes Soares Moura)**
10:00 **(Hand-On Experience) Adaptive Optics Systems (Denise Valente)**

Hands-On Optics Workshop II — Room 2, 10:00 – 12:00

10:00 **(Hand-On Experience) Optical Tweezer Systems (Diógenes Soares Moura)**

Hands-On Optics Workshop III — Room 3, 10:00 – 12:00

10:00 **(Hand-On Experience) Optical Techniques (OSA and SPIE Recife Chapters)**