MOCCA

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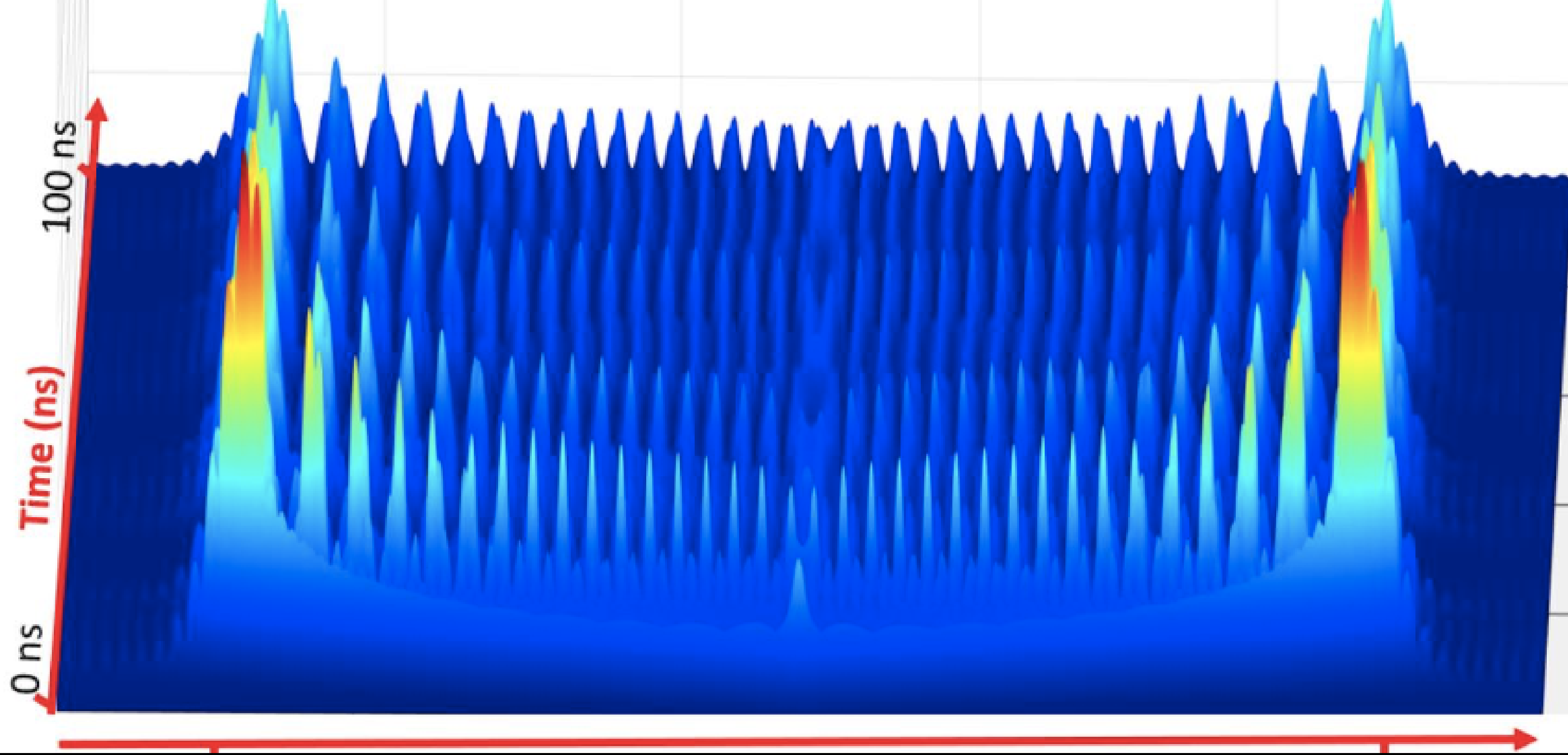
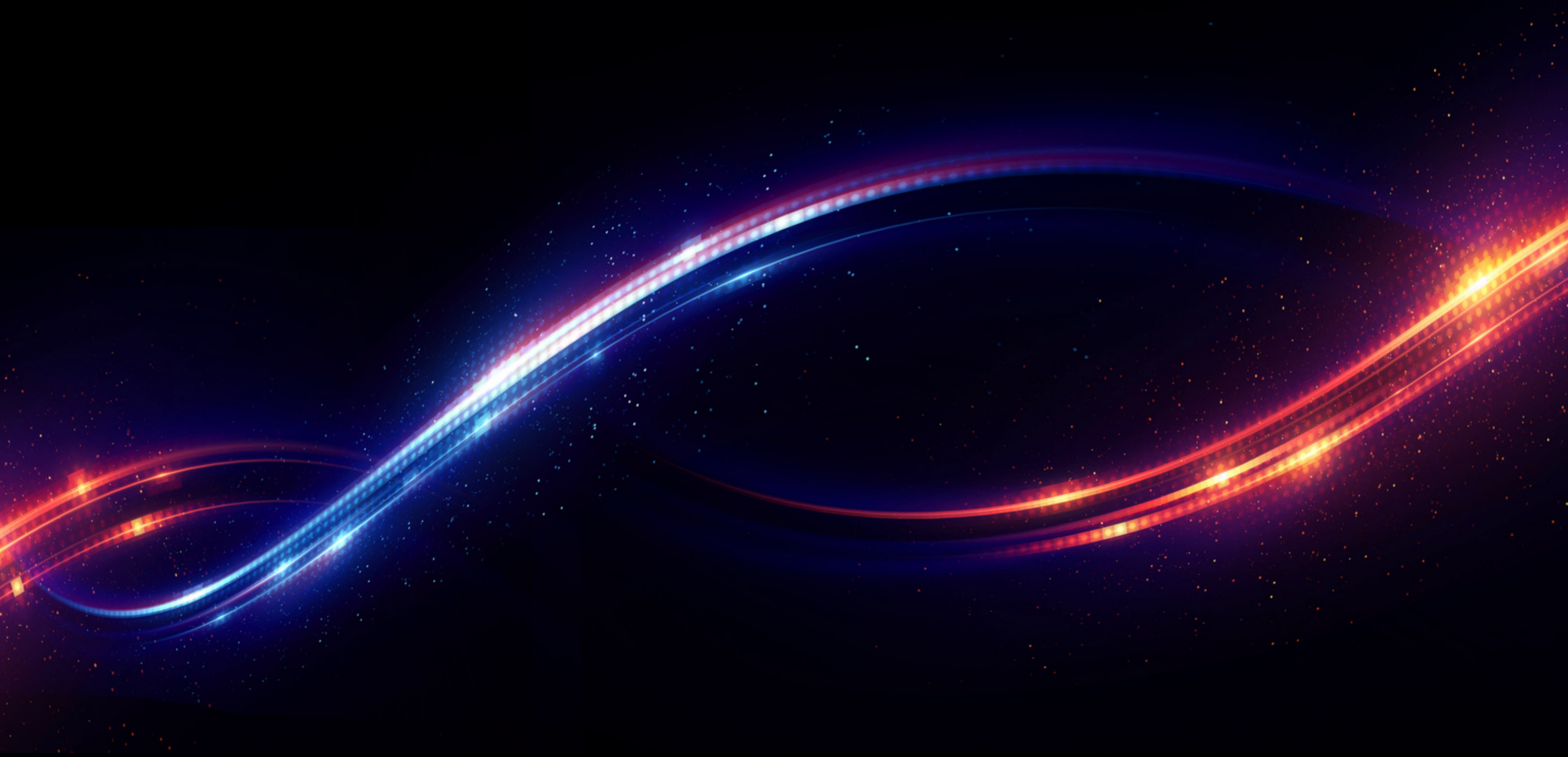


Victor Vassiliev
ESR1
Aston University

Leveraging Technology for a Better Tomorrow

PHD THESIS: NEW CONCEPTS FOR MICRORESONATOR COMB GENERATION

The project of my thesis aims to ‘reshape’ light in a very precise and controlled manner: we take a simple one frequency beam of light and we transform it into a complex and wonderful tool, a ’frequency comb’.
This transformation is made by taking advantage of the fascinating properties that light has when propagating inside a medium like glass: All the effects are carefully balanced in a small ‘bottle’ made from an optical fibre to split the initial frequency in a multitude of closely packed, equally spaced frequencies creating a very precise ‘spectral ruler’, that is used in many scientifical fields.
Unfortunately, these transformations cannot be observed with a naked eye, but we have analyse and simulation tools allowing us to have a glance on how the light is reshaped inside of the resonator.



Loredana Massaro

ESR2

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PHD THESIS: NONLINEAR SEMICONDUCTOR PLATFORMS FOR OPTICAL MICROCOMB GENERATION

The focus of my thesis is the nanoscale localisation of light.
In order to localise light I design and fabricate Photonic Crystal cavities (PhC) based on hybrid platforms such as III-V materials on Silicon On Insulator (SOI).
A photonic crystal is a nanostructure where the refractive index is modulated periodically. To construct a photonic crystal cavity starting from the basic periodic structures, a parameter of the design is varied smoothly in order to have diffraction limited mode volumes and high quality (Q) factors. This design rule leads to the lowering of the power threshold for parametric interations, while the choice of the III-V semiconductor material prevents two photon absorption while working at telecom wavelength.
The PhC cavities that I am implementing are working as frequency comb sources. These PhC cavities are indeed designed and fabricated in order to have multiple and equispaced resonant modes, spanning above 20 THz.
The integration of these cavities on SOI here is key to demonstrate novel integrated sources for quantum photonics, ready to join photonic integrated circuits! The development of such comb systems is meant to be applied across various field of sciences and engineering as multi wavelength lasers, metrology and quantum information theories.

Francesco Talenti

ESR3

Sapienza University of Rome

Optimize geometry for a DFB silicium gratin

PHD THESIS: THEORETICAL MODELLING THE BUILD-UP AND EVOLUTION OF THE FIELDS IN MICRORESONATORS AND ACTIVE CAVITIES

Frequency combs are novel optical sources with a wide range of application, from metrology to molecular spectroscopy or optical communications. Their most special feature is the electromagnetic spectrum which exhibits discrete and equally spaced frequencies. This suggests the use of these sources for wavelengths measurements or multimode signal transmission in integrated all optical circuits. The state of the art research aims towards the miniaturization and integration on-chip of devices suitable for the comb generation. An optical micro-resonator is the structure of study. Here we show the optical output of a photonic crystal (PhC) cavity.
The structure has an optimized geometry for equally-spaced frequencies confined by an harmonic potential. The wave shape is the same of the so called Hermite- Gauss modes, mathematical solutions to the quantum harmonic oscillator problem.
By adjusting the geometrical layout of the PhC, we can tune the potential well shape, its deepness and broadness. The optical output is affected accordingly. In the design process we carefully tune some of these parameters till obtaining the optimized geometry for the modal confinement seek. In our case, we seek the best configuration for an optical output with confined frequencies the most possible equally spaced, by minimizing the dispersive effects. We believe that PhC cavities are the close future for the compact integration of all-optical circuits suitable for any kind of frequency comb applications.

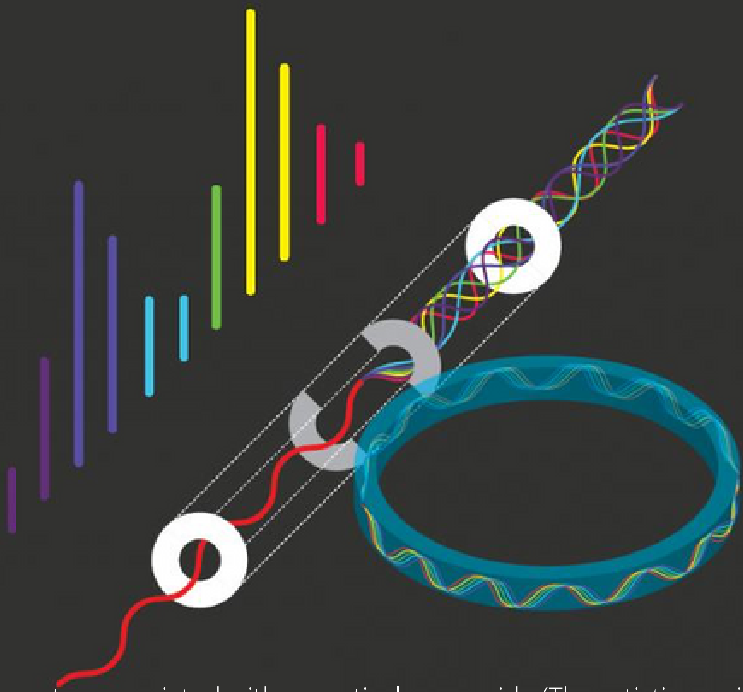

Figure: Forming a comb in a microresonator associated with an optical waveguide (The artistic version). Credit: Mikhail Gorodetsky

Avinash Kumar

ESR4

AMO GmbH

Leveraging existing technology for a sustainable tomorrow

PHD THESIS: GENERATING OPTICAL NON-LINEARITY ON THE SI/SI3N4 MATERIAL PLATFORM AND EXPLOITING IT FOR COMB GENERATION VIA MICRORESONATORS

Frequency comb is a laser source whose spectrum consists of a series of discrete, equally spaced frequency lines (Wikipedia).
Due to its unique output spectrum which provides high resolution between two consecutive frequencies making it potentially applicable anywhere where precision measurements are needed noninvasively at low power
In recent years, there is a lot of research work has been done on exploring the field of frequency comb with different materials and designs across the accessible electromagnetic spectrum. In project MOCCA, at AMO we are developing these frequency combs with Silicon Nitride on scalable CMOS platform. Silicon Nitride material properties allows fabrication of frequency combs with already existing CMOS fabrication processes.

It is very important from sustainability point of view to develop frequency combs on CMOS platform to have existing electronics and developing photonics working together on a single chip..
Simultaneously, we are also looking into integrating Silicon Nitride with other CMOS compatible nonlinear materials to expand the output spectrum of the device at lower input power.
An example to point the technological advantages of frequency combs: Autonomous vehicles rely on the precision of data they receive while interacting with the environment. Existing technologies suffers with lower precision, heavy infrastructure and additional cost. On chip integrated frequency comb device in future can provide a solution for an efficient, faster and highly precise way for data gathering making autonomous vehicles much safer.